US012385481B2

(12) **United States Patent**
Rosinski et al.

(10) **Patent No.: US 12,385,481 B2**
(45) **Date of Patent: *Aug. 12, 2025**

(54) **THERMISTOR FLOW PATH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 63 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **18/325,410**

(22) Filed: **May 30, 2023**

(65) **Prior Publication Data**

US 2023/0296094 A1 Sep. 21, 2023

Related U.S. Application Data

(63) Continuation-in-part of application No. 17/544,215, filed on Dec. 7, 2021, now Pat. No. 11,959,481, (Continued)

(51) **Int. Cl.**
F04C 2/10 (2006.01)
F04C 15/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F04C 2/102*** (2013.01); ***F04C 15/0096*** (2013.01); ***F04C 29/045*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC F04C 15/0096; F04C 29/04; F04C 29/047; F04C 29/045; F04C 29/5806;
(Continued)

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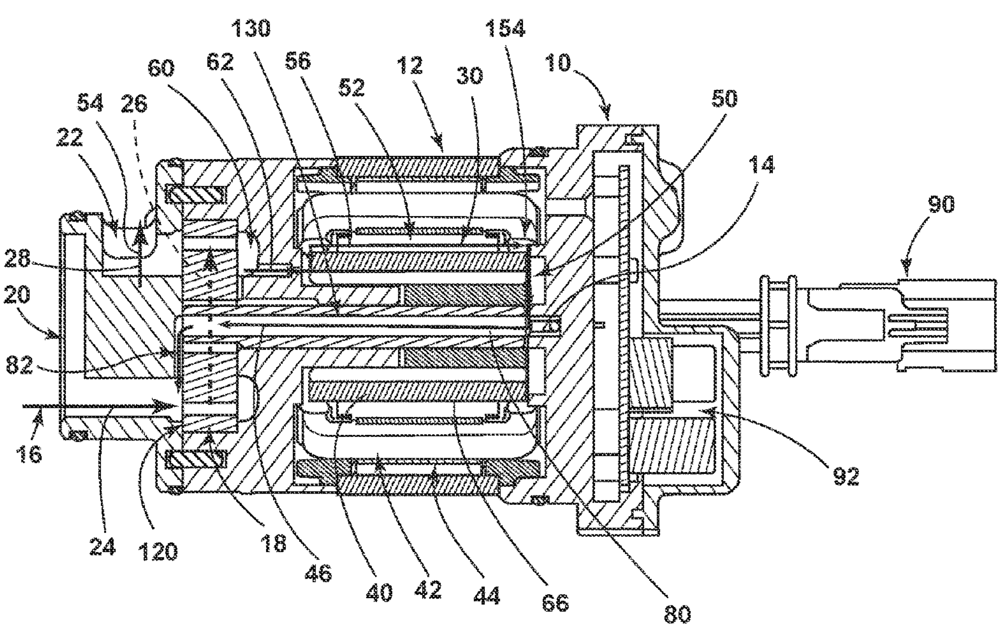
(57) **ABSTRACT**

A fluid pump includes a pump element where rotation of the pump element generates suction at the inlet and pressure at the outlet to move fluid through a fluid path. An inlet orifice directs a portion of the fluid through the accessory fluid path that includes a low-restriction return path providing a continuous flow of the fluid through the accessory fluid path and to an outlet orifice. A circuit board housing includes a contoured portion and a PCB with a thermistor in communication with contoured portion. The continuous flow is directed between the contoured portion and the outlet orifice between a rotor and the outer wall. The low-restriction return path maintains a temperature of the continuous flow of the fluid within the contoured portion of the accessory fluid path to be similar to a temperature of the fluid in the fluid path.

20 Claims, 14 Drawing Sheets



Related U.S. Application Data

which is a continuation-in-part of application No. 17/141,265, filed on Jan. 5, 2021, now Pat. No. 11,454,235, which is a continuation of application No. 15/590,248, filed on May 9, 2017, now Pat. No. 10,914,305.

(60) Provisional application No. 62/342,615, filed on May 27, 2016.

(51) **Int. Cl.**
F04C 29/04 (2006.01)
F04D 13/06 (2006.01)
F04D 29/58 (2006.01)

(52) **U.S. Cl.**
CPC ***F04C 29/047*** (2013.01); ***F04D 13/0646*** (2013.01); ***F04D 13/0653*** (2013.01); ***F04D 29/58*** (2013.01); ***F04D 29/5806*** (2013.01); ***F04D 29/5813*** (2013.01); ***F04D 29/588*** (2013.01)

(58) **Field of Classification Search**
CPC F04C 29/5813; F04C 29/588; F04C 29/58; F04C 2/102; F04C 13/0646; F04C 13/0653
See application file for complete search history.

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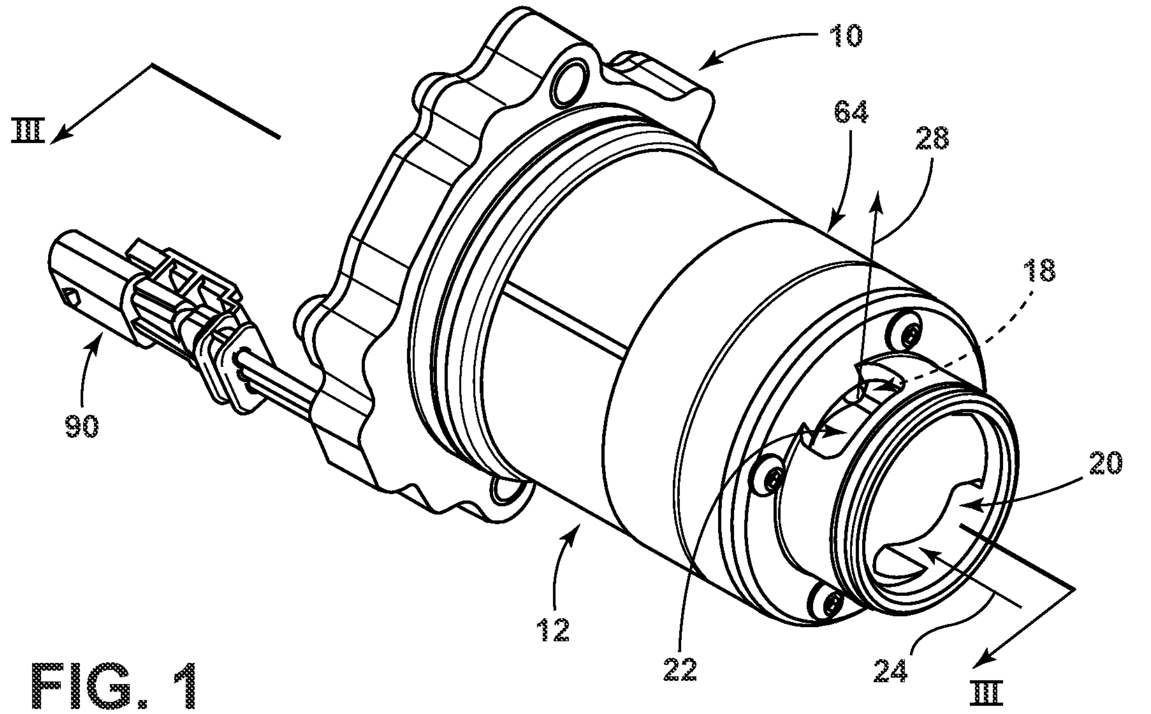

