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

(10) **Patent No.: US 8,079,829 B2**
(45) **Date of Patent: *Dec. 20, 2011**

(54) **SUBMERGED DC BRUSHLESS MOTOR AND PUMP**

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(73) Assignee: **Vaporless Manufacturing, Inc.**, Prescott Valley, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/403,627**

(22) Filed: **Mar. 13, 2009**

(65) **Prior Publication Data**

US 2009/0202366 A1 Aug. 13, 2009

Related U.S. Application Data

(63) Continuation of application No. 10/883,229, filed on Jul. 1, 2004, now Pat. No. 7,513,755.

(60) Provisional application No. 60/485,047, filed on Jul. 3, 2003.

(51) **Int. Cl.**
F04B 39/06 (2006.01)
F04B 35/04 (2006.01)

(52) **U.S. Cl.** **417/366**; 417/423.3; 417/423.9; 417/423.12; 417/424.1

(58) **Field of Classification Search** 417/366, 417/423.3, 423.9, 423.12, 423.13, 424.1; 415/143, 222, 221, 121.2
See application file for complete search history.

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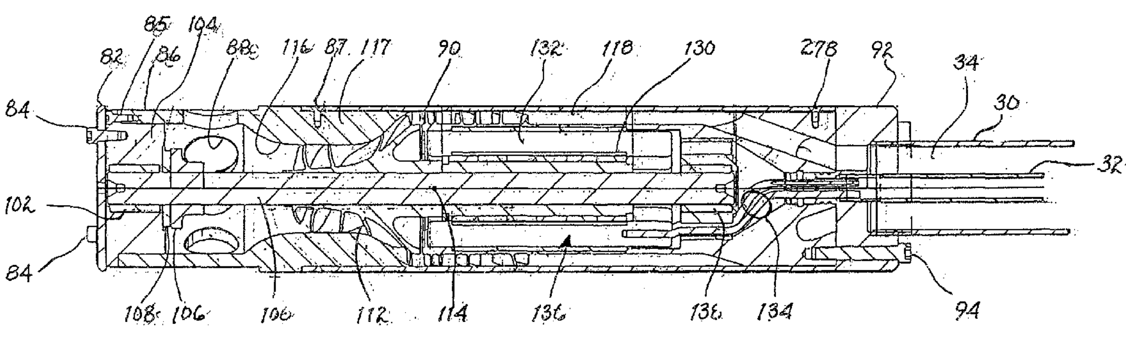
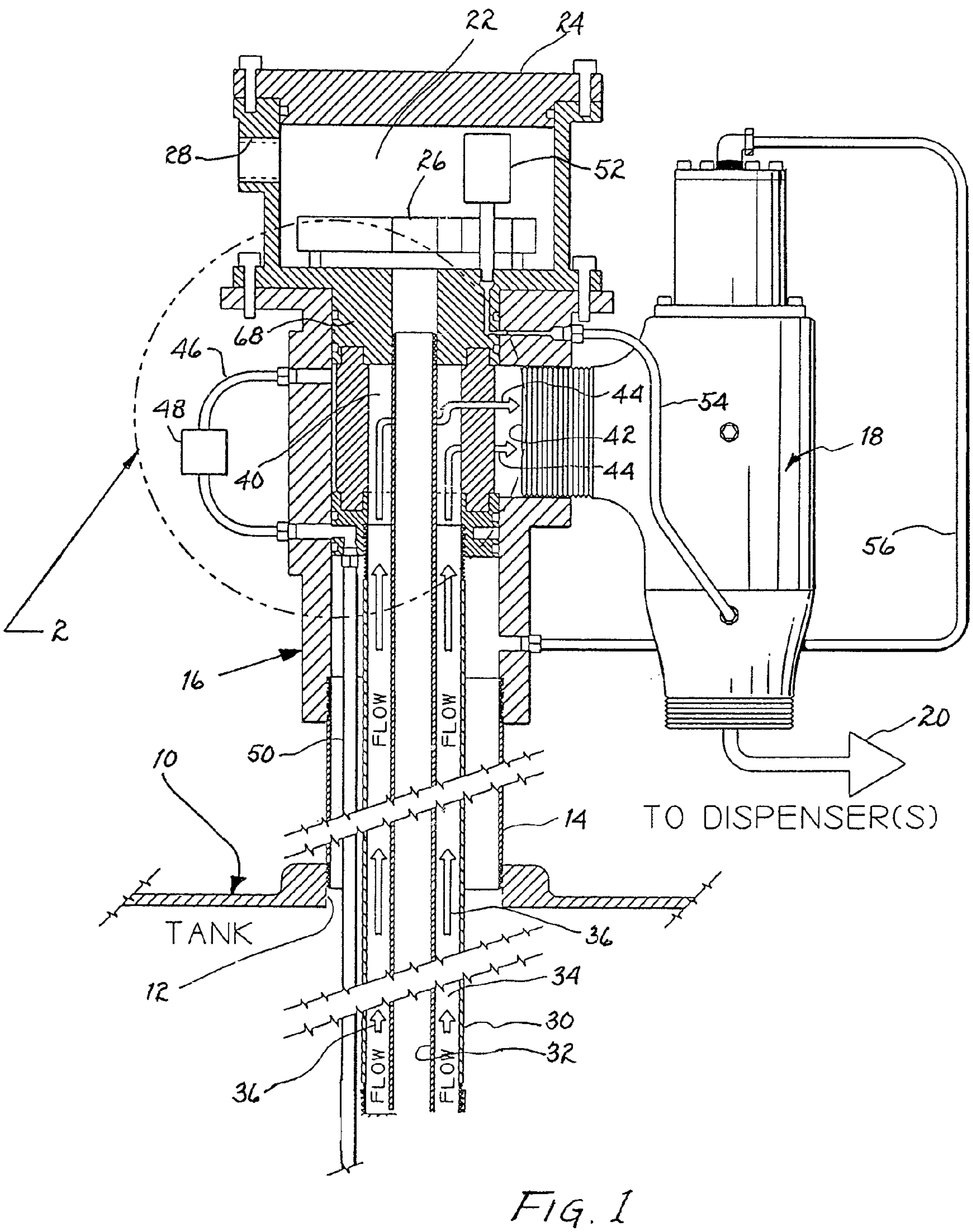
Primary Examiner — Charles Freay
(74) *Attorney, Agent, or Firm* — The vol Hellens Law Firm, Ltd.

(57) **ABSTRACT**

An in-line motor and pump assembly is supported at the bottom of a fuel storage tank by a pipe and an internal concentric conduit for housing electrical conductors extending therewithin to the motor. An impeller, coaxial with the rotor of the motor, draws the fuel into an annular passageway surrounding the stator of the motor. Further passageways convey the fuel to an annular passageway defined between the pipe and the conduit for discharge external of the storage tank. A low pressure environment attendant the inflow of the fuel is used to channel fuel for lubrication and cooling purposes to a lower journal bearing and thrust bearing supporting a common shaft for the impeller and the motor. A high pressure environment attendant outflow of fuel is used to channel fuel for lubrication and cooling purposes to a journal bearing supporting the upper end of the shaft.

9 Claims, 15 Drawing Sheets

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FLOW
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TO DISPENSER(S)
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TANK
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FLOW
FLOW