FIG. 1

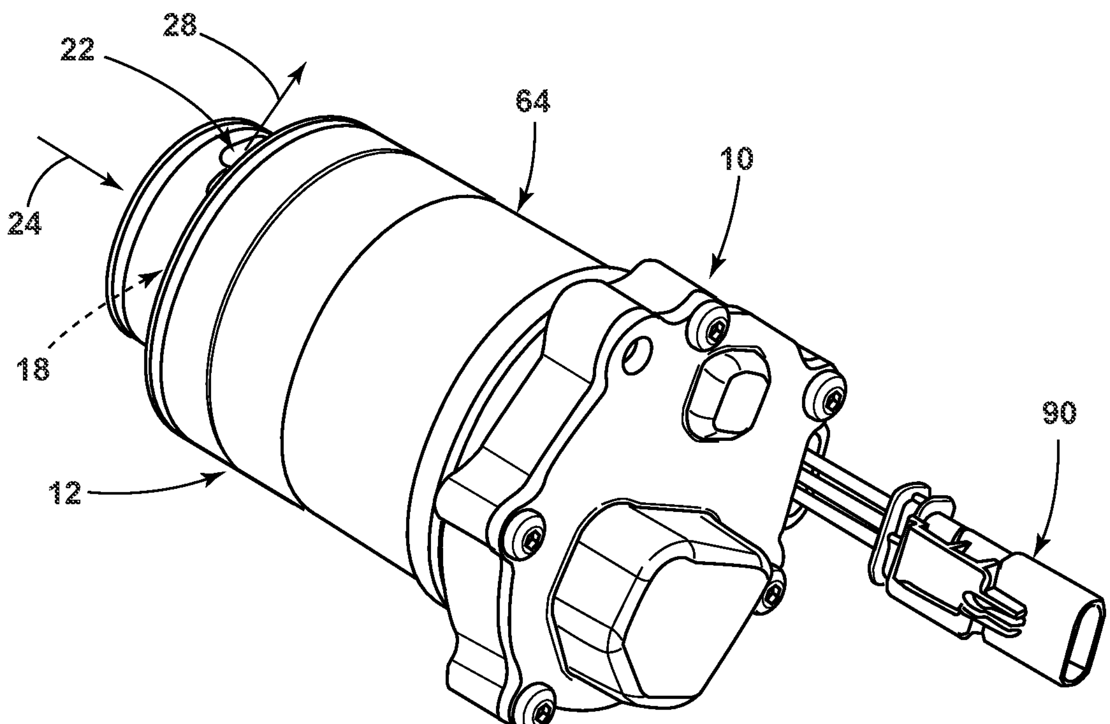

FIG. 2

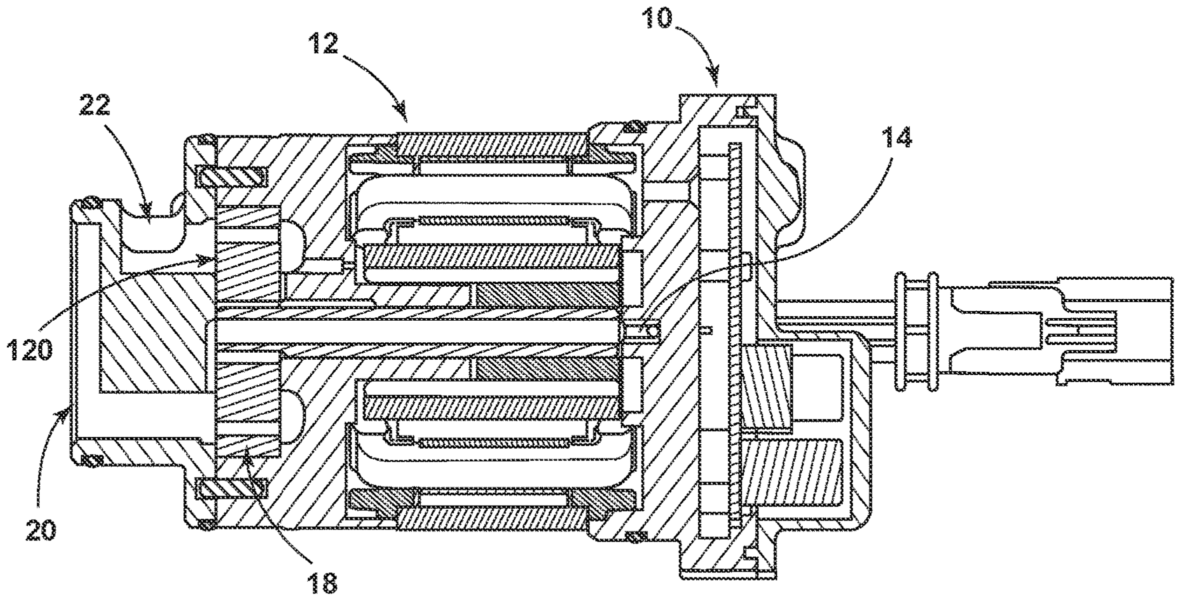

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FIG. 3

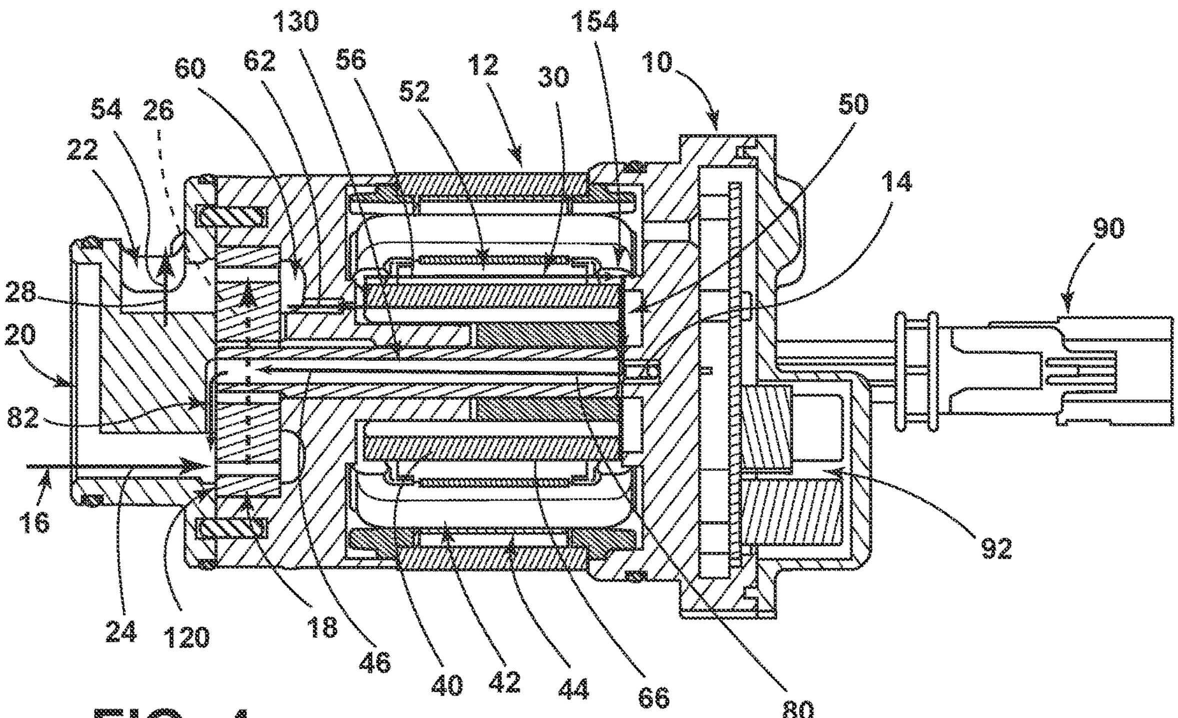

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FIG. 4

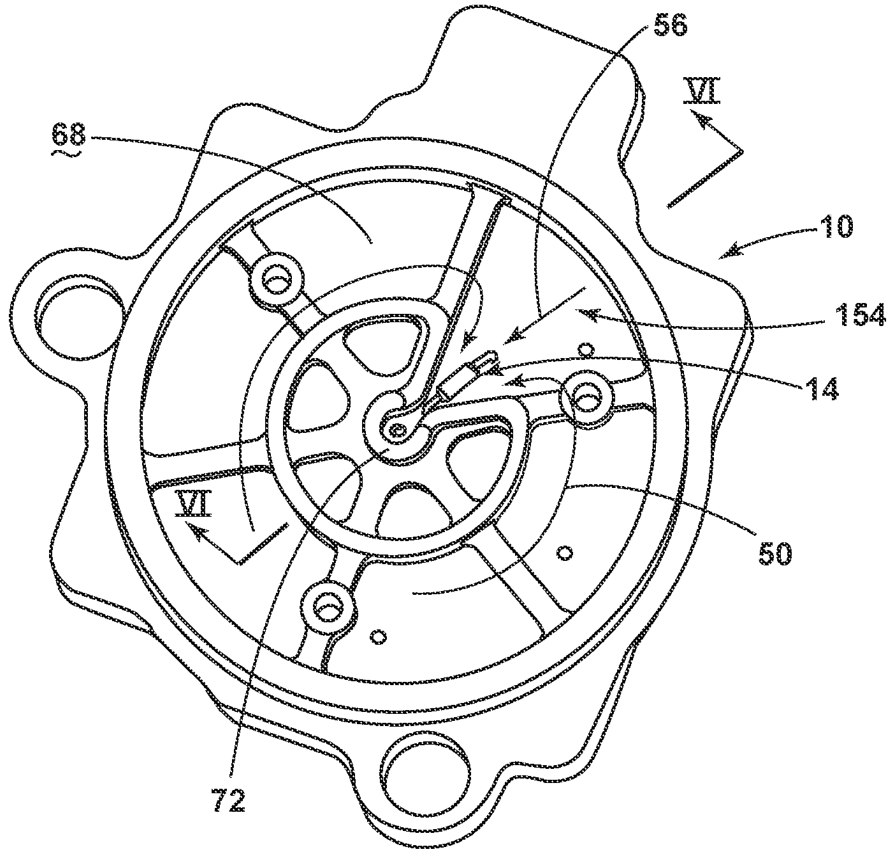

FIG. 5

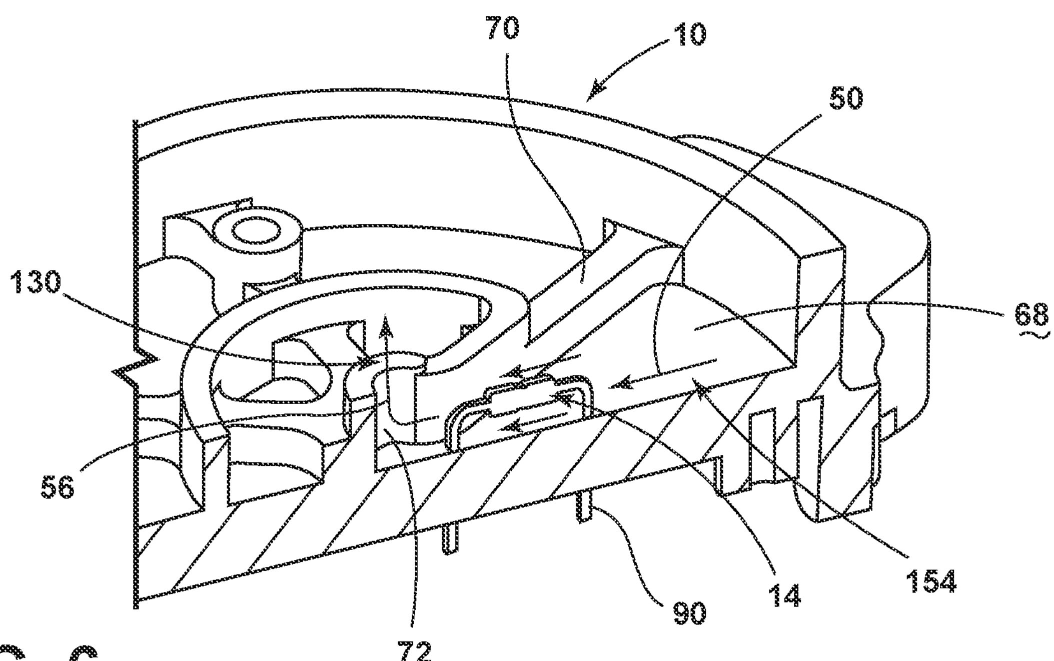

FIG. 6

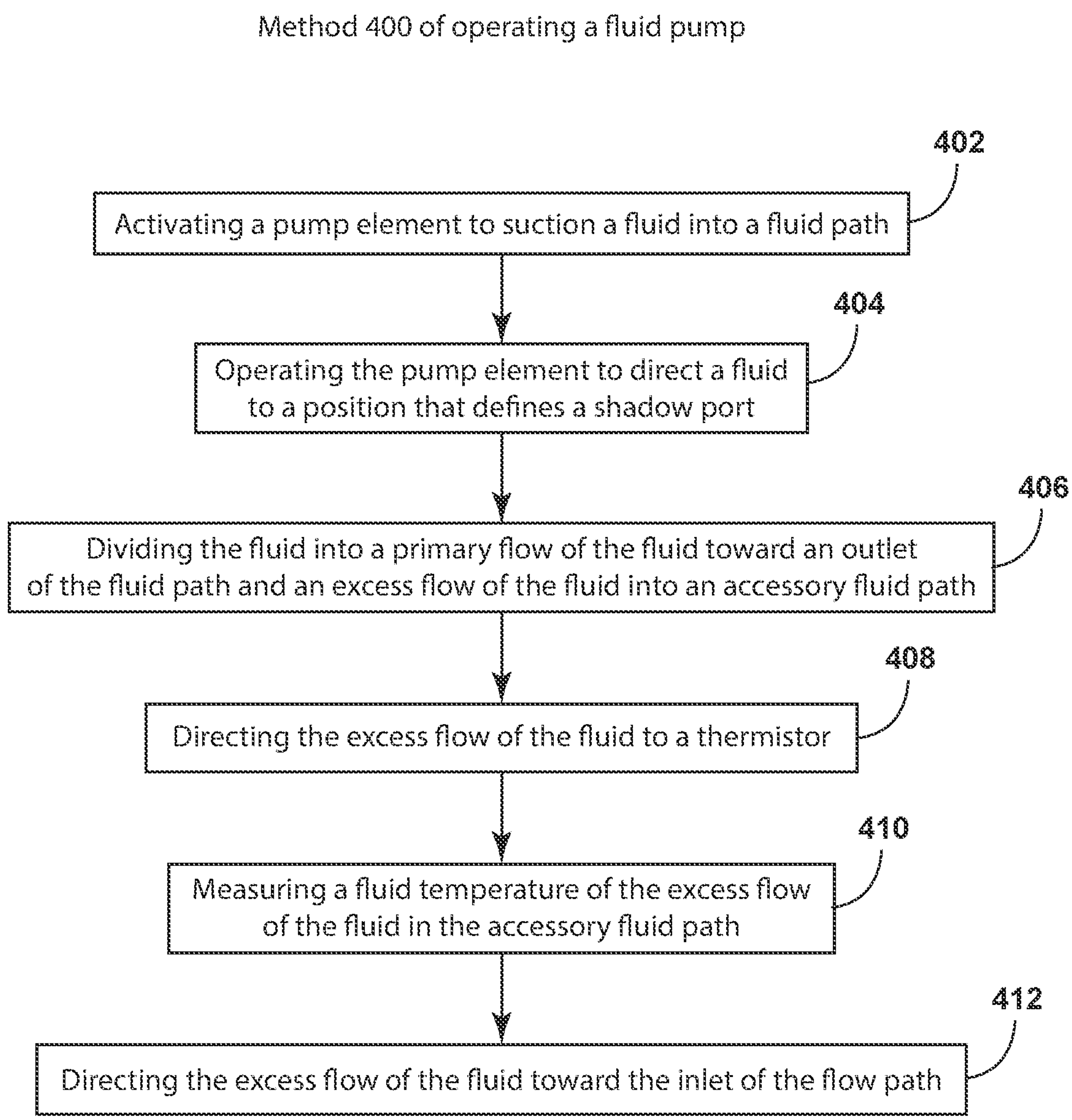
Method 400 of operating a fluid pump
402
Activating a pump element to suction a fluid into a fluid path
404
Operating the pump element to direct a fluid to a position that defines a shadow port
406
Dividing the fluid into a primary flow of the fluid toward an outlet of the fluid path and an excess flow of the fluid into an accessory fluid path
408
Directing the excess flow of the fluid to a thermistor
410
Measuring a fluid temperature of the excess flow of the fluid in the accessory fluid path
412
Directing the excess flow of the fluid toward the inlet of the flow path

FIG. 7

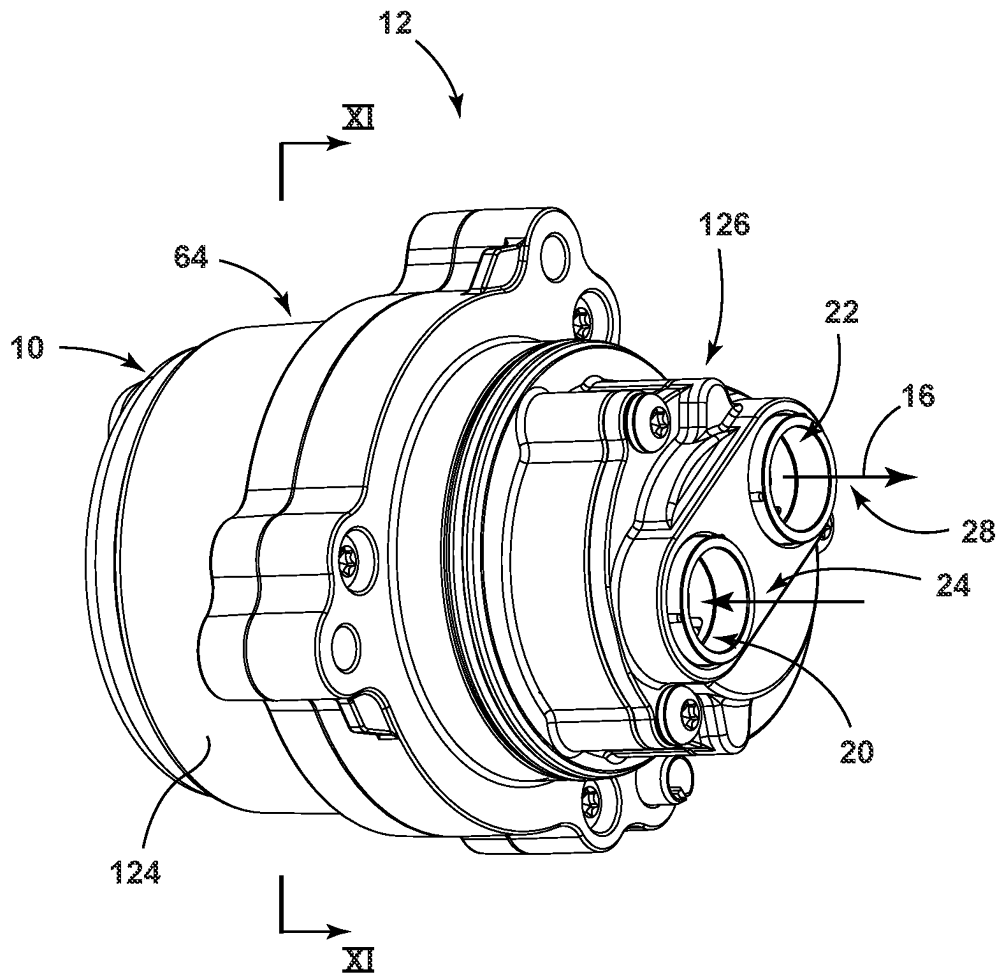

FIG. 8

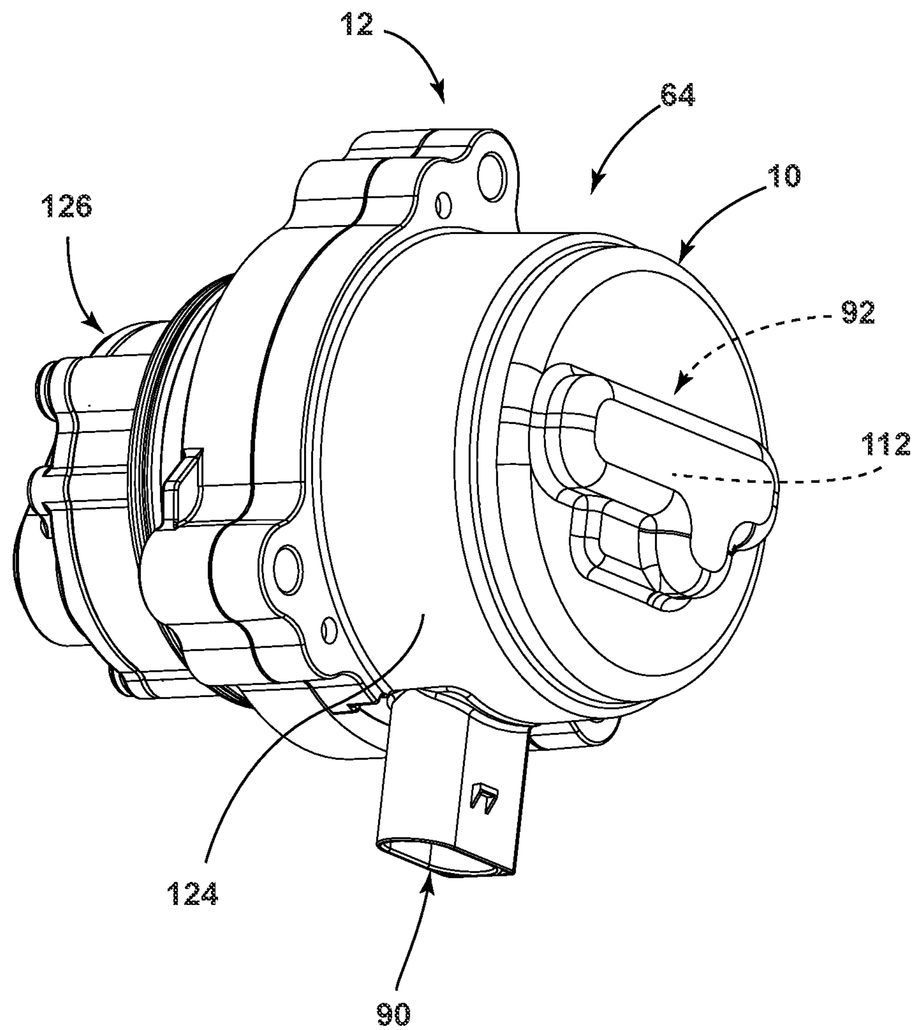

FIG. 9

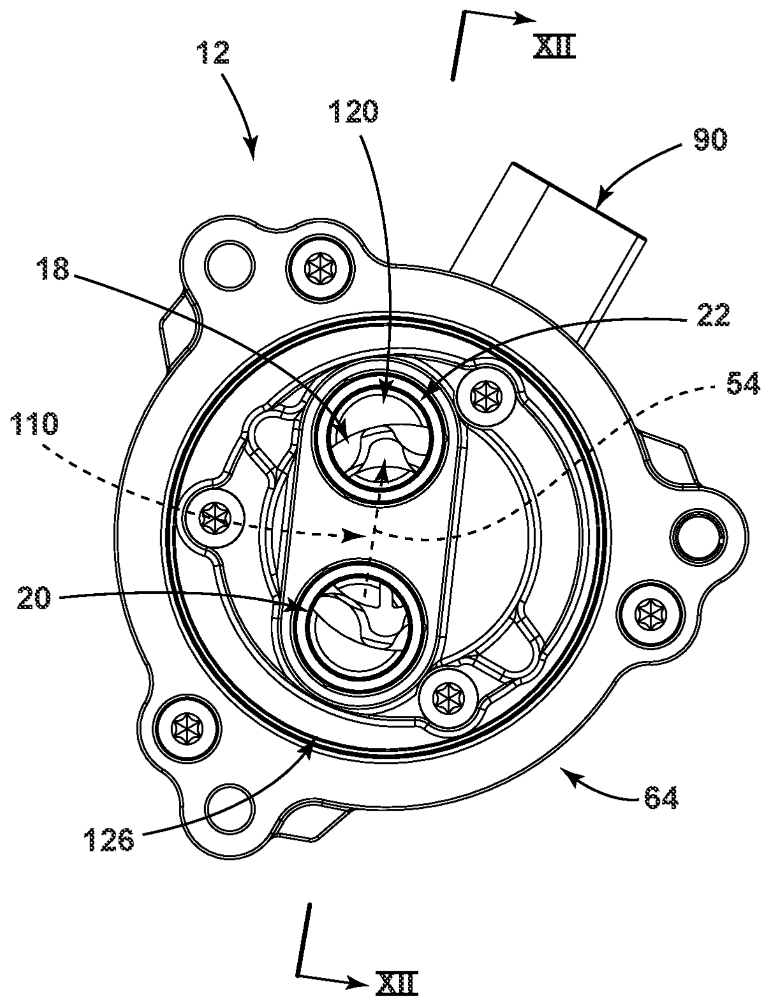

FIG. 10

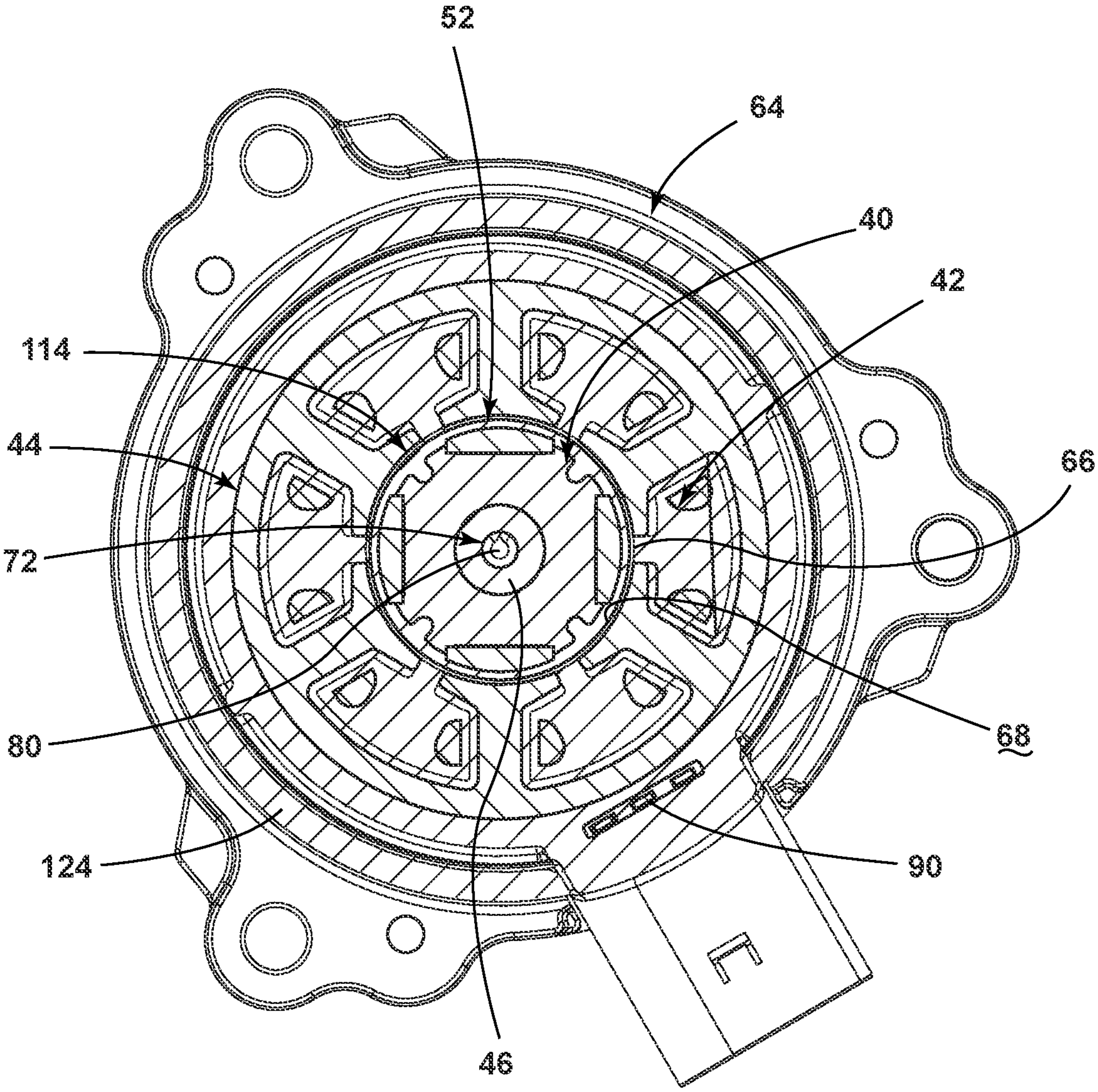

FIG. 11

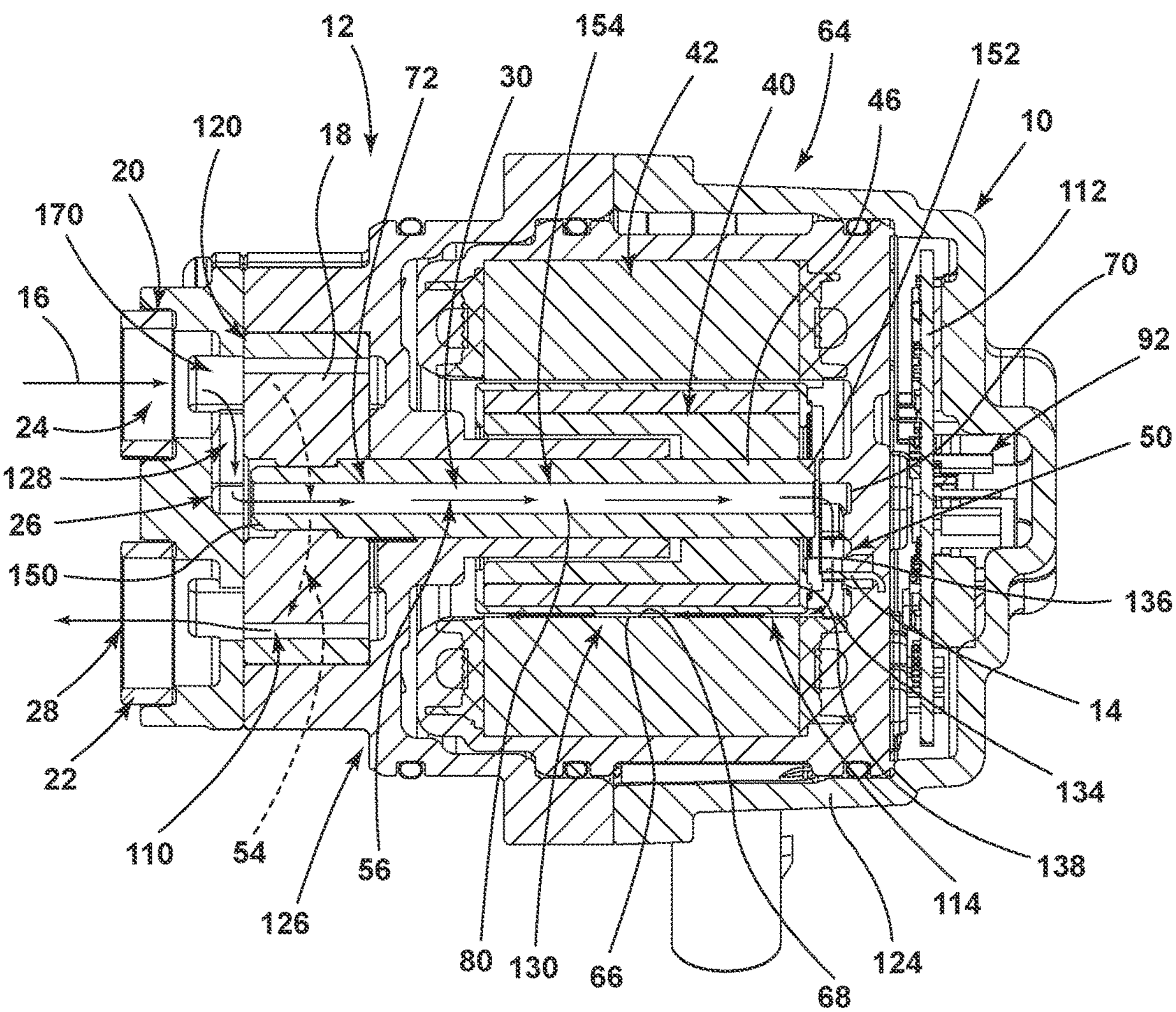
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FIG. 12