FIG. 1

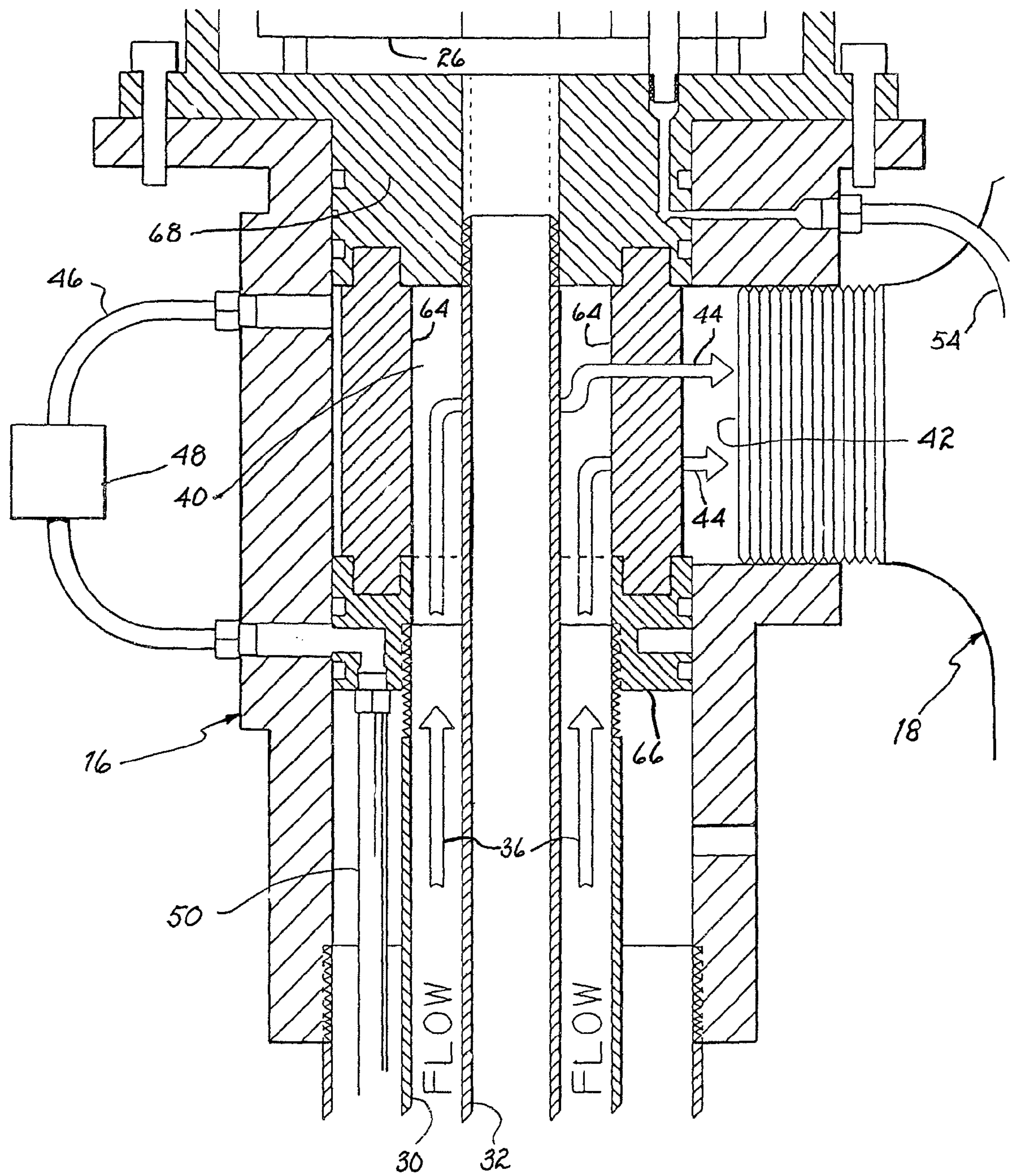
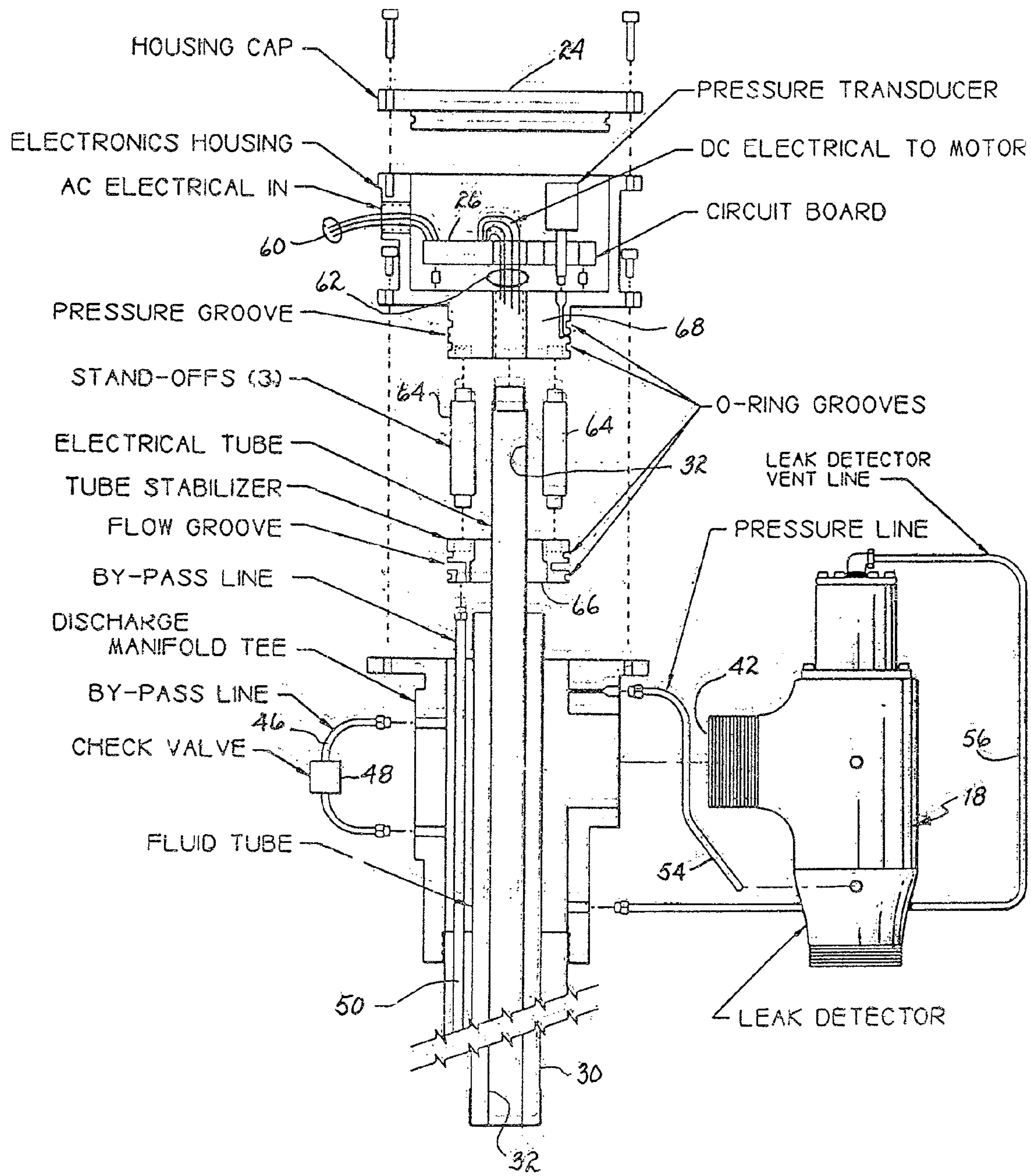


FIG. 2



HOUSING CAP
24
PRESSURE TRANSDUCER
ELECTRONICS HOUSING
DC ELECTRICAL TO MOTOR
AC ELECTRICAL IN
26
CIRCUIT BOARD
60
62
PRESSURE GROOVE
68
STAND-OFFS (3)
64
64
O-RING GROOVES
ELECTRICAL TUBE
32
LEAK DETECTOR VENT LINE
TUBE STABILIZER
FLOW GROOVE
PRESSURE LINE
BY-PASS LINE
66
DISCHARGE MANIFOLD TEE
42
BY-PASS LINE
46
56
CHECK VALVE
48
18
FLUID TUBE
54
50
LEAK DETECTOR
30
32

FIG. 2A

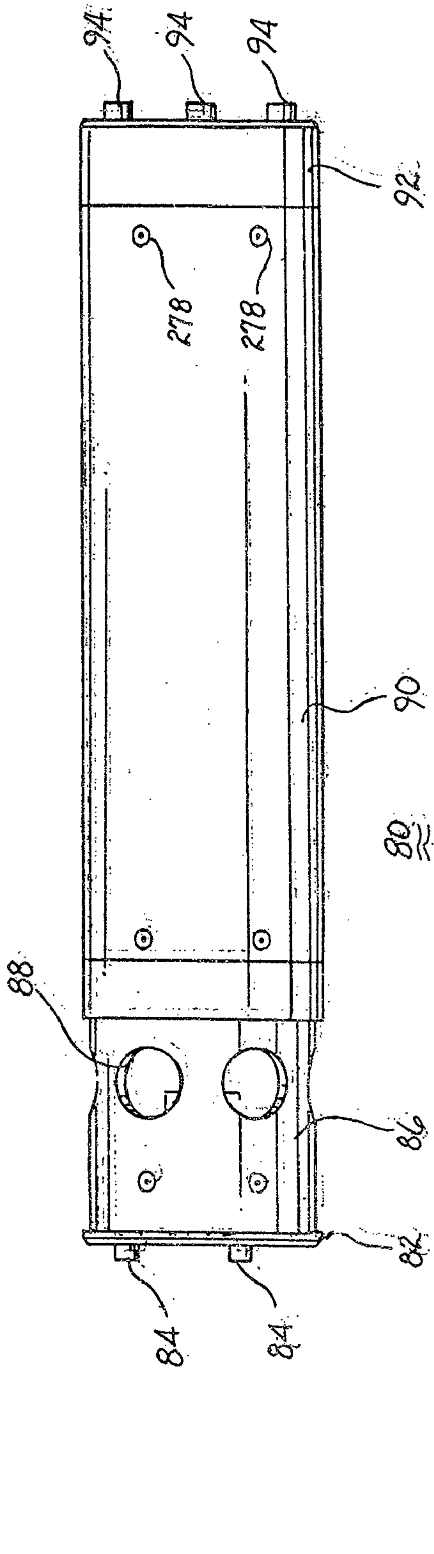

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FIG. 3

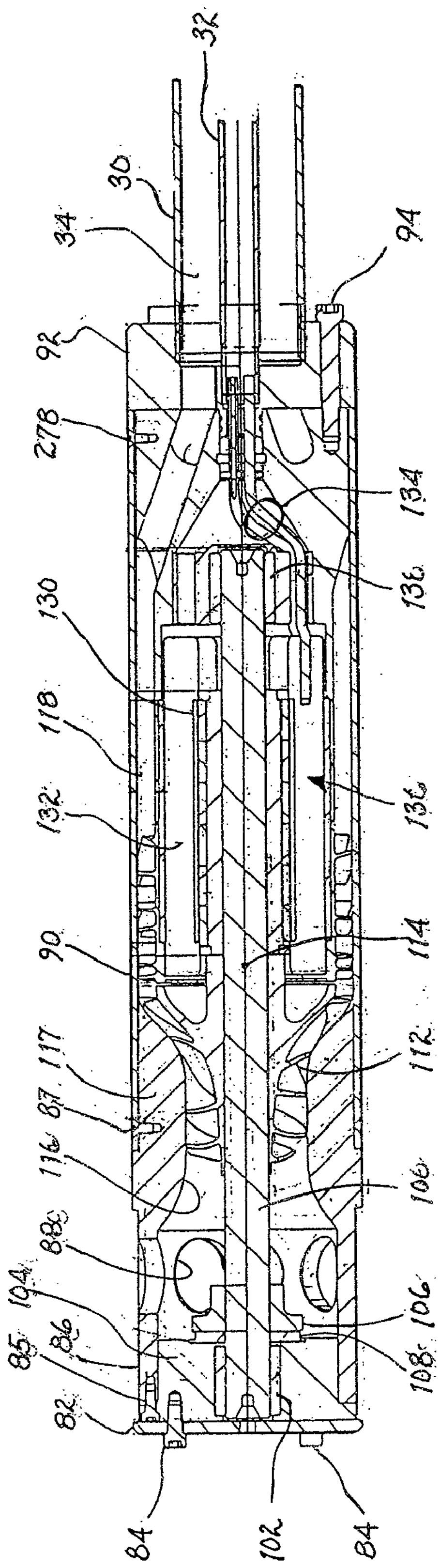
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FIG. 4