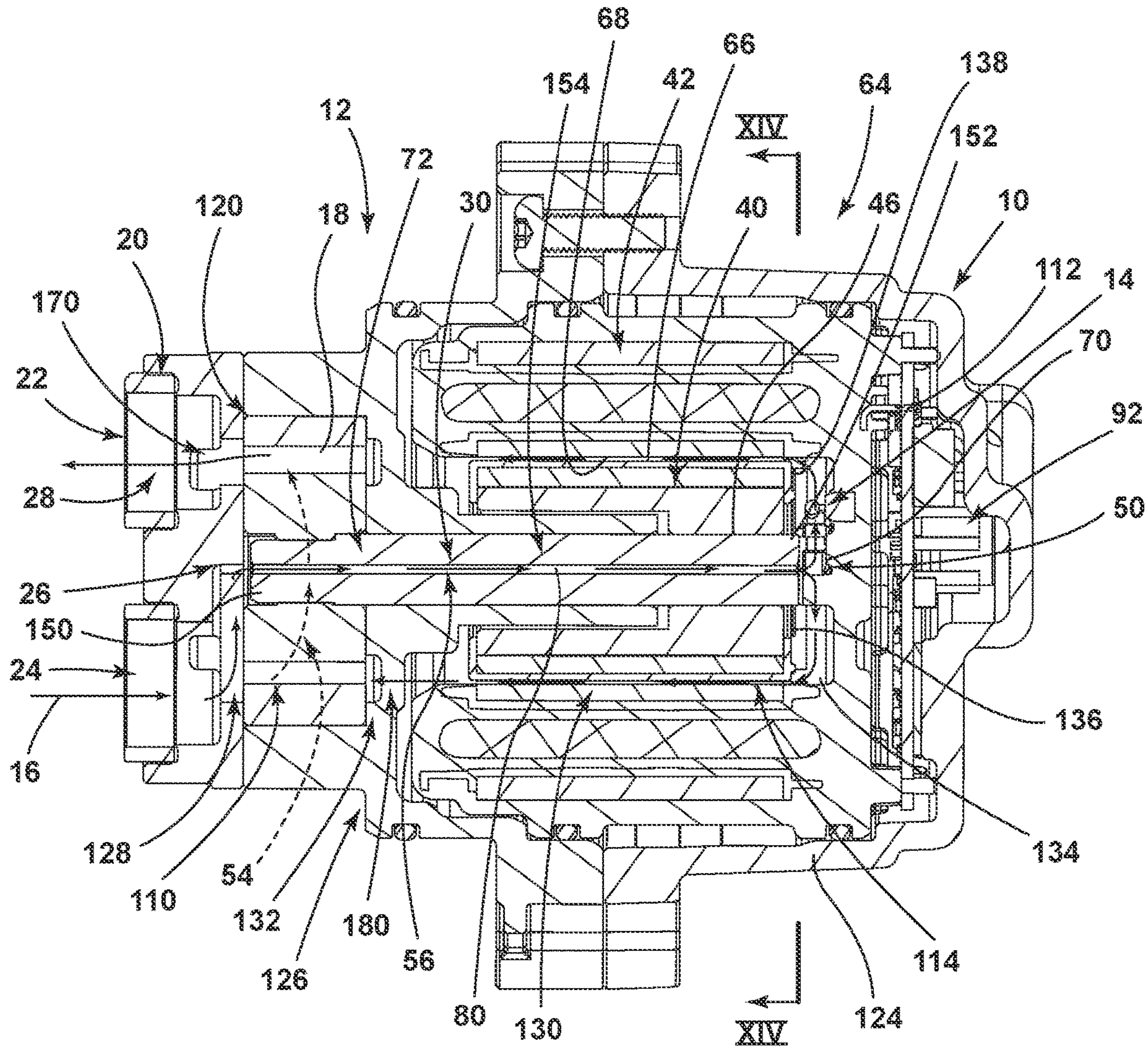
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FIG. 13

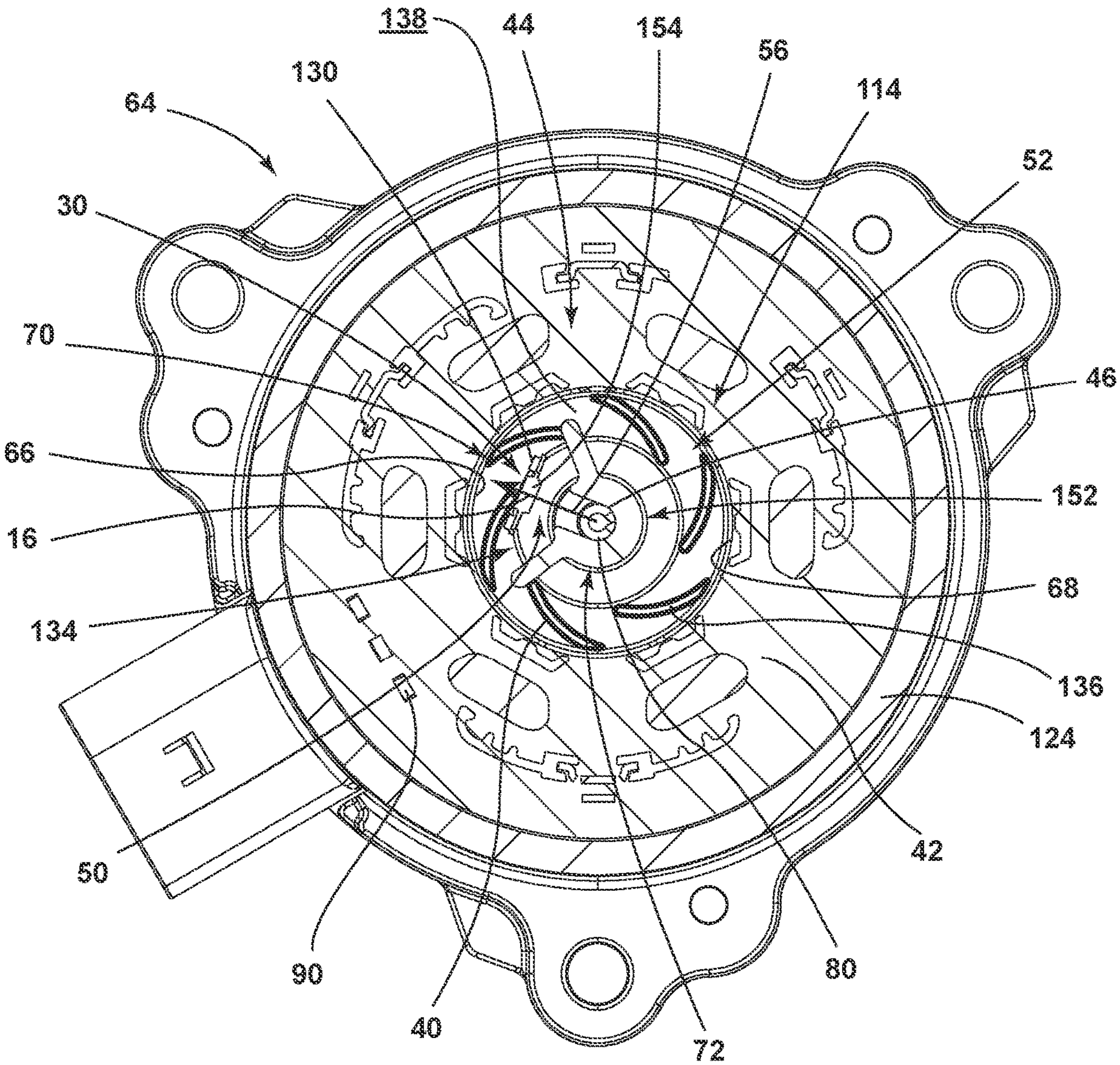
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FIG. 14

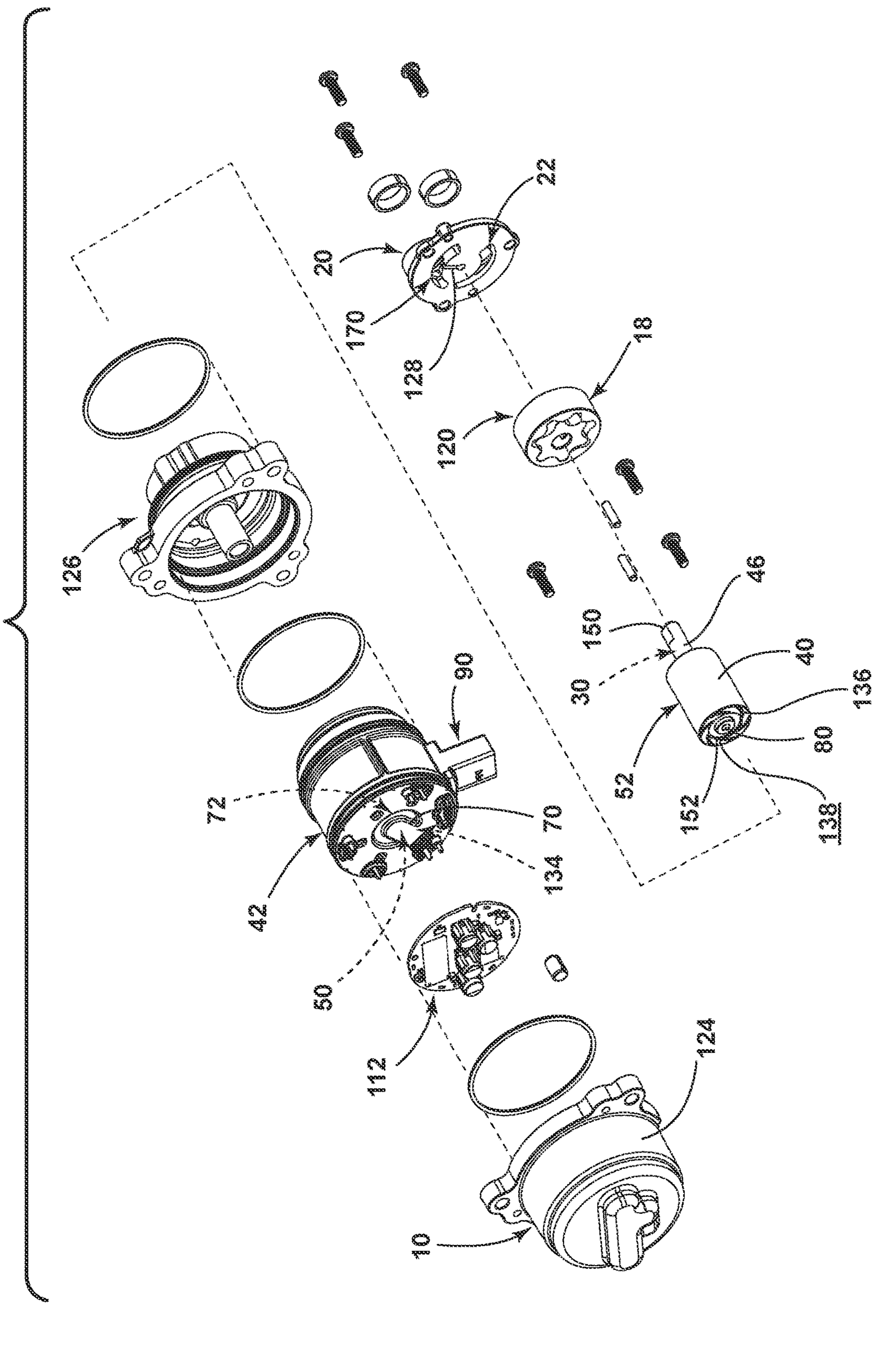
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FIG. 15

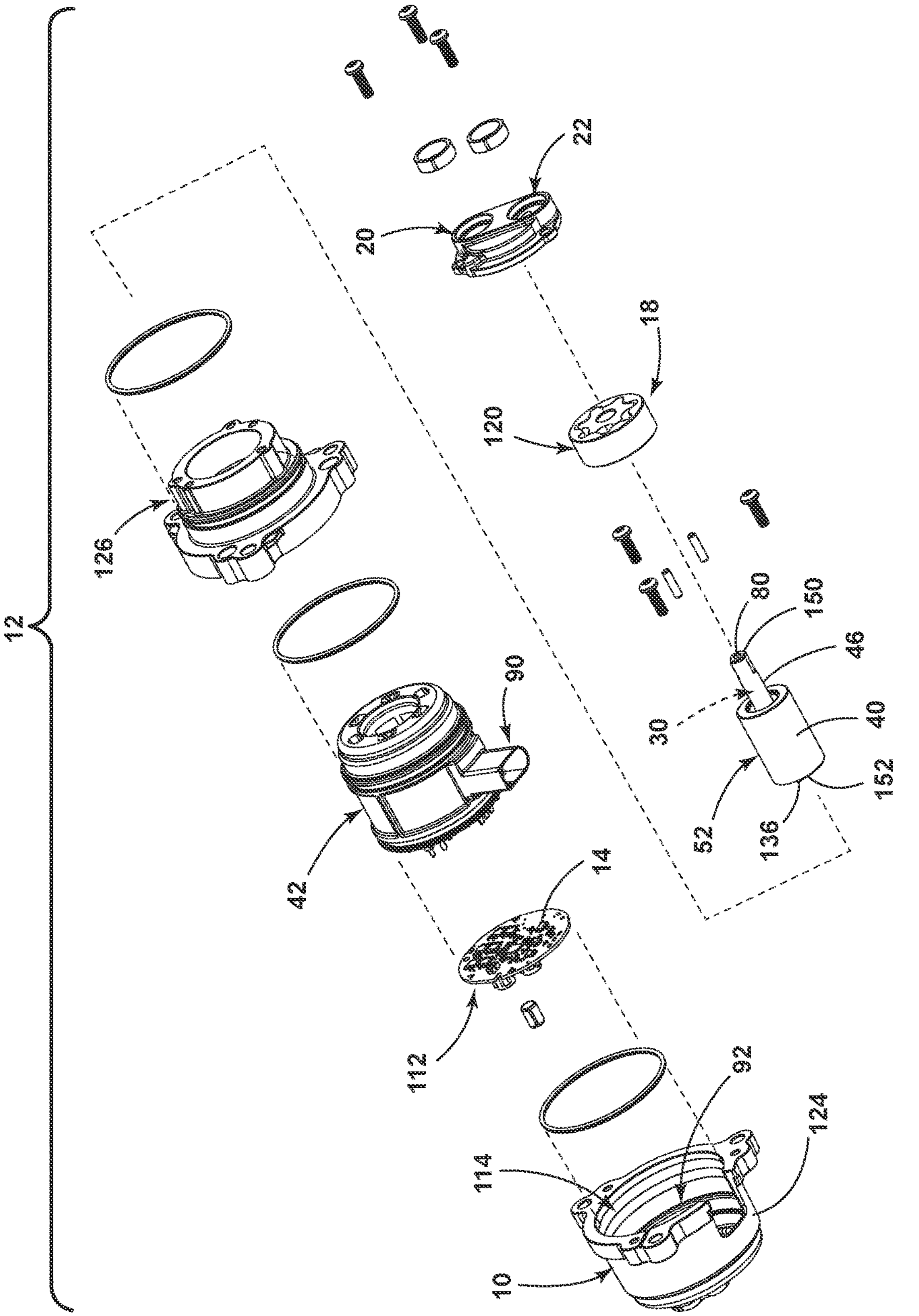
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FIG. 16

A Method 600 of Operating a Fluid Pump having a Thermistor Flow Path

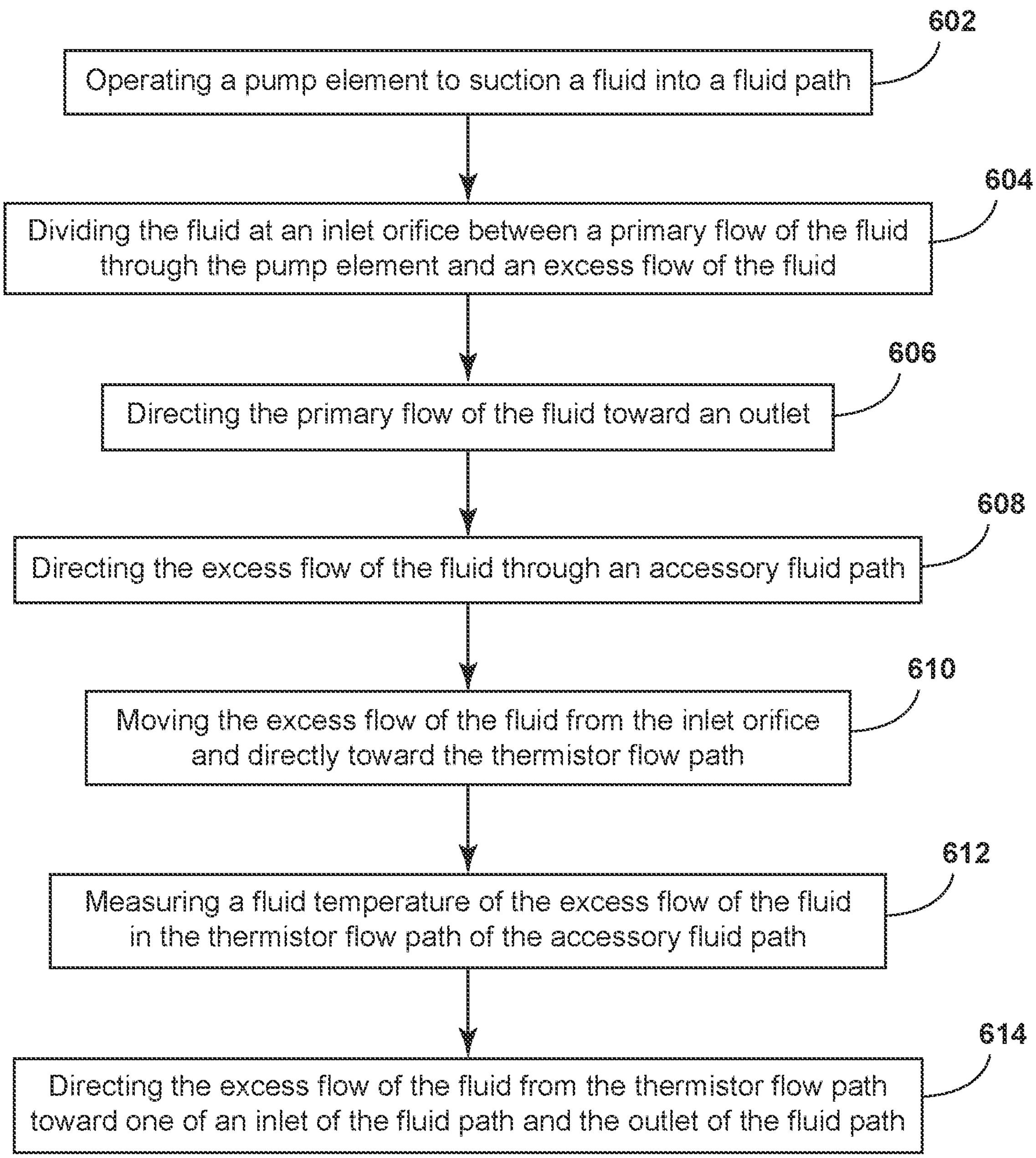

FIG. 17

THERMISTOR FLOW PATH

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of U.S. patent application Ser. No. 17/544,215 filed Dec. 7, 2021, entitled THERMISTOR FLOW PATH, now U.S. Pat. No. 11,959,481, which is a continuation-in-part of U.S. patent application Ser. No. 17/141,265 filed Jan. 5, 2021, entitled THERMISTOR FLOW PATH, now U.S. Pat. No. 11,454,235, which is a continuation of U.S. patent application Ser. No. 15/590,248 filed May 9, 2017, entitled THERMISTOR FLOW PATH, now U.S. Pat. No. 10,914,305, which claims priority to and the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Patent Application No. 62/342,615, filed on May 27, 2016, entitled THERMISTOR FLOW PATH, the entire disclosures of which are hereby incorporated herein by reference.

FIELD OF THE INVENTION

The present invention generally relates to fluid pumps, and more specifically, fluid pumps with a temperature sensing mechanism.

BACKGROUND OF THE INVENTION

Fluid pumps can be included within various fluid reservoirs for moving a fluid from within the reservoir to within another portion of the mechanism. Such pumps are configured to be submerged within the reservoir.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a fluid pump includes a pump element in communication with an inlet and an outlet. Rotation of the pump element generates an inward suction at the inlet and outward pressure at the outlet that cooperatively moves a fluid through a fluid path. The pump element includes a stator and a rotor within a housing. An accessory fluid path is in communication with the inlet and the fluid path. An inlet orifice directs a portion of the fluid through the accessory fluid path. The accessory fluid path includes a low-restriction return path that provides a continuous flow of the fluid through the accessory fluid path and to an outlet orifice during operation of the pump element. A circuit board housing includes a contoured portion that aligns with one side of an outer wall. The circuit board housing includes a printed circuit board (PCB) with a thermistor in communication with contoured portion of the circuit board housing and the accessory fluid path. The inlet orifice and the contoured portion are positioned at opposing ends of the housing. The continuous flow is directed between the contoured portion and the outlet orifice between the rotor and the outer wall. The low-restriction return path between the contoured portion and the outlet orifice is configured to maintain a temperature of the continuous flow of the fluid within the contoured portion of the accessory fluid path to be similar to a temperature of the fluid in the fluid path.

According to another aspect of the present invention, a fluid pump includes a pump element in communication with a fluid path. The pump element includes a rotor and a stator within a housing. An inlet orifice is in communication with the pump element. The pump element and the inlet orifice direct a primary flow of a fluid to an outlet and an excess flow of the fluid into an accessory fluid path having a portion that extends between the rotor and an outer wall of the housing. A circuit board housing includes a contoured portion that aligns with the one side of the outer wall. The accessory fluid path includes a low-restriction return path that moves the excess flow of the fluid as a continuous flow through the accessory fluid path and toward an outlet orifice. The low-restriction return path is configured to maintain a temperature of the excess flow of the fluid in the contoured portion of the accessory fluid path to be similar to a temperature of the primary flow of the fluid. A thermistor is positioned in communication with the contoured portion to simultaneously monitor, in real time, the temperature of the excess flow of the fluid in the accessory fluid path and the temperature of the primary flow of the fluid in the fluid path.

According to another aspect of the present invention, a fluid pump includes a stator and rotor in electromagnetic communication and disposed within a housing. A pump element is attached to a first end of a drive shaft of the rotor. An inlet orifice is in communication with the pump element that diverts a primary flow of a fluid to an outlet and an excess flow of the fluid through the inlet orifice and into an accessory fluid path. An outlet orifice is in communication with the pump element. The outlet orifice directs excess fluid from the accessory fluid path to a primary fluid path. A circuit board housing is positioned at a second end of the drive shaft that opposes a first end. The circuit board housing includes a contoured portion that aligns with the one side of an outer wall of the housing. The accessory fluid path directs the excess flow of fluid along a linear path directly from the inlet orifice to the contoured portion. The accessory fluid path includes a low-restriction return path that moves the excess flow of the fluid as a continuous flow through the accessory fluid path and toward the outlet orifice. The low-restriction return path is configured to maintain a temperature of the excess flow of the fluid in the contoured portion of the accessory fluid path to be similar to a temperature of the primary flow of the fluid. A thermistor is positioned in communication with the contoured portion to simultaneously monitor, in real time, the temperature of the excess flow of the fluid in the accessory fluid path and the temperature of the primary flow of the fluid in the fluid path.