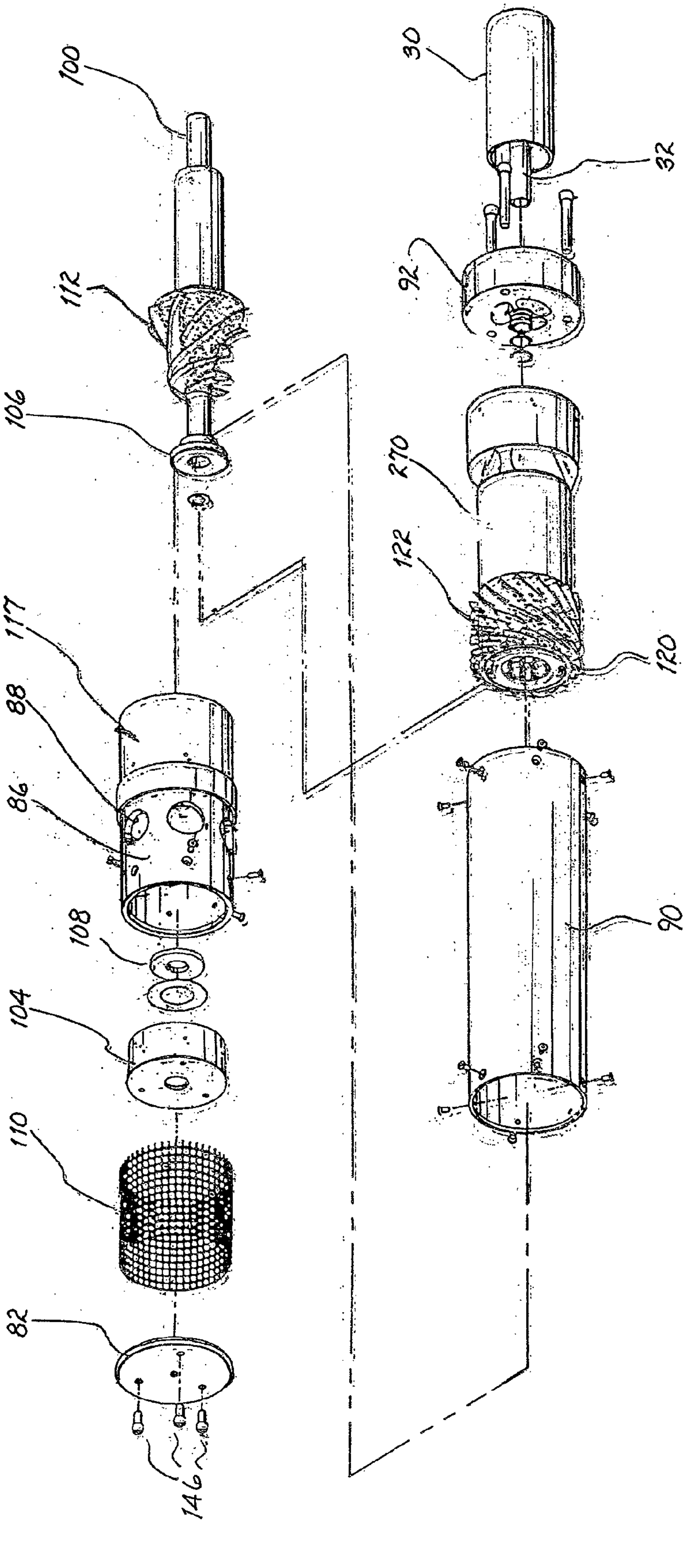


FIG. 5

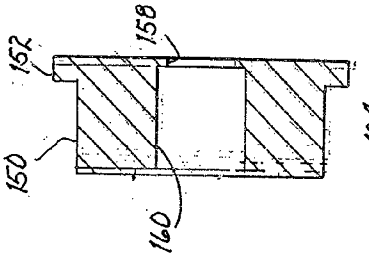


FIG. 7C

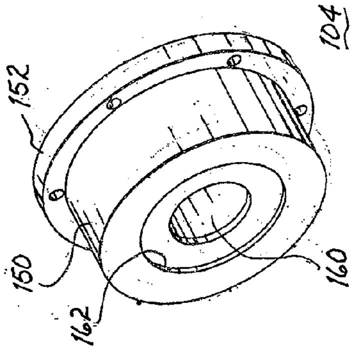


FIG 7B

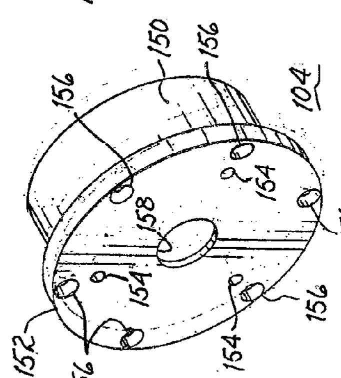


FIG. 7A

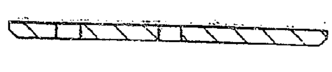


FIG. 6B

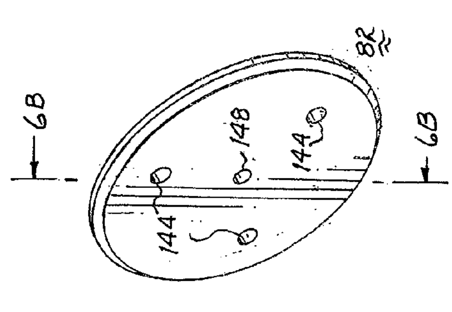


FIG. 6A

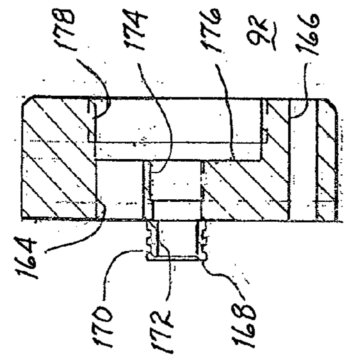


FIG. 8C

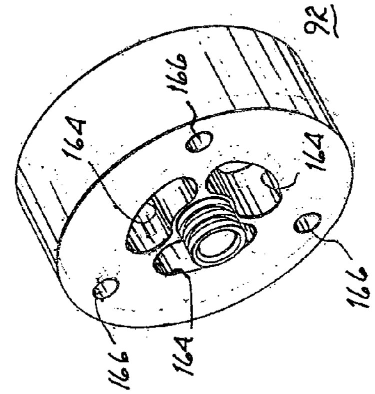


FIG. 8B

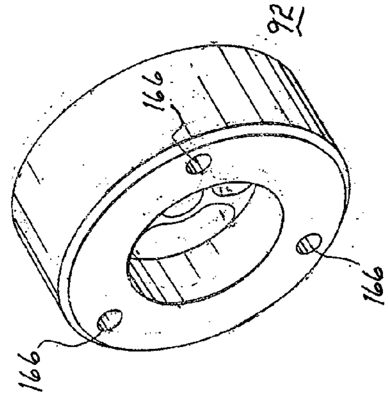


FIG. 8A

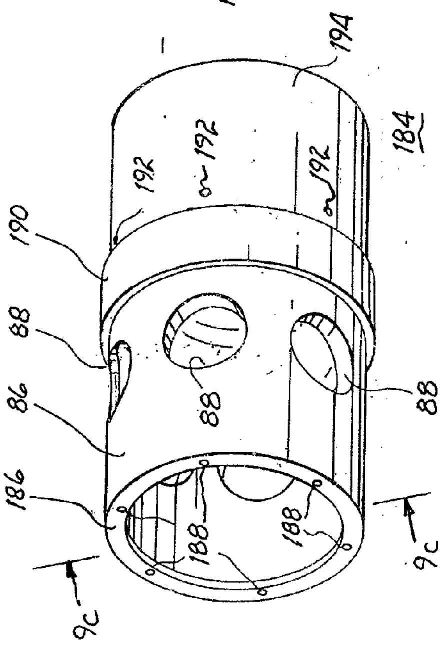


FIG. 9A

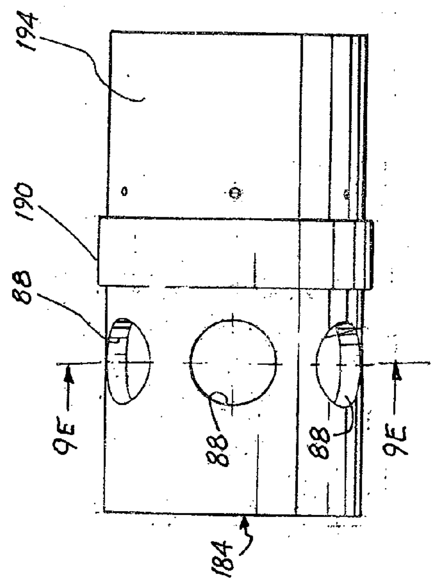


FIG. 9B

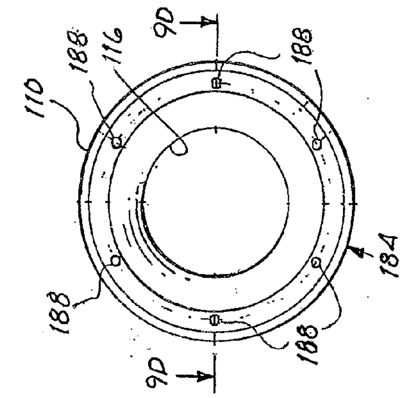


FIG. 9C

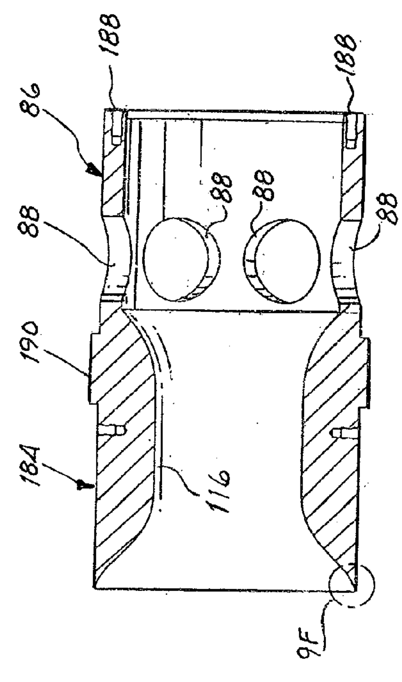


FIG. 9D

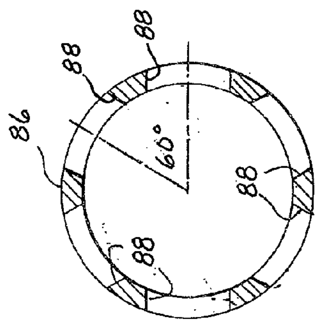


FIG. 9E

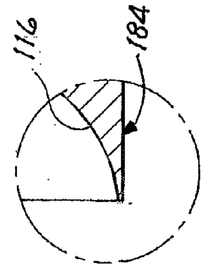


FIG. 9F

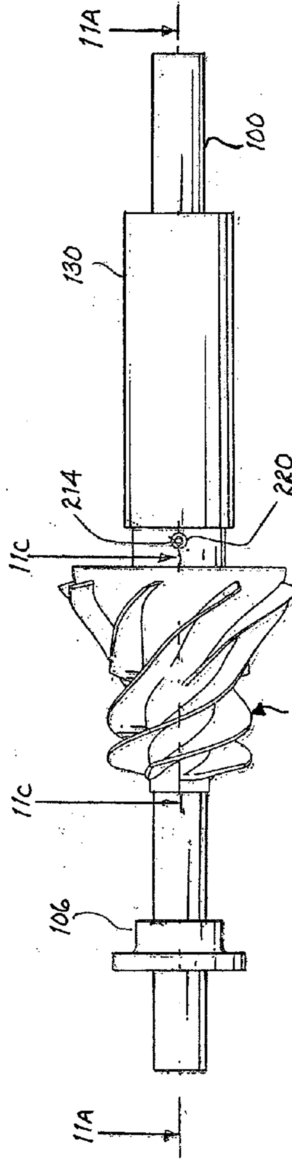


FIG. 11

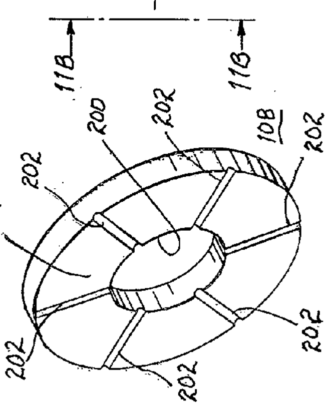


FIG. 10

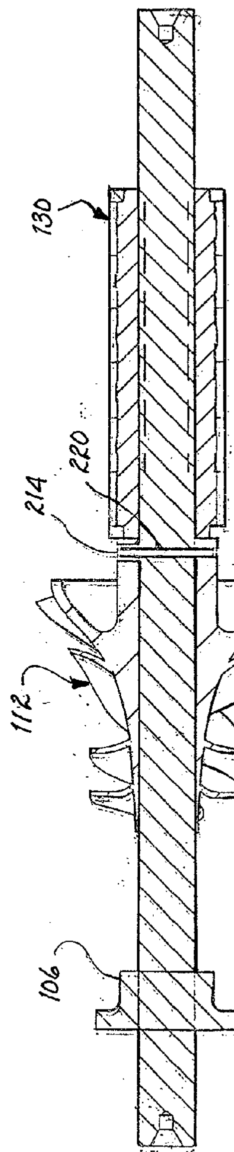


FIG. 11A

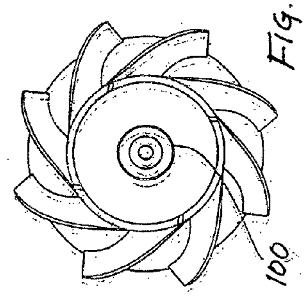


FIG. 11B

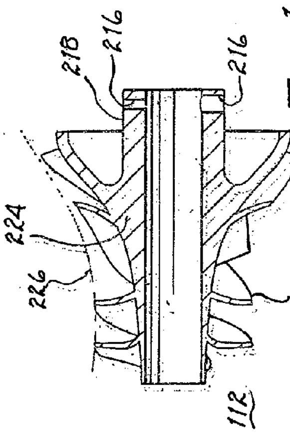


FIG. 11C

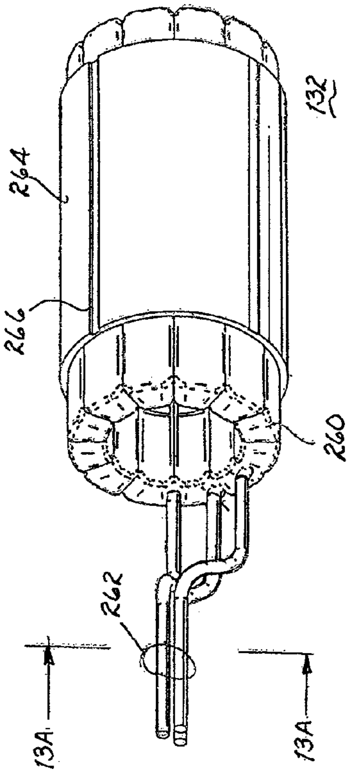


FIG. 13

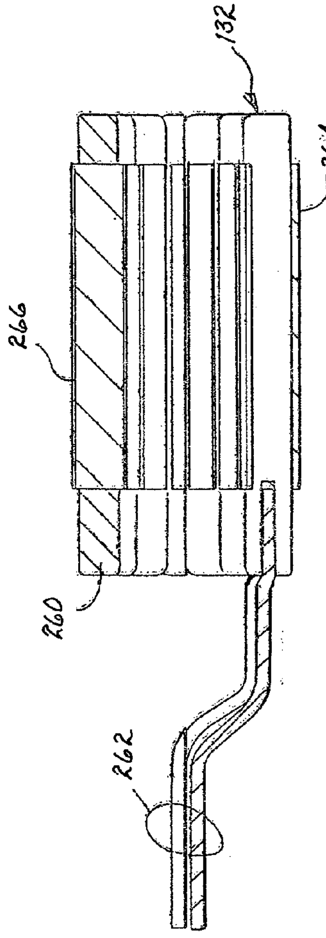


FIG. 13B

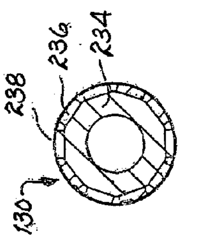


FIG. 12B

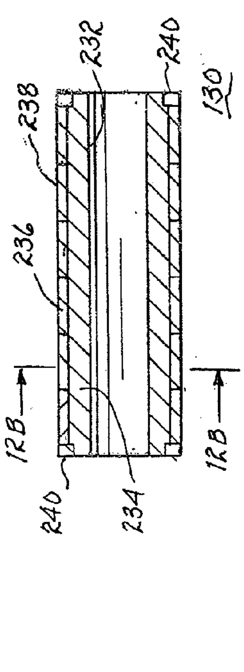


FIG. 12A

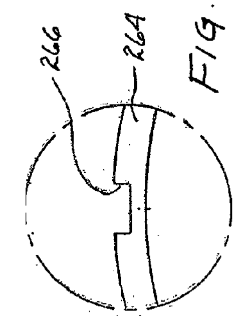


FIG. 13C

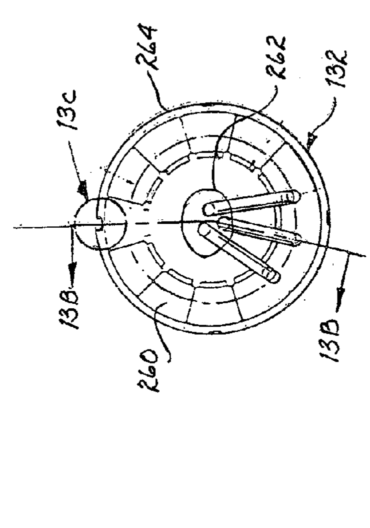


FIG. 13A

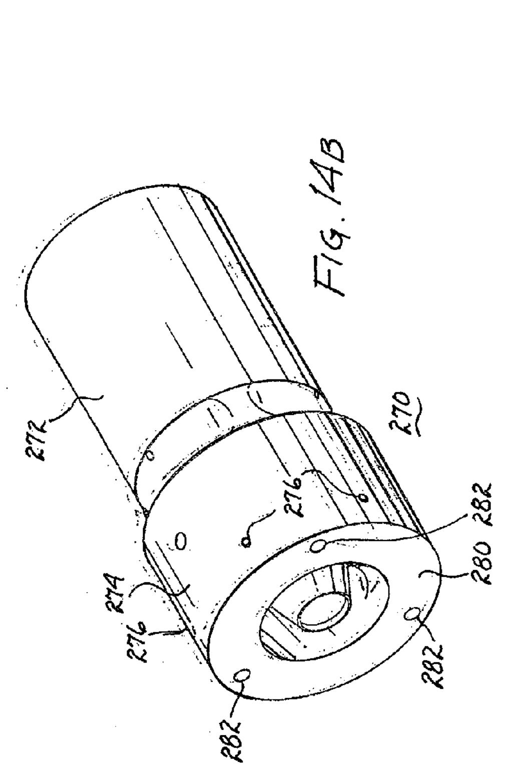


FIG. 14B

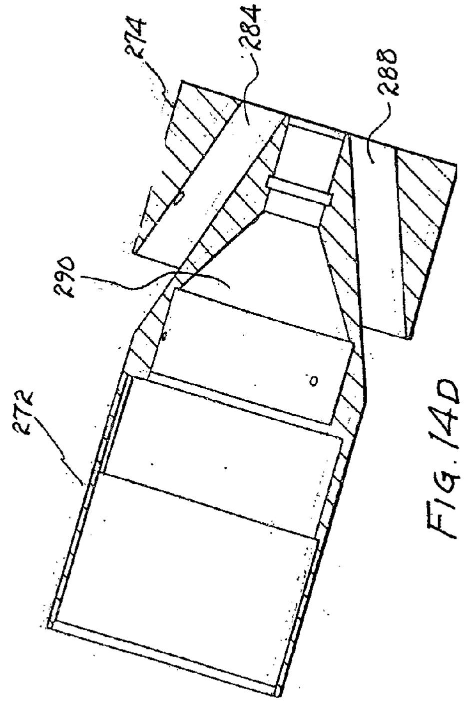


FIG. 14D

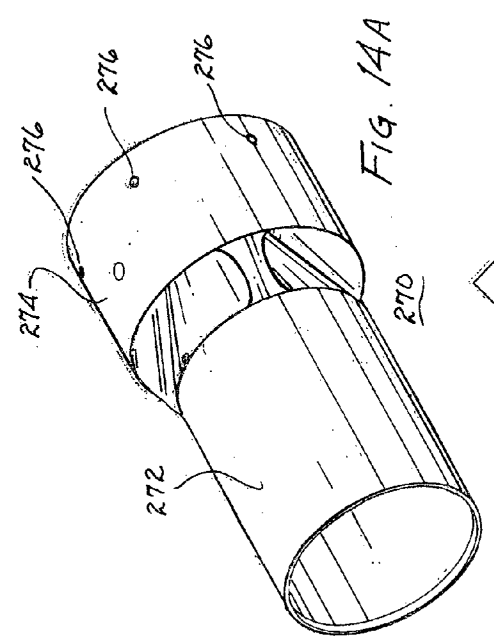


FIG. 14A

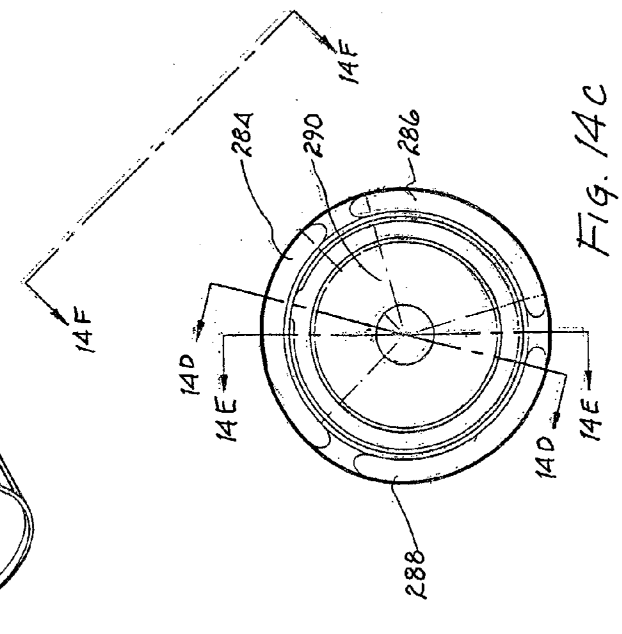


FIG. 14C

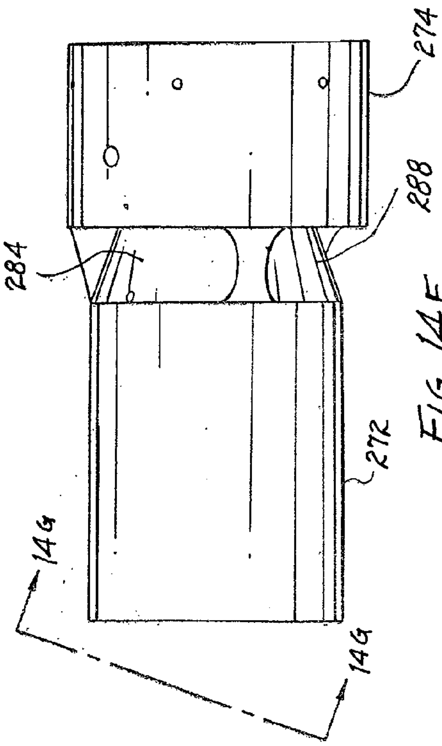


FIG. 14F

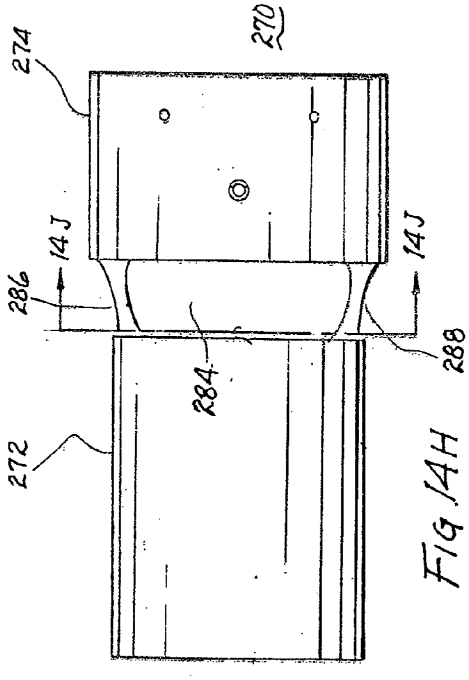
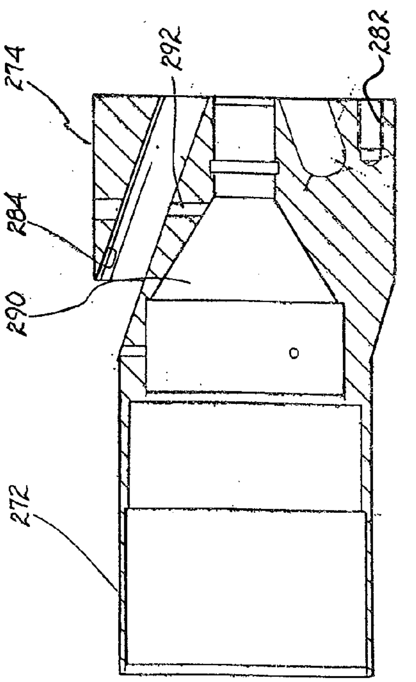


FIG. 14H



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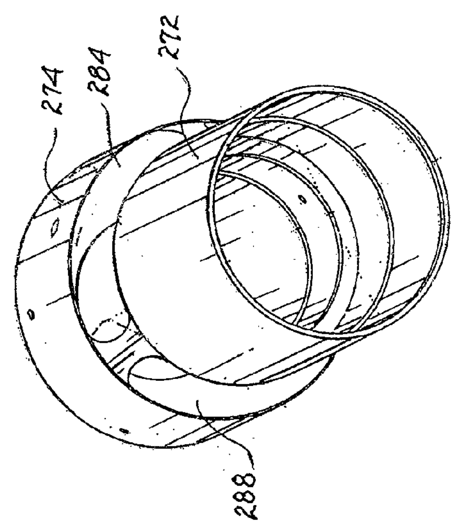