These and other aspects, objects, and features of the present invention will be understood and appreciated by those skilled in the art upon studying the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a first perspective view of a fluid pump incorporating an aspect of the thermistor fluid path;

FIG. **2** is a second perspective view of the fluid pump of FIG. **1**;

FIG. **3** is a cross-sectional view of the fluid pump of FIG. **1** taken along line III-III;

FIG. **4** is a cross-sectional view of the fluid pump of FIG. **3** illustrating a flow of a fluid through the thermistor flow path;

FIG. **5** is a perspective view of a printed circuit board (PCB) housing assembly for a fluid pump that incorporates an aspect of the thermistor;

FIG. **6** is a cross-sectional perspective view of the PCB housing assembly of FIG. **5**, taken along line VI-VI;

FIG. **7** is a schematic flow diagram illustrating a method for operating a fluid pump;

FIG. **8** is a side perspective view of a fluid pump incorporating an aspect of the thermistor flow path;

FIG. **9** is a side perspective view of the fluid pump of FIG. **8**;

FIG. **10** is an end elevation view of the fluid pump of FIG. **8** and showing aspects of the pump element;

FIG. **11** is a cross-sectional view of the fluid pump of FIG. **8** taken along line XI-XI;

FIG. **12** is a cross-sectional view of the fluid pump of FIG. **10** taken along line XII-XII;

FIG. **13** is a schematic cross-sectional view of an aspect of the fluid pump of FIG. **8** and showing movement of the fluid through the primary fluid path and the accessory fluid path for the fluid pump;

FIG. **14** is a schematic cross-sectional view of the fluid pump of FIG. **8** and showing movement of fluid through the thermistor fluid path;

FIG. **15** is an exploded perspective view of the fluid pump of FIG. **8**;

FIG. **16** is another exploded perspective view of the fluid pump of FIG. **8**; and

FIG. **17** is a schematic flow diagram illustrating a method for operating a fluid pump.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

For purposes of description herein, the terms “upper,” “lower,” “right,” “left,” “rear,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the invention as oriented in FIG. **1**. However, it is to be understood that the invention may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

As shown in FIGS. **1-6**, reference numeral **10** generally refers to a printed circuit board (PCB) housing assembly for a fluid pump **12** that incorporates a thermistor **14** for measuring the temperature of fluid **16** being passed through the fluid pump **12**. The fluid pump **12** includes a pump element **120**, such as a generated rotor or gerotor **18**, or other similar positive displacement pump, in communication with an inlet **20** and an outlet **22** of the fluid pump **12**. Activating rotation of the gerotor **18** generates a suction **24**, or inward pressure, at the inlet **20** that draws fluid **16** into the fluid path **26** and outward pressure **28** at the outlet **22** that pushes fluid **16** out of the fluid path **26**. The suction **24** and outward pressure **28** generated through operation of the gerotor **18** cooperate to move the fluid **16** through the fluid path **26**. An accessory fluid path **30**, which defines a portion of the fluid path **26**, is disposed in communication with the inlet **20** and outlet **22**. The accessory fluid path **30** includes the thermistor **14** that is placed in communication with fluid **16** flowing through the accessory fluid path **30**. The thermistor **14** is adapted to monitor a temperature of the fluid **16** moving through the accessory fluid path **30** of the fluid pump **12**.

Referring again to FIGS. **1-6**, a fluid pump **12**, such as an electric oil pump, generally provides lubrication and cooling to various mechanisms, such as a gear box, differential unit, or other similar mechanism. The fluid pump **12**, typically in the form of a gerotor **18**, brushless DC (BLDC) electric motor **44**, and a controller can be fully integrated into a housing assembly that manages the sealing, thermal transfer and part assembly for the electric fluid pump **12**. The fluid pump **12** can include a rotor **40** and stator **42** that make up the motor **44** for the fluid pump **12**. A drive shaft **46** is driven by rotation of the rotor **40** and serves to rotate the gerotor **18** for generating the suction **24** and outward pressure **28** for moving fluid **16** through the fluid path **26** and, in turn, the accessory fluid path **30**.

Referring again to FIGS. **1-6**, the accessory fluid path **30**, in the form of a thermistor flow path **50**, serves to provide a fluid pump **12** with a temperature sensing functionality for providing real time measurements regarding fluid temperature during operation of the fluid pump **12**. The temperature sensor can be a thermistor-style leaded component that is installed in the same cavity as the rotor assembly **52** that serves to drive the gerotor **18**. Typically, this cavity is “wet” as the rotor **40** is submerged in fluid **16**, such as oil. Within the fluid pump **12**, the fluid **16** moving through the gerotor **18** flows through an outlet shadow port **60** having an orifice **62** that helps to regulate and divide the flow of fluid **16** through the fluid path **30** of the fluid pump **12**, as will be described more fully below.

The fluid **16** is divided between a regulated primary flow **54** of the fluid **16** and the remaining fluid **16** that defines an excess flow **56** of the fluid **16**. In regulating the flow of fluid **16** from the outlet shadow port **60** and orifice **62**, the primary flow **54** is a predetermined amount of the fluid **16** that is directed to the outlet **22**. By dividing the fluid **16**, the excess flow **56** of fluid **16** that is not part of the regulated primary flow **54** of the fluid **16** is directed through the orifice **62** and into the accessory fluid path **30**. In this manner, the gerotor **18** pushes the primary flow **54** of the fluid **16** through the outlet **22** and simultaneously pushes the excess flow **56** of the fluid **16** through the orifice **62** and into the accessory fluid path **30**. Directing the movement of the excess flow **56** of fluid **16** helps to ensure that there is a continuous or substantially continuous flow **154** of fluid **16** across the thermistor **14**. Additionally, this configuration of the accessory fluid path **30** in relation to the outlet shadow port **60** and orifice **62** also helps to ensure that the temperature of the excess flow **56** of the fluid **16** is at least substantially similar to the primary flow **54** of fluid **16** that is directed through the outlet **22**. This configuration helps to provide real time or substantially real time temperature measurements of the fluid **16**.

In this disclosed device, the accessory fluid path **30** is placed in communication with the outlet shadow port **60** through the orifice **62** that controls the excess flow **56** of the fluid **16** from the outlet shadow port **60** and into the accessory fluid path **30**. From the orifice **62** at the outlet shadow port **60**, the excess flow **56** of fluid **16** flows around at least a portion of the rotor assembly **52**, but within the housing **64** of the fluid pump **12**. After passing along the side **66** of the rotor assembly **52**, the excess flow **56** of fluid **16** is directed along an inner surface **68** of the PCB housing assembly **10** where the thermistor **14** is located. The inner surface **68** of the PCB housing assembly **10** includes contours **70** that are configured to direct the excess flow **56** of fluid **16** from the sides **66** of the rotor assembly **52** along the contours **70**, into engagement with the thermistor **14**, and to a central portion **72** of the PCB housing assembly **10**. In this manner, the contours **70** and central portion **72** of the inner surface **68** of the PCB housing assembly **10** at least partially defines the thermistor flow path **50** and the accessory fluid path **30**. The central portion **72** of the PCB housing assembly **10** is in communication with a channel **80** of the drive shaft

46. This channel **80** of the drive shaft **46** extends through the center of the drive shaft **46** and the rotor assembly **52** and up through the gerotor **18** and to a recirculation path **82** that recombines the excess flow **56** of the fluid **16** with fluid **16** entering the inlet **20**. In this manner, the excess flow **56** of the fluid **16** is drawn back into the inlet **20** by the suction **24** generated by the gerotor **18**. The recombined fluid **16** is then delivered via the gerotor **18** and is divided into the primary and excess flows **54**, **56** of fluid **16** as described above. In this configuration, a portion of the excess flow **56** upon leaving the recirculation path **82** may be divided again as part of the excess flow **56**. It is contemplated that the excess flow **56** from the recirculation path **82** will be sufficiently mixed with the fluid **16** entering the inlet **20**. Accordingly, the amount of the excess flow **56** that is divided again into a portion of the excess flow **56** is substantially minimal. The effects of a portion of the excess flow **56** being directly recirculated again through the accessory fluid path **30** as part of the excess flow **56** will have minimal effects on the temperature measurements of the thermistor **14**.

In various embodiments, the recirculation path **82** may direct the excess flow **56** of fluid **16** from the accessory fluid path **30** to the outlet **22** of the fluid pump **12**. In this manner, the excess flow **56** can be at least partially re-combined with the primary flow **54** of fluid **16** that is moved through the outlet **22**.

Referring again to FIGS. **1-6**, the return path **130** of the fluid **16** within the accessory fluid path **30** and through the central channel **80** of the drive shaft **46** forces the excess flow **56** of the fluid **16** to flow directly over the thermistor **14**. Accordingly, temperature measurements of the excess flow **56** of the fluid **16** moving through the thermistor flow path **50** can be taken by the thermistor **14** in real time or substantially in real time. The amount of fluid **16** moving through the accessory fluid path **30** is controlled by the size of the orifice **62** on the high pressure side of the fluid path **26**. Additionally, the return path **130** of the accessory fluid path **30** is maintained at a lower restriction to prevent a pressure build-up within the motor cavity **114**. In order to deliver the signal from the thermistor **14** within the PCB housing assembly **10**, terminals **90** are used to connect the thermistor **14** to the PCB housing assembly **10**. These terminals **90** are sealed to prevent leaking into the PCB cavity **92** on the opposite side of the thermistor **14**.

Within conventional fluid pumps **12**, very little fluid **16** is moved in and around the motor cavity **114**. As such, placing a thermostat or other temperature sensing device within this area provides little, if any, temperature-related information.

Referring again to FIGS. **1-6**, the accessory fluid path **30** that provides the thermistor flow path **50** provides a convenient and accurate mechanism for measuring the temperature of the fluid **16** flowing through the fluid pump **12** while not diminishing the performance of the fluid pump **12**.

It is contemplated that the fluid pump **12** described herein can be used in various applications that can include, but are not limited to, fuel pumps, oil pumps, water pumps, combinations thereof, and other fluid pumps **12** that may be submerged or non-submerged.

It is contemplated that the PCB housing assembly **10** and terminals **90** can be incorporated within new pumps or can be manufactured for installation with after-market pumps.

Having described various aspects of the device, a method **400** is disclosed for operating the fluid pump **12**. This method **400** includes step **402** of activating a pump element **120** to draw a fluid **16** into a fluid path **26**. The pump element **120** operates to direct a fluid **16** to a position that defines a shadow port **60** (step **404**). The fluid **16** is divided into a primary flow **54** of the fluid **16** toward an outlet **22** of the fluid path **26** and an excess flow **56** of the fluid **16** through an orifice **62** of the shadow port **60** and into an accessory fluid path **30** (step **406**). The excess flow **56** of the fluid **16** is directed to a thermistor **14** (step **408**). A fluid temperature of the excess flow **56** of the fluid **16** in the accessory fluid path **30** is measured (step **410**). The excess flow **56** of the fluid **16** is directed toward the inlet **20** of the fluid path **26** (step **412**).

Referring now to FIGS. **1-6** and **8-16**, the fluid pump **12**, as discussed herein, can incorporate various fluid paths **26** that can include, but are not limited to, a primary fluid path **110**, the accessory fluid path **30**, and other similar fluid paths **26** through which the fluid **16** can translate within the fluid pump **12**. In each of these aspects, at least one of these fluid paths **26** is configured to monitor, in real time, the fluid temperature of the excess flow **56** of fluid **16** within the accessory fluid path **30**. This temperature reading, due to the configuration of the accessory fluid path **30**, is similar to a temperature of the primary flow **54** of the fluid **16** within the primary fluid path **110**. The various configurations of the accessory fluid path **30** provide for a direct and generally linear path for the excess flow **56** of fluid **16** to move from the inlet **20** and to the thermistor flow path **50** that is in communication with the thermistor **14** of the PCB **112**.

According to various aspects of the device, the pump element **120** is in communication with the inlet **20** and the outlet **22** for the fluid pump **12**. Rotation of the pump element **120** generates an inward suction **24** through the inlet **20** and an outward pressure **28** through the outlet **22** that cooperatively moves the fluid **16** through the fluid path **26**. The pump element **120** includes the stator **42** and rotor **40** that are positioned within a motor cavity **114** of the housing **64**. The housing **64** includes the outer wall **124**, a pump housing **126** that surrounds the pump element **120** and a circuit board housing assembly **10** that houses the PCB **112** and the various components disposed thereon. The accessory fluid path **30** is in communication with the inlet **20** and the fluid path **26**. An inlet orifice **128** directs a portion of the fluid **16**, typically in the form of the excess flow **56** of fluid **16**, through the accessory fluid path **30**. During operation of the pump element **120**, the accessory fluid path **30** includes a low-restriction return path **130** that provides a continuous flow **154** of fluid **16** through the accessory fluid path **30** and to an outlet orifice **132**. The circuit board housing assembly **10** includes the contoured portion **134** that extends toward one side **66** of the outer wall **124** of the housing **64**. The thermistor **14** is positioned on the PCB **112** within the circuit board housing assembly **10**.