FIG. 14G

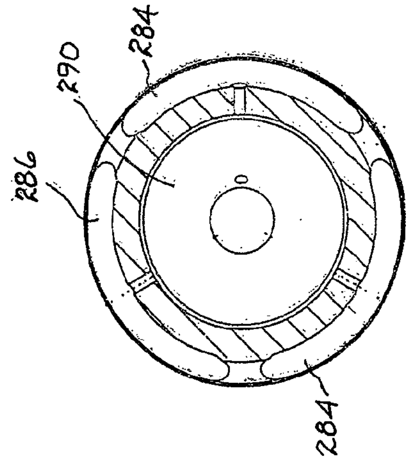

FIG. 14J

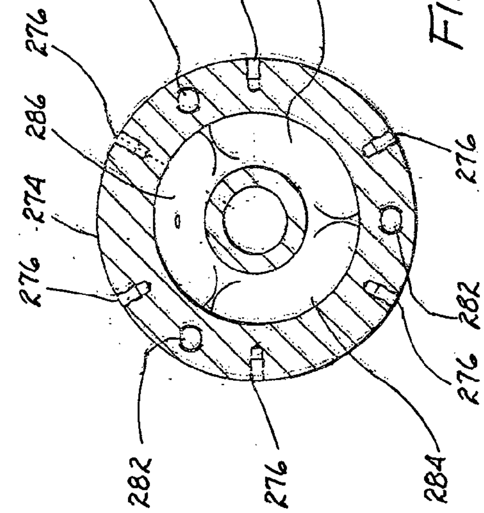

FIG. 14K

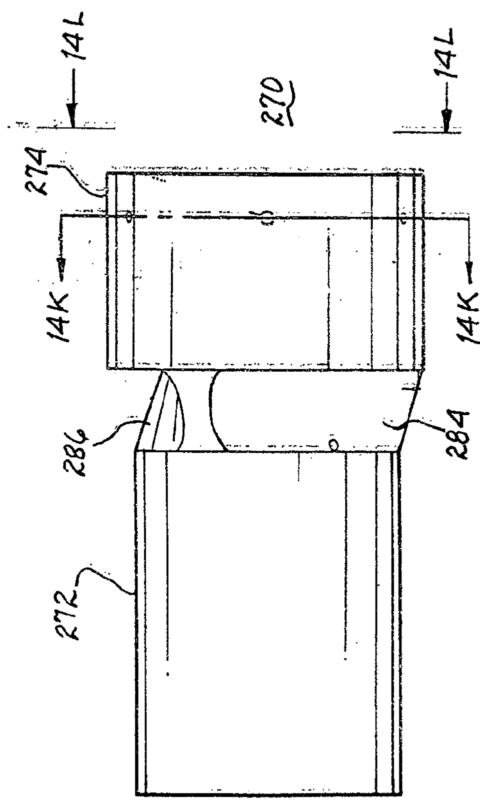

FIG. 14I

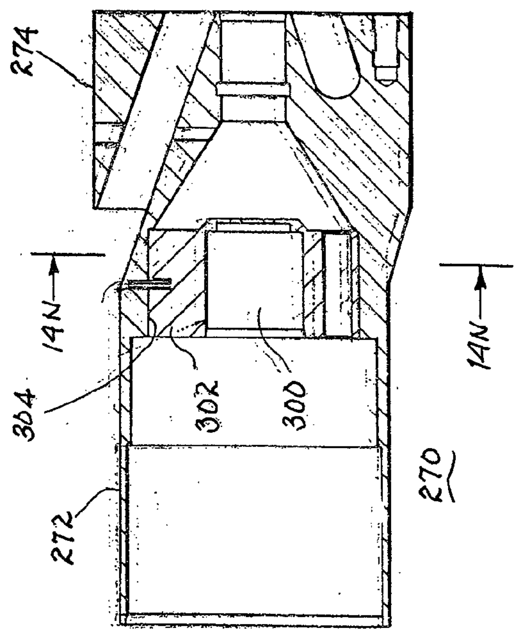

FIG 14M

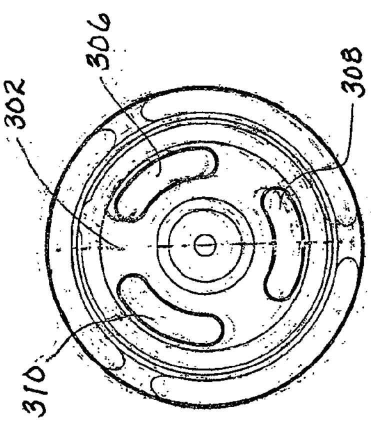

FIG. 14N

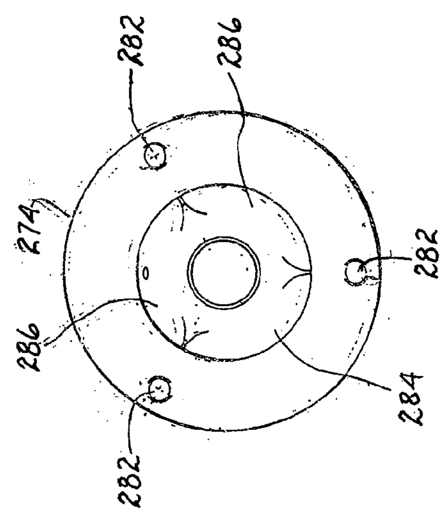

FIG. 14L

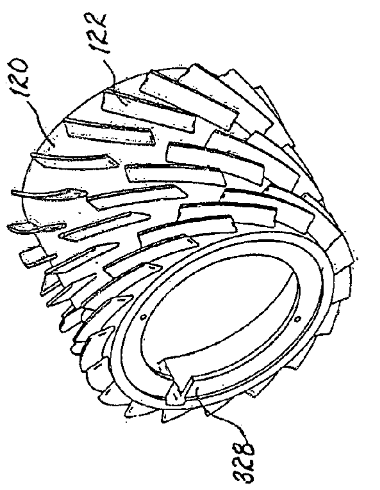

FIG. 15A

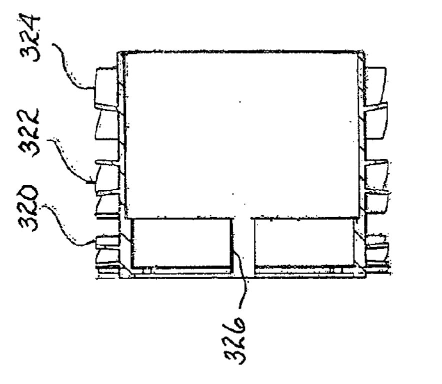

FIG. 15D

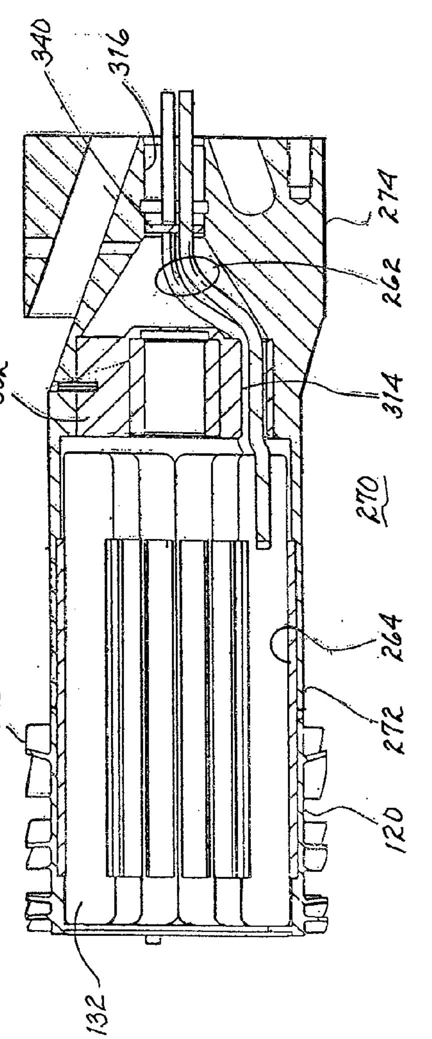

FIG. 15

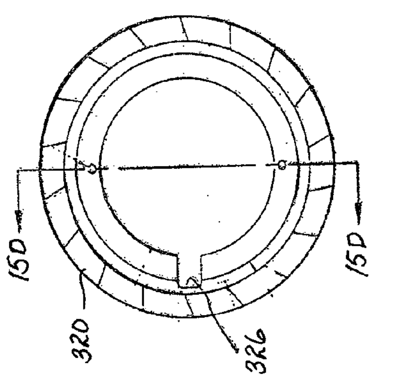

FIG. 15C

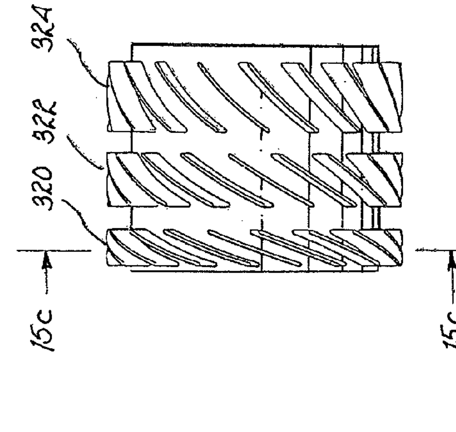

FIG. 15B

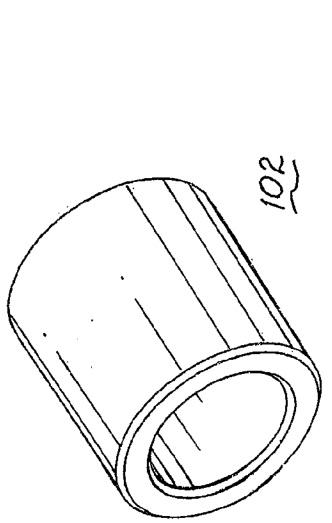

FIG. 16

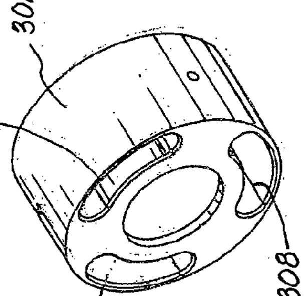

FIG. 17A

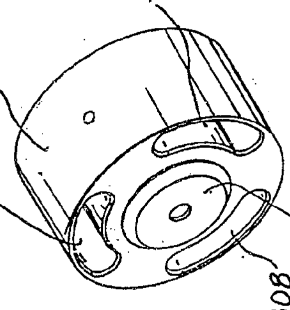

FIG. 17B

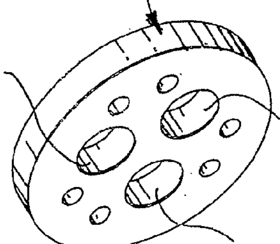

FIG. 18

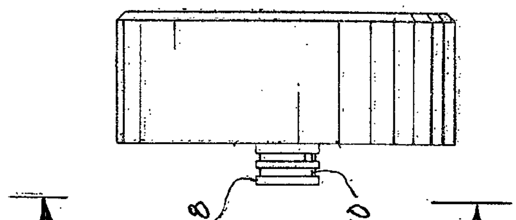

FIG. 19A

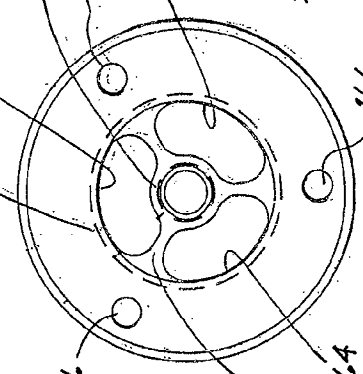

FIG. 19B

SUBMERGED DC BRUSHLESS MOTOR AND PUMP

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of an application entitled "SUBMERGED MOTOR AND PUMP ASSEMBLY", filed Jul. 1, 2004, assigned Ser. No. 10/883,229 and includes subject matter disclosed in and claims priority to a provisional application entitled "IN LINE MOTOR AND FLUID PUMP ASSEMBLY" filed Jul. 3, 2003 and assigned Ser. No. 60/485,047 describing an invention assigned to the present assignee and disclosing an invention of the present inventors.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a pump for underground storage tanks and, more particularly, to an in-line DC brushless motor and fluid pump assembly for use in an underground storage tank to pump liquid into underground delivery lines for distribution through one or more dispensers.

2. Description of Related Prior Art

Gasoline dispensers used at automotive service stations dispense gasoline from an underground tank through a nozzle to be placed in the fill tube of an automobile gas tank. The underground tank includes a pump actuated by a user upon manipulation of a lever at the time of lifting the nozzle from its stored position on the gasoline dispenser. Downstream of the pump is a leak detector for sensing the presence of a fluid leak between the storage tank and the dispenser and to curtail dispensation in the event a leak is sensed.

Several decades ago, these pumps were suction pumps, such as centrifugal pumps, that were located above the storage tank. The pump drew liquid out of the storage tank through a pipe extending into the storage tank. The liquid was thereafter forced into the delivery line from the pump. A pump of this type required a check valve at the inlet of the pump to keep the pump from losing its prime during periods of inactivity. Often, the prime was lost because of a faulty check valve. Furthermore, the required suction or vacuum necessary to lift the fluid out of the storage tank often caused vapor bubbles or vaporlock to occur. In view of these problems attendant above ground suction pumps, submersible turbine pumps were developed and used with storage tanks. Such pumps are still widely used. A turbine pump includes a turbine impeller placed below a submersible electric motor. The motor and impeller are contained within a cylindrical shell connected to a vertical delivery pipe that extends to the top of the tank. The liquid passes through a discharge manifold and into the delivery line connected to the dispenser.

About 90 percent of storage tanks presently in use include a four inch pipe extending into the storage tank. This dimension limits the pump size to less than four inches in diameter and the motor is similarly limited in cross section. Because of the relative sizes of the impeller and the motor compared to the internal diameter of the pipe, the flow capacity past the motor is severely limited. Furthermore, the intake for the pump should be below the motor to place the intake as close as possible to the tank bottom and thereby permit essentially complete evacuation of the liquid from the storage tank.

Where flow capacity available through a pump and impeller mounted within a four inch pipe is inadequate, the present solution is that of installing a second pipe and associated impeller and pump. This adds significant costs for the additional equipment as well as the costs of installation. Another alternative is to install a pipe with a six inch diameter to accommodate a larger motor and pump. This solution includes significant costs of replacement for existing storage tanks.

SUMMARY OF THE INVENTION

A brushless direct current (DC) motor and a pump are in line and provide a small enough cross sectional diameter to permit lowering same through a conventional four inch pipe extending from a storage tank for gasoline or diesel fuel. A common shaft supports the rotor of the motor and the impeller of the pump. Preferably, the pump is at the lower end and liquid is drawn into the impeller through filtered apertures in the side wall of the pump. The outflow from the impeller flows upwardly through an annular passageway surrounding the motor and into a further annular passageway between a supporting pipe and a concentric conduit. The conduit houses the electrical conductors extending from a control circuit remotely located from the electric motor. As the liquid being dispensed flows around and about the motor and the common shaft, the liquid performs a cooling function and lubricates the thrust bearing and the journal bearings. As the depth of the storage tank can be accommodated by simply adding or subtracting a requisite length of pipe and internal conduit (or a telescoping pipe and conduit may be used), any length can be readily accommodated for existing installations or new installations. Furthermore, replacement of the motor/pump assembly is a simple matter of raising the assembly by raising the pipe and the concentric conduit. At the upper end of the pipe, the liquid is channeled into a compartment and may or may not pass through a leak detector to sense any leaks in the line to the dispenser. If no leaks are detected, appropriate signals are transmitted to the control circuit to cause operation of the motor at a nominal rotation speed in the range of 6,000 to 8,000 RPM.

It is therefore a primary object of the present invention to provide an in-line pump and motor assembly for use with a storage tank.

Another object of the present invention is to provide an in-line motor and pump to be used in existing installations of gasoline or diesel fuel storage tanks.

Yet another object of the present invention is to provide a brushless DC motor for operating an impeller in a submerged environment within a storage tank and under control of a control circuit external of the storage tank.

Still another object of the present invention is to provide a common shaft for rotating the rotor and the impeller of an in-line motor and pump assembly.

A further object of the present invention is to provide an in-line motor and pump assembly as a replacement for existing submersible turbine pumps in fuel storage tanks.

A yet further object of the present invention is to provide a method for pumping liquid from a storage tank with a submersible in-line motor and pump assembly.

A still further object of the present invention is to provide a motor driven impeller for discharging a flow of liquid upwardly from a storage tank through an annular passageway within a pipe and concentric conduit extending out of the storage tank.

A still further object of the present invention is to provide a method for using the liquid to be pumped by an in-line motor and pump to lubricate the bearings attendant a common shaft interconnecting the rotor of the motor and the impeller of the pump while simultaneously cooling the motor.

These and other objects of the present invention will become apparent to those skilled in the art as the description of the invention proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described with greater specificity and clarity with reference to the following drawings, in which:

FIG. **1** is a partial cross sectional view of super structure attendant a storage tank for dispensing gasoline or diesel fuel and illustrating a pipe extending into the tank;

FIGS. **2** and **2**A are detailed views of certain components identified by dashed line **2** illustrated in FIG. **1**;

FIG. **3** illustrates the exterior of an in-line motor and pump assembly;

FIG. **4** illustrates a cross section of the in-line motor and pump assembly;

FIG. **5** is an exploded view of the major components of the in-line motor and pump assembly;

FIG. **6**A illustrates the end plate;

FIG. **6**B is a cross sectional view taken along lines **6**B-**6**B, as shown in FIG. **6**A;

FIGS. **7**A, **7**B and **7**C illustrate the lower bearing unit viewed from one end, from the other end and in cross section, respectively;

FIGS. **8**A, **8**B and **8**C illustrate the tube holder mounted at the upper end of the motor and pump assembly and showing a view from one end, from the other end and in cross section, respectively;

FIGS. **9**A and **9**B illustrate an isometric view and a side view of the throat unit, respectively;

FIG. **9**C is an end view taken along lines **9**C-**9**C, as shown in FIG. **9**A;

FIG. **9**D is a cross sectional view taken along line **9**D-**9**D, as shown in FIG. **9**C;

FIG. **9**E is a cross sectional view taken along lines **9**E-**9**E, as shown in FIG. **9**B;

FIG. **9**F is a detail view taken within dashed line **9**F shown in FIG. **9**D;

FIG. **10** illustrates the thrust bearing;

FIG. **11** is a side view of the shaft assembly showing the rotor of the motor, the impeller and a support mounted upon a shaft;

FIG. **11**A is a cross sectional view taken along lines **11**A-**11**A, as shown in FIG. **11**;

FIG. **11**B is an end view taken along lines **11**B-**11**B, as shown in FIG. **11**;

FIG. **11**C is a cross sectional view taken along lines **11**C-**11**C, as shown in FIG. **11**;

FIG. **12**A is a cross sectional view of the rotor of the motor;

FIG. **12**B is a cross sectional view of the rotor taken along lines **12**B-**12**B, as shown in FIG. **12**A;

FIG. **13** is an isometric view of the stator of the motor;

FIG. **13**A is an end view of the stator taken along lines **13**A-**13**A, as shown in FIG. **13**;

FIG. **13**B is a cross sectional view taken along lines **13**B-**13**B, as shown in FIG. **13**A;

FIG. **13**C is a detail view of the elements in circle **13**C, as shown in FIG. **13**A;

FIGS. **14**A and **14**B show isometric views of the lower end and the upper end, respectively, of the motor mount;

FIG. **14**C is a cross sectional view illustrating three peripheral arcuate channels for fluid flow;

FIG. **14**D is a cross section taken along lines **14**D-**14**D, as shown in FIG. **14**C;

FIG. **14**E is a cross sectional view taken along lines **14**E-**14**E, as shown in FIG. **14**C;

FIG. **14**F is a side view taken along lines **14**F-**14**F, as shown in FIG. **14**C;

FIG. **14**G is an exterior and interior view taken along lines **14**G-**14**G, as shown in FIG. **14**F;

FIGS. **14**H and **14**I illustrate different external views of the motor mount;

FIG. **14**J is a cross sectional view taken along lines **14**J-**14**J, as shown in FIG. **14**H;

FIG. **14**K is a cross sectional view taken along lines **14**K-**14**K, as shown in FIG. **14**I;

FIG. **14**L is an end view taken along lines **14**L-**14**L, as shown in FIG. **14**I;

FIG. **14**M is similar to FIG. **14**E except that the upper bearing housing is mounted therein;

FIG. **14**N is a cross sectional view taken along lines **14**N-**14**N, as shown in FIG. **14**M;

FIG. **15** illustrates a cross sectional view of the stator of the motor mounted within the motor mount;

FIG. **15**A is an isometric view of the stationary vanes mounted about the motor mount;

FIG. **15**B is a side view of the stationary vanes;

FIG. **15**C is a cross sectional view taken along lines **15**C-**15**C, as shown in FIG. **15**B;

FIG. **15**D is a cross sectional view taken along lines **15**D-**15**D, as shown in FIG. **15**C;

FIG. **16** is an isometric view of the upper radial bearing;

FIGS. **17**A and **17**B are isometric views illustrating opposed sides of the upper bearing mount;

FIG. **18** is an isometric view of the wire spacer;

FIG. **19**A is a side view of the tube holder; and

FIG. **19**B is an end view taken along lines **19**B-**19**B, as shown in FIG. **19**A.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, there is representatively shown a storage tank **10** for storing a liquid, such as gasoline or diesel fuel, hereinafter referred to as "product". These storage tanks are generally underground and a pump of some type must be used to draw the product from the underground storage tank to a dispenser located above ground and used to fill the gas tank of a vehicle. Tank **10** includes an access port **12** having a four inch (4") threaded tube **14** in threaded engagement therewith and extending upwardly to support a super structure collectively identified by numeral **16**. A leak detector **18** is (or the leak detector could be omitted and substituted by a pipe or a conduit) in fluid communication with the super structure to receive product therefrom and transmit the product to one or more dispensers of the product, as reflected by arrow **20**. The function of the leak detector is that of determining whether there exists a leak downstream of the leak detector. If no leak is found, a flow of product through the superstructure to the dispenser(s) will occur. In the event a leak or other fault is detected, the product will not be conveyed through the superstructure to the dispenser(s). The top of super structure **16** includes a compartment **22** closed with a cap **24** that may be bolted in place, as illustrated. Circuitry **26** is located within the compartment and the circuitry controls operation of the motor to be described and which is coupled with a pump. A port **28** serves in a manner of a conduit to provide electrical power to circuitry **26**.

A pipe **30** is threadedly secured to the super structure and extends through access port **12** of tank **10** into the tank. The length of this pipe is a function of internal height of the tank.

A conduit **32** is threadedly attached to super structure **16** and extends downwardly within pipe **30** and may be concentric therewith. Annular space **34** is the space between the pipe and the conduit and accommodates an upward flow of product from within tank **10**, as depicted by arrows **36**.

Referring jointly to FIGS. **1**, **2** and **2**A, the details attendant superstructure **16** will be described. At service stations dispensing gasoline and/or diesel fuel (product), a motor and pump assembly associated with a storage tank is actuated by an authorized method; some dispensers actuate the pump and motor assembly by the simple act of removal of the nozzle from its resting place. When the motor and pump assembly is actuated, product will flow upwardly through annular space **34** into a chamber **40** and into the line system, which may include inlet **42** of leak detector **18**. This flow is depicted by arrows **44**. As described above, leak detector **18** performs a detecting function to determine if there is a leak downstream between the leak detector and the dispensers. During periods of time the pump is running, the dispenser may not be dispensing product. To facilitate a cooling and lubricating flow for mechanical and electrical elements, flow of product occurs through line **46**, check valve **48** and into return line **50**. The outflow of the return line is into tank **10**. Simultaneously, the pressure downstream of leak detector **18** is sensed by a pressure transducer **52** through a line **54** extending from downstream of leak detector **18** into superstructure **16** and conveying product to the pressure transducer. In the event a leak detector as shown is not present, line **54** would be connected to and sense the pressure in chamber **40**. In any event, line **54** transmits line pressure to transducer **52**. The pressure transducer provides an electrical signal to circuitry **26**; then, a control signal for operation of the motor of the pump and pump assembly is generated. Moreover leak detector **18** includes a return line **56** venting air from the leak detector housing into superstructure **16** for discharge into tank **10**, as depicted.

Particularly depicted in FIG. **2**A, electrical conductors collectively identified by reference numeral **60** provide power to signal control circuitry **26** and to circuitry that changes AC power to DC power. Power to the motor and pump assembly is provided by further conductors collectively identified by reference numeral **62** as a function of the pressure sensed by the transducer and conveyed to the control circuit and the signal generating functions. Conductors **62** extend into conduit **32** and ultimately are electrically connected with the stator of the motor, as will be described. Particularly, the power provided to the motor is direct current (DC). Stand offs **64** interconnect tube stabilizer **66** and base **68**. As illustrated, conduit **32** is in threaded engagement with base **68** and pipe **30** is in threaded engagement with tube stabilizer **66**. The space therebetween, chamber **40**, is established by the length of stand offs **64**.

By inspection, it will become self evident that the circuitry **26** is readily accessible by simple removal of cap **24** to permit repair or replacement. Furthermore, disconnecting the electrical conductors connected to circuitry **26** and removing the bolts holding base **68** in place permits withdrawal of pipe **30** and the motor and pump assembly attached to the lower end thereof. Thereby, the pump and motor assembly can be readily repaired or replaced if and when necessary. The motor and pump assembly is essentially independent of the depth to which it is placed within tank **10** as the length of pipe **30** and conduit **32** can be changed at will by adding or deleting sections thereof; alternatively the pipe and conduit may be of the telescoping type. These features are of significant importance in the commercial world when repair/replacement may be necessary from time to time and the time for such repair/replacement must be minimized to reduce the down time of the attendant product dispensers.

Referring to FIG. **3**, there is illustrated the exterior of an in-line motor and pump assembly **80**. The lower end includes a plate **82** secured by bolts **84**. Inlet section **86** includes a plurality of inlets **88** through which the product within the storage tank is drawn. Although not illustrated in FIG. **3**, the inlet section is enveloped within a sleeve of screen material to minimize the inflow of debris and other foreign matter that may have migrated to the bottom of the storage tank. A cylindrical housing **90** envelopes the major internal assemblies attendant an impeller and a brushless DC motor along with the various channels for directing product through the motor and pump assembly. A tube holder **92** is secured by a plurality of bolts **94**. The primary purpose of the tube holder is to permit and accommodate attachment of motor and pump assembly **80** to pipe **30** and conduit **32** illustrated in FIG. **1**. Thereby, electrical power is supplied to the motor through a plurality of conductors extending downwardly through conduit **32** into engagement with the motor. The upward flow of product produced by the rotating impeller flows through channels within motor and pump assembly **80** into the annular space between conduit **32** and pipe **30** and is ultimately conveyed to chamber **40** and leak detector **18** or conduit extending from the chamber.

An overview of the major components of motor and pump assembly **80** will be described with joint reference to FIGS. **4** and **5**. A shaft, **100** journaled within journal **102**, is disposed in lower bearing mount **104**. A thrust bearing **108** supports a thrust support **106** to accommodate the downwardly directed force exerted by operation of the impeller. A cylindrical screen **110** envelopes inlet section **86**, as described above. An impeller **112** is mounted on shaft **100** and is secured by a pin **114** to prevent independent rotation between the impeller and the shaft. The impeller rotates within a throat **116** of throat unit **117** which is venturi-like in cross section, as illustrated. The configuration of the throat closely corresponds with the cross sectional curvature of the impeller when rotating. Upon rotation, the impeller draws product through inlets **88**, through throat **116** and into an annular passageway **118**. The flow entering the annular passageway will be rotating due to the forces imposed by the impeller. To counter such rotation, a cylinder **120** having a plurality of vanes **122** protrude into the annular passageway and render the flow therethrough essentially axial. At the upper end of the annular passageway, the flow is channeled into three equi-angularly located arcuate channels converging toward one another and the product is directed into annular space **34** intermediate pipe **30** and conduit **32**. Thereafter, the flow of product continues upwardly into chamber **40** and through the leak detector or conduit extending from the chamber, as described above.

Rotor **130** of the motor is mounted on shaft **100**. Stator **132** of the motor is mounted within motor mount assembly **270** in concentric stationary relationship with the rotor. A plurality of electrical conductors **134** extend from within conduit **32** to the stator to provide the requisite power to operate brushless DC motor **136**. A bearing **138** upstream of the motor supports shaft **100**. As will be described in further detail below, the high pressure attendant discharge of product from the annular passageway is used to channel product for lubrication and cooling purposes to upper bearing **138**. The low pressure present within inlet section **86** is used to draw product through plate **82** into the lower journal bearing and the thrust bearing to lubricate and cool them. The flow of product through annular passageway **118** draws heat from the stator to cool motor **136**.

Referring to FIGS. **6**A and **6**B, there is shown plate **82**. The plate includes a plurality of apertures **144** for penetrably receiving bolts **146** (see FIG. **5**, the same as bolts **84** in FIGS. **3** and **4**) to secure the plate with the lower bearing mount. A centrally located aperture **148** is in fluid communication with the journal bearing and thrust bearings attendant the lower bearing mount. As a result of the low pressure environment within inlet section **86**, product will be drawn through aperture **148** to lubricate the journal bearing and thrust bearings. Additionally, such fluid flow will perform a cooling function.

Lower bearing mount **104** is illustrated in FIGS. **7**A, **7**B and **7**C. The lower bearing mount includes a body **150** terminated by a radially enlarged disc **152**. The disc includes three threaded apertures **154** for receiving the bolts extending through plate **82**. A plurality of peripherally located apertures **156** penetrably receive bolts for threaded engagement with the end of inlet section **86**. A further aperture **158** is centrally located coincident with aperture **148** in plate **82** to accommodate flow of product therethrough. An annular indentation **162** supports the thrust bearing for shaft **100**.

FIGS. **8**A, **8**B and **8**C illustrate tube holder **92** disposed at the top end of the motor and pump assembly. The tube holder receives the flow of product from annular passageway **118** via three arcuate channels and discharges it through three equiangularly located outlets **164**. Bolts, as shown in FIG. **4**, penetrate apertures **166** into threaded engagement with the end of the motor mount assembly **270** of motor and pump assembly **80**. A centrally located hollow boss **168** extends into a corresponding passageway in the motor mount assembly. One or more channels **170** are disposed about the boss to receive o-rings and effect a sealed engagement with the passageway in the motor mount assembly. As illustrated in FIG. **4**, the electrical conductors from the stator of the motor extend through boss **168** and into conduit **32**. Passageway **172** extending through the boss and the tube holder includes threads **174** for threaded engagement with conduit **32**. Radially expanded cavity **176** includes threads **178** for threaded engagement with pipe **30**. Thereby, the motor and pump assembly is supported from the pipe via the tube holder.

Referring jointly to FIGS. **9**A, **9**B, **9**C, **9**D, **9**E and **9**F, throat unit **184** will be described. Inlet section **86** includes an end **186** having a plurality of threaded apertures **188** disposed therein. These apertures correspond with apertures **156** in lower bearing unit **104** described above. Bolts **85** (see FIG. **4**) penetrate apertures **156** and threadedly engage apertures **188**. Thereby, the lower bearing unit is rigidly attached to the throat unit. An annular ridge **190** serves to locate one end of screen **110**, as described above. Additionally, housing **90** abuts thereagainst, as shown in FIG. **4**. The housing is attached to throat unit **184** by a plurality of bolts **87** extending through apertures in the sleeve and threadedly engaging threaded apertures **192** in the throat unit. The exterior surface of skirt **194** supports housing **90**. The interior surface of the skirt defines in part throat **116**. The configuration of the throat closely matches the curvature of the impeller as defined during rotation of the impeller in accordance with good hydraulic practices to minimize losses due to eddy currents and the like. To minimize disruption of flow from within the throat to the annular passageway surrounding the stator of the motor, the throat terminates in a sharp point, as particularly illustrated in FIG. **9**F; thereby, the transition of flow from the throat to the annular passageway is minimized. As illustrated in FIG. **9**E, six inlets **88** are disposed about the inlet section equi-angularly spaced from one another by 60°. However, a single inlet could be used.

FIG. **10** illustrates thrust bearing **108**. It includes a central aperture **200** to accommodate passage of shaft **100** therethrough and, to some extent, accommodate passage of product between thrust support **106** and thrust bearing **108**. A plurality of radial grooves **202** are disposed in face **204** of the thrust bearing, which face bears against the thrust support. The purpose of these grooves is to accommodate lateral flow of product drawn thereinto by the low pressure environment within the inlet section. Thus, the thrust support will float.

Referring to FIGS. **11**, **11**A, **11**B and **11**C, shaft **100** and the elements mounted thereon will be described. A thrust support **106** is press fit onto shaft **100** and bears against thrust bearing **108**. An impeller **112** is mounted on the shaft and fixedly secured thereto by a pin **214** extending through passageways **216** of sleeve **218** and passageway **220** extending through the shaft. The impeller may include an inducer formed as part of it, as illustrated, or as an upstream element. Thus, the impeller is axially and rotationally secured in place and yet easily replaceable in the event of required maintenance or repair. Impeller **112** includes vanes **222** that extend from a geometrically radially increasing base **224**. The configuration of the plurality of these vanes, when the impeller is rotating, defines a curvature replicated by the configuration of throat **116**, as depicted by dashed line **226** in FIG. **11**C. Rotor **130** of the motor is secured to the shaft in such a manner as to preclude independent rotation between the rotor and the shaft, as is well known to those skilled in the art. For reasons that will become evident as the description proceeds, the rotor is located downstream of the impeller. However, such location is presently considered the preferred embodiment but may be located upstream of the impeller. Such secondary location would necessarily require some adaptations of the structure recited herein.

As particularly shown in FIGS. **12**A and **12**B, rotor **130** includes a central passageway **232** for receiving shaft **100**. The rotor includes a core **234**, magnets **236** and sleeve **238**. A pair of end rings **240** secure and maintain the assembly of the components of the rotor and allow a surface that may be altered to balance the impeller, rotor and shaft rotating assembly.

Referring jointly to FIGS. **13**, **13**A, **13**B and **13**C, details of stator **132** will be described. The stator includes a plurality of windings **260**, as is conventional. Electrical conductors, collectively referenced by numeral **262**, extend from the windings to a source of electrical power. A sleeve **264** surrounds windings **260** and may include one or more longitudinally extending grooves **266** for engagement with one or more keys to preclude rotation of stator **132**. As is well known and depicted in FIG. **4**, the stator envelopes rotor **130**.

Referring jointly to FIGS. **14**A and **14**B, two opposing isometric views of motor mount assembly **270** are shown. The motor mount assembly includes a sleeve **272** for enveloping and retaining stator **132** of brushless DC motor **136**. An enlarged section **274** channels the flow of product from annular passageway **118** into three converging arcuate channels that distribute the product into the annular space between conduit **32** and pipe **30**. Section **274** includes a plurality of threaded apertures **276** for threadedly receiving screws, such as screw **278** (shown in FIG. **4**) which screws secure the section within the end of housing **90**. End **280** includes threaded apertures **282** for receiving bolts **94** (see FIG. **4**) to secure tube holder **92** to section **274**. As illustrated in FIGS. **4** and **15**, sleeve **264** supports cylinder **120** having vanes **122** extending therefrom into the annular passageway. Moreover, cylinder **120** and sleeve **272** serve as the interior wall of the annular passageway; housing **90** serves as the exterior wall of the interior annular passageway.

FIG. **14**C illustrates three peripheral arcuate channels or passageways **284**, **286** and **288** disposed within section **274** and conveying product from the annular passageway through the section. It also illustrates in cross section conical passageway **290** disposed downstream of motor **136**. As also illustrated in the cross sectional view shown in FIG. **14**D, arcuate passageways **284**, **286** and **288** converge to deliver the product to tube holder **92** (see FIG. **4**). FIG. **14**E is similar to FIG. **14**D except that it is rotated a few degrees as depicted in FIG. **14**C. With such rotation, there is shown a radial passageway **292** interconnecting arcuate passageway **284** with conical passageway **290**. The product passing through arcuate passageways **284**, **286** and **288** is at high pressure. Such high pressure will cause a stream of product to flow through radial passageway **292** into conical section **290**. This product will bathe the bearing supporting the upper end of shaft **100** to retain it lubricated and have a cooling effect. A threaded aperture **282** is also illustrated in FIG. **14**K, which aperture threadedly engages bolt **94** as one of the bolts for retaining tube holder **92** with the motor mount assembly.

FIGS. **14**F and **14**G further illustrate the transition of product flow from within the annular passageway into each of arcuate passageways **284**, **286** and **288**. FIGS. **14**H and **14**I are different side views of motor mount assembly **270** and