As discussed herein, the thermistor **14** is at least in communication with the contoured portion **134** of the circuit board housing assembly **10**. In certain aspects of the device, the thermistor **14** can extend into the thermistor flow path **50** that is defined by the contoured portion **134** of the circuit board housing assembly **10**. The inlet orifice **128** and the contoured portion **134** are positioned at opposing ends of the housing **64**. Through this configuration, a drive shaft **46** of the rotor **40** is positioned such that the inlet orifice **128** is located at a first end **150** of the drive shaft **46** and the contoured portion **134** of the circuit board housing assembly **10** is positioned at an opposing second end **152** of the drive shaft **46** for the rotor **40**. The continuous flow **154** of the fluid **16** that is provided through the low-restriction return path **130** is directed between the contoured portion **134** and the outlet orifice **132** such that the fluid **16** moves between the rotor **40** and the inner surface **68** of the outer wall **124**, and more particularly, between the rotor **40** and the stator **42**.

In addition, the low-restriction return path **130** between the contoured portion **134** and the outlet orifice **132** is configured to maintain a temperature of the continuous flow **154** of the fluid **16** within the contoured portion **134** of the accessory fluid path **30** to be similar to the temperature of the fluid **16** as it enters the inlet **20** and moves through the primary fluid path **110**. Through this configuration, the temperature of the continuous flow **154** of fluid **16** within the contoured portion **134** of the accessory fluid path **30** is similar to a temperature of the fluid **16** that is within the primary fluid path **110** moving through the pump element **120** between the inlet **20** and the outlet **22**. As discussed herein, the thermistor **14** is positioned in communication with the contoured portion **134** of the circuit board housing assembly **10**. This is to simultaneously monitor, in real time, the temperature of the continuous flow **154** of the fluid **16** in the accessory fluid path **30** and also the temperature of the fluid **16** within the primary fluid path **110**. Because the temperature of the fluid **16** in these two locations, which are positioned at opposite ends of the motor cavity **114** for the fluid pump **12**, have a similar temperature, the thermistor **14** within the contoured portion **134**, or in communication with the contoured portion **134**, is sufficient to provide a temperature reading with respect to both locations.

Referring again to FIGS. **3-6** and **12-16**, the inlet orifice **128** directs a portion of the fluid **16** from the inlet **20** to the central channel **80** of the pump element **120**. This central channel **80** extends through the drive shaft **46** of the rotor **40**. The central channel **80** of the drive shaft **46** extends from the inlet orifice **128** and to the contoured portion **134** of the circuit board housing assembly **10**. Through this configuration, the excess fluid **16** moving through the accessory fluid path **30** is moved directly, and generally linearly, from the inlet orifice **128**, through this central channel **80** and to the contoured portion **134**. This portion of the accessory fluid path **30** moves the fluid **16** quickly to the thermistor flow path **50** so that any heat that may be generated by the motor **44** and the PCB **112** does not alter, or appreciably alter, the temperature of the fluid **16** in the accessory fluid path **30**. In this manner, the thermistor **14** is able to provide the real time measurement of the temperature of the fluid **16** within each of the contoured portion **134** (the thermistor flow path **50**) as well as the primary fluid path **110** through the pump element **120**.

As exemplified in FIGS. **12-16**, various features contained within the fluid pump **12** can supplement operation of the pump element **120** in moving fluid **16** through the accessory fluid path **30**. In at least one aspect of the device, the rotor **40** can include a plurality of ridges **136**, typically in the form of vanes or fins, that extend outward from a bottom surface **138** of the rotor **40**. These ridges **136** can be sized and shaped to move through a portion of the fluid **16**. As a result of the rotation of the rotor **40**, these ridges **136** are able to interact with the accessory fluid path **30** in the area of the contoured portion **134**. Accordingly, the ridges **136** operate to direct the fluid **16** through at least a portion of the accessory fluid path **30**.

Referring again to FIGS. **12-16**, the ridges **136** can be in the form of arcuate fins that extend from a bottom surface **138** of the rotor **40**, where these ridges **136** are positioned adjacent to the contoured portion **134** of the accessory fluid path **30**. As the rotor **40** rotates about a rotational axis, the ridges **136** operate to move the fluid **16** in an outward direction with respect to the channel **80** that is positioned adjacent to the contoured portion **134**. Accordingly, as the rotor **40** rotates, the ridges **136** interact with the contoured portion **134** to move the fluid **16** away from the channel **80**, and through the remainder of the accessory fluid path **30**. Through this configuration, operation of the rotor **40**, including the ridges **136**, supplements the outward pressure **28** and the inward pressure **24** produced by the pump element **120**. These ridges **136** also assist in moving the fluid **16** through the low-restriction return path **130** of the accessory fluid path **30** for producing the continuous flow **154** of the fluid **16** toward the outlet. As discussed herein, this operation of the rotor **40** relative to the accessory fluid path **30** provides for expedient movement of the fluid **16** from the inlet and past the thermistor **14** for providing accurate temperature measurements of the fluid **16** within the primary fluid path **110**, by taking measurements of the fluid **16** in the accessory fluid path **30**.

It is contemplated that the ridges **136** that extend from a bottom surface **138** of the rotor **40** can be formed during a molding process of the rotor **40**. This molding process can be in the form of an injection molding process, compression molding process, or other similar molding process that can be used to form the rotor **40**, including the ridges **136** that extend from the bottom surface **138** of the rotor **40**, or other part of the outer surface for the rotor **40**. The ridges **136** can also be incorporated within a frame around which the molding material is disposed for forming the rotor **40**. In such an aspect of the device, the ridges **138** can extend through the molding material or the molding material can surround the frame to form the ridges **136**. In the various configurations of the rotor **40**, the ridges **136** are configured to extend proud of a surrounding surface of the rotor **40** such that these ridges **136** can interact with the contoured portion **134** of the accessory fluid path **30**, or another portion of the accessory fluid path **30** that moves through the fluid pump **12**.

As exemplified in FIGS. **12-16**, the ridges **136** that extend from the rotor **40** can, in certain aspects of the device, be used to direct the fluid **16** toward the channel **80** for applications where the accessory fluid path **30** moves from the channel **80** and toward the outlet of the fluid pump **12**.

Referring again to FIGS. **12-16**, the ridges **136** that extend from the bottom surface **138** of the rotor **40** include an arcuate configuration. The ridges **136** typically extend radially away from a rotational axis of the rotor **40**. In this radial configuration, the ridges **136** can extend directly outward from the rotational axis of the rotor **40** in a true radial configuration. It is also contemplated that the ridges **136** can extend oblique to a radius of the rotor **40** in a linear configuration or, as exemplified, in FIG. **14**, in an arcuate configuration. It is contemplated that the ridges **136** extend from a center point of the bottom surface **138** of the rotor **40** to an outer edge of the rotor **40**. It is also contemplated that the ridges **136** can extend through a certain radial range of the bottom surface **138** of the rotor **40** such that certain portions of the rotor **40** contain ridges **136**, and other portions of the bottom surface **138** of the rotor **40** are smooth or contain a different textured or patterned configuration.

Referring again to FIGS. **10-16**, the outlet orifice **132** is positioned to align with a diverging portion **170** of the inlet orifice **128**. This diverging portion **170** of the inlet orifice **128** is where the fluid **16** moving through the inlet **20** is diverted to move either into the inlet orifice **128** and through the accessory fluid path **30**, or into the pump element **120** to be moved through the primary fluid path **110** of the pump element **120** and to the outlet **22**. The outlet orifice **132** is positioned near the opposing surface of the pump element **120**. In this manner, the inlet orifice **128** is positioned near the inlet **20** and the outlet orifice **132** is positioned near the stator **42** and the rotor **40**. As discussed in greater detail herein, the outlet orifice **132** receives the excess flow **56** of fluid **16** that has moved through the accessory fluid path **30**.

As exemplified in FIG. **13**, the diverging portion **170** of the inlet orifice **128** operates to divert a portion of the fluid **16**, the excess flow **56**, from the inlet **20** and into the accessory fluid path **30** before the fluid **16** is able to reach the pump element **120**. At a downstream position of the accessory fluid path **30**, the outlet orifice **132** and the pump element **120** receive the excess flow **56** of the fluid **16** from the accessory fluid path **30** and direct this excess flow **56** of fluid **16** toward the outlet **22** via the primary fluid path **110** within the pump element **120**. Through this configuration, the inlet orifice **128** and the outlet orifice **132** are each positioned proximate the pump element **120**. The outlet orifice **132** and the pump element **120** regulates a flow of the fluid **16** into the fluid path **26** and also regulates the flow of excess fluid **16** into the accessory fluid path **30**. Accordingly, the primary flow **54** of the fluid **16** moving through the fluid pump **12** is typically configured to move either from the inlet **20**, through the primary fluid path **110**, and to the outlet **22**. In addition, the excess flow **56** of the fluid **16** moves from the inlet **20**, into the inlet orifice **128** and to the thermistor flow path **50**. From the thermistor flow path **50**, the excess flow **56** of the fluid **16** moves to the outlet orifice **132** to be rejoined with the primary flow **54** of the fluid **16**. At this point, the primary flow **54** and the excess flow **56** are rejoined and are moved to the outlet **22** via the primary fluid path **110**.

As discussed herein, and as exemplified in FIGS. **10-16**, the pump element **120** at the inlet **20** generates the inward suction **24** to draw fluid **16** into the flow path that moves through the pump element **120**. A portion of this inward suction **24** is used to draw the excess fluid **16** from the outlet orifice **132** and into the pump element **120** and the primary fluid path **110**. This portion of the suction **24** at the outlet orifice **132** also serves to draw or suction the excess flow **56** of fluid **16** from the inlet **20** and into the inlet orifice **128** to be moved through the accessory fluid path **30**. Accordingly, the outlet orifice **132** and pump element **120** cooperate to form a suction interface **180** that draws the excess fluid **16** into the accessory fluid path **30**. This suction interface **180** also serves to draw the excess flow **56** of the fluid **16** in a substantially linear and direct manner from the inlet orifice **128** and to the thermistor flow path **50**. Also, the suction interface **180** draws fluid **16** toward the outlet orifice **132** and generates the low-restriction return path **130** that provides the continuous flow **154** of fluid **16** through the accessory fluid path **30** and to the outlet orifice **132**. This promotes the continuous and regular flow of fluid **16** through the thermistor flow path **50** to account for the consistent and real time measurements of the fluid **16** within the fluid pump **12**, as described herein.

The suction interface **180** also promotes the excess flow **56** of the fluid **16** into the inlet orifice **128** and into the accessory fluid path **30**. In addition, the suction **24** generated at the inlet **20** also prevents the excess flow **56** of fluid **16** that enters into the outlet orifice **132** from returning to the inlet orifice **128** and the accessory fluid path **30**. This configuration of the suction interface **180** and the positioning of the inlet orifice **128** and the outlet orifice **132** at opposite sides of the pump element **120**, prevents the recirculation of the excess flow **56** of fluid **16** through the accessory fluid path **30**. Such a recirculation may result in an undesirable buildup of heat within the excess flow **56** of fluid **16**. This undesirable buildup of heat could result in the readings of the thermistor **14** being inaccurate. The configuration of the inlet orifice **128** and the suction interface **180** prevents this recirculation of the excess flow **56** from occurring.

Referring again to FIGS. **1-16**, use of the various aspects of the pump element **120** are configured to provide for movement of fluid **16** through a plurality of flow paths within the fluid pump **12**. These plurality of flow paths comprise at least the primary fluid path **110** and the accessory fluid path **30**, as described herein. Each of these flow paths are typically configured to move the fluid **16** to the outlet **22** for the fluid pump **12**.

Referring again to FIGS. **9-16**, the fluid pump **12** includes the pump element **120** that is in communication with the fluid path **26**, where the pump element **120** includes the rotor **40** and the stator **42** that are positioned within the housing **64**. The inlet orifice **128** is in communication with a pump element **120**. The pump element **120** and the inlet orifice **128** direct a primary flow **54** of fluid **16** to the outlet **22** and an excess flow **56** of fluid **16** into the accessory fluid path **30**. A portion of the accessory fluid path **30** extends between the rotor **40** and the outer wall **124** of the housing **64**, and typically between the rotor **40** and the stator **42**. The circuit board housing assembly **10** includes the contoured portion **134** that aligns with and is directed toward one side **66** of the outer wall **124**. The accessory fluid path **30** includes the low-restriction return path **130** that moves the excess flow **56** of the fluid **16** as a continuous flow **154** through the accessory fluid path **30** and toward the outlet orifice **132**.

In addition, the low-restriction return path **130** is configured to maintain a temperature of the excess flow **56** of fluid **16** within the contoured portion **134** of the accessory fluid path **30** to be similar to a temperature of the primary flow **54** of the fluid **16** within the primary fluid path **110**. The thermistor **14** is positioned in communication with a contoured portion **134** to simultaneously monitor, in real time, the temperature of the excess flow **56** of the fluid **16** in the accessory fluid path **30** as well as the temperature of the primary flow **54** of the fluid **16** in the primary fluid path **110**. As discussed herein, the temperature of the fluid **16** within these two separate locations is substantially similar due to the direct and continuous flow **154** of fluid **16** from the inlet **20** and to the contoured portion **134** that defines the thermistor flow path **50**. Through this configuration, the pump element **120** generates the inward pressure **24** of the inlet **20** of the fluid path **26** as well as at the outlet orifice **132** of the accessory fluid path **30**. The pump element **120** also generates an outward pressure **28** at the outlet **22** of the fluid path **26**. Using the inward suction **24** generated by the pump element **120**, the primary flow **54** of fluid **16** is moved though the primary fluid path **110** of the pump element **120**, and the excess flow **56** of fluid **16** is drawn through the accessory fluid path **30** through the interaction of the outlet orifice **132** and the pump element **120** that forms the suction interface **180** of the accessory fluid path **30**.

According to the various aspects of the device, as exemplified in FIGS. **1-16**, the pump element **120** includes the stator **42** and rotor **40** that are in electromagnetic communication with one another. The stator **42** and rotor **40** are disposed within the housing **64** for the fluid pump **12**. The pump element **120** is attached to the first end **150** of a drive shaft **46** of the rotor **40**. The inlet orifice **128** is in communication with a pump element **120** and diverts the primary flow **54** of fluid **16** to an outlet **22**, via the primary fluid path **110**. In addition, the inlet orifice **128** directs the excess flow **56** of fluid **16** through the inlet orifice **128** and into the accessory fluid path **30**. The outlet orifice **132** is in communication with a pump element **120**. The outlet orifice **132** directs the excess fluid **16** from the accessory fluid path **30** and into the primary fluid path **110** for movement to the outlet **22**. The circuit board housing assembly **10** is positioned at the second end **152** of the drive shaft **46** that opposes the first end **150**. The circuit board housing assembly **10** includes a contoured portion **134** that is directed toward and aligns with one side **66** of the outer wall **124** of the housing **64**. The accessory fluid path **30** directs the excess flow **56** of fluid **16** along a linear path directly from the inlet orifice **128** and to the contoured portion **134** positioned at the opposite side of the motor cavity **114** and the drive shaft **46**.

The accessory fluid path **30** includes a low-restriction return path **130** that moves the excess flow **56** of fluid **16**, as a continuous flow **154**, through the accessory fluid path **30** and toward the outlet orifice **132**. The low-restriction return path **130** is configured to maintain the temperature of the excess flow **56** of fluid **16** within the contoured portion **134** of the accessory fluid path **30** to be similar to a temperature of a primary flow **54** of the fluid **16** within the primary fluid path **110** in the pump element **120**. The thermistor **14** is positioned in communication with the contoured portion **134** to monitor the temperature of the excess flow **56** of fluid **16** in the thermistor flow path **50** defined by the contoured portion **134**. As a result, the thermistor **14** also simultaneously monitors, in real time, the temperature of the primary flow **54** of the fluid **16** in the primary fluid path **110**. This is done through the use of a single thermistor **14** that is in communication with the contoured portion **134**. Through this configuration, the thermistor **14** can be positioned in close proximity to the PCB **112** within the circuit board housing assembly **10**.

Referring again to FIGS. **1-6** and **8-17**, having described various aspects of the device, a method **600** is disclosed for operating a fluid pump **12** that utilizes an aspect of the thermistor flow path **50**. According to the method **600**, a step **602** includes operating a pump element **120** to suction a fluid **16** into a fluid path **26**. Step **604** of the method **600** includes dividing the fluid **16** at an inlet orifice **128** between a primary flow **54** of the fluid through the pump element **120** and an excess flow **56** of fluid **16**. When the excess flow **56** of fluid **16** is divided away from the primary flow **54** of the fluid **16**, the primary flow **54** of the fluid **16** is directed toward the outlet **22** via the primary fluid path **110** (step **606**) and the excess flow **56** of fluid **16** is directed toward the accessory fluid path **30** (step **608**). As discussed herein, the accessory fluid path **30** includes the low-restriction return path **130** that moves excess flow **56** of the fluid **16** as a continuous flow **154** through the accessory fluid path **30** and toward the outlet orifice **132**. As part of the process for directing the excess flow **56** of fluid **16** through the accessory fluid path **30**, the excess flow **56** of fluid **16** is moved from the inlet orifice **128** and directly toward a contoured portion **134** of the circuit board housing assembly **10** (step **610**). The fluid temperature of the excess flow **56** of fluid **16** is measured within the contoured portion **134** of the accessory fluid path **30** (step **612**). According to the method **600**, the excess flow **56** of fluid **16** from the contoured portion **134** is then directed toward one of the inlet **20** of the fluid path **26** and the outlet **22** of the fluid path **26** (step **614**).

As discussed herein, the various aspects of the device, as exemplified in FIGS. **1-17**, are used to expediently deliver an excess flow **56** of fluid **16** through the accessory fluid path **30** to quickly take a temperature measurement of this fluid **16**. This temperature measurement is used to also measure, in real time, the temperature of the primary flow **54** of fluid **16** moving through the pump element **120** for the fluid pump **12**. This configuration allows the thermistor **14** and other controls for the fluid pump **12** to be all located within the PCB **112** that is located within the circuit board housing assembly **10**. Accordingly, need for additional electrical components to be run through the fluid pump **12** is substantially minimized or eliminated. In addition, by locating the controls, the electrical components and electromagnetic components within the PCB **112** and the circuit board housing assembly **10**, assembly of the fluid pump **12** is configured to be an efficient process that allows for convenient attachment of the circuit board housing assembly **10** having the PCB **112** to the remainder of the fluid pump **12**. In addition, maintenance and repair of the fluid pump **12** is also made easier by allowing various components to be separated and quickly and conveniently replaced as needed over the life of the fluid pump **12**. This configuration also allows for the convenient and efficient selection of a circuit board housing assembly **10** having a PCB **112** that includes a PCB **112** and controller components. Accordingly, a wide range of circuit board housing assemblies **10** having various models and types of PCBs **112** can be assembled in an interchangeable and selectable fashion. Through this configuration, assembly of any one of various fluid pumps **12** can be accomplished from a kit of selectable parts that can be attached to one another to provide a customizable solution for generating a wide range of fluid pump solutions.

It is to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

1. A fluid pump comprising:

a rotary pump element in communication with an inlet and an outlet that cooperate to move fluid through a fluid path that extends between the inlet and the outlet, wherein the rotary pump element includes a stator and a rotor disposed within a housing;

an accessory fluid path in communication with the inlet and the fluid path, wherein an inlet port directs a portion of the fluid through the accessory fluid path, the accessory fluid path having a low-restriction return path that defines a continuous flow of the fluid through the accessory fluid path and to an outlet port during operation of the rotary pump element; and

a circuit board housing having a contoured portion that aligns with one side of an outer wall, the circuit board housing having a printed circuit board (PCB) with a thermistor in communication with contoured portion of the circuit board housing and the accessory fluid path, wherein:

the inlet port and the contoured portion are positioned within the housing and at opposing ends of the rotor;

the continuous flow is directed between the contoured portion and the outlet port between the rotor and the outer wall; and

the low-restriction return path between the contoured portion and the outlet port is configured to maintain a temperature of the continuous flow of the fluid within the contoured portion of the accessory fluid path to be similar to a temperature of the fluid in the fluid path.

2. The fluid pump of claim **1**, wherein the thermistor is positioned in communication with the contoured portion to simultaneously monitor, in real time, the temperature of the continuous flow of the fluid in the accessory fluid path and the temperature of the fluid in the fluid path.

3. The fluid pump of claim **1**, wherein the inlet port directs a portion of the fluid from the inlet to a central channel of the rotary pump element, wherein the central channel extends through a drive shaft of the rotor.

4. The fluid pump of claim **3**, wherein the central channel of the drive shaft extends from the inlet port and to the contoured portion of the circuit board housing.

5. The fluid pump of claim **1**, wherein the outlet port is aligned with a diverging portion of the inlet port.

6. The fluid pump of claim **5**, wherein the diverging portion of the inlet port diverts a portion of the fluid into the accessory fluid path before reaching the rotary pump element.

7. The fluid pump of claim **1**, wherein the outlet port and the rotary pump element receive an excess flow of the fluid from the accessory fluid path and direct the excess flow of the fluid to the outlet through the fluid path.

8. The fluid pump of claim **1**, wherein operation of the rotary pump element moves the fluid through a plurality of flow paths, wherein the plurality of flow paths comprise the fluid path and the accessory fluid path.

9. The fluid pump of claim **8**, wherein the plurality of flow paths each move the fluid to the outlet.

10. The fluid pump of claim **1**, wherein the thermistor is disposed within the contoured portion of the circuit board housing.

11. The fluid pump of claim **1**, wherein the inlet port and the outlet port are each positioned proximate the rotary pump element, and wherein the outlet port and the rotary pump element regulates a flow of the fluid into the fluid path and regulates the flow of the fluid into the accessory fluid path.

12. The fluid pump of claim **1**, wherein the rotary pump element is a positive displacement pump.

13. A fluid pump comprising:

a pump element in communication with a fluid path, the pump element including a rotor and a stator within a housing; and

an inlet port in communication with the pump element, wherein the pump element and the inlet port direct a primary flow of a fluid to an outlet and an excess flow of the fluid into a temperature sensing fluid path having a portion that extends between the rotor and an outer wall of the housing, and

a circuit board housing having a contoured portion that defines a portion of the temperature sensing fluid path, the contoured portion in alignment with one side of the outer wall; wherein

the temperature sensing fluid path includes a low-restriction return path that moves the excess flow of the fluid as a continuous flow through the temperature sensing fluid path and toward an outlet port;

the low-restriction return path is configured to maintain a temperature of the excess flow of the fluid in the contoured portion of the temperature sensing fluid path to be similar to a temperature of the primary flow of the fluid; and

a thermistor is positioned in communication with the contoured portion to simultaneously monitor, in real time, the temperature of the excess flow of the fluid in the temperature sensing fluid path and the temperature of the primary flow of the fluid in the fluid path.

14. The fluid pump of claim **13**, wherein the inlet port directs a portion of the fluid from an inlet to a central channel of the pump element, wherein the central channel extends through a drive shaft of the rotor to the contoured portion of the circuit board housing.

15. The fluid pump of claim **14**, wherein the outlet port is aligned with a diverting portion of the inlet port that diverts a portion of the fluid into the temperature sensing fluid path before reaching the pump element.

16. The fluid pump of claim **13**, wherein the outlet port and the pump element receive temperature sensing fluid from the temperature sensing fluid path and direct the temperature sensing fluid to the outlet through the fluid path.

17. The fluid pump of claim **13**, wherein the pump element generates an inward suction at an inlet of the fluid path and at the outlet port of the temperature sensing fluid path, and wherein the pump element generates an outward pressure at the outlet of the fluid path.

18. A fluid pump comprising:

a stator and rotor in electromagnetic communication and disposed within a housing;

a pump element attached to a first end of a drive shaft of the rotor; and

an inlet port in communication with the pump element that diverts a primary flow of a fluid to an outlet and an excess flow of the fluid through the inlet port and into an accessory fluid path;

an outlet port in communication with the pump element, the outlet port directing excess fluid from the accessory fluid path to a primary fluid path; and

a circuit board housing positioned at a second end of the drive shaft that opposes a first end, the circuit board housing having a contoured portion that defines a portion of the accessory fluid path and aligns with one side of an outer wall of the housing; wherein

the accessory fluid path directs the excess flow of fluid along a linear path directly from the inlet port to the contoured portion;

the accessory fluid path includes a low-restriction return path that moves the excess flow of the fluid as a continuous flow through the accessory fluid path and toward the outlet port;

the low-restriction return path is configured to maintain a temperature of the excess flow of the fluid in the contoured portion of the accessory fluid path to be similar to a temperature of the primary flow of the fluid; and

a thermistor is positioned in communication with the contoured portion to simultaneously monitor, in real time, the temperature of the excess flow of the fluid in the accessory fluid path and the temperature of the primary flow of the fluid in the fluid path.

19. The fluid pump of claim **18**, wherein the outlet port is aligned with a diverting portion of the inlet port that diverts the excess fluid into the accessory fluid path before reaching the pump element, and wherein the outlet port and the pump element receive accessory fluid from the accessory fluid path and direct the accessory fluid to the outlet through the fluid path.

20. The fluid pump of claim **18**, wherein the pump element generates an inward pressure at an inlet of the fluid path and at the outlet port of the accessory fluid path, and wherein the pump element generates an outward pressure at the outlet of the fluid path.

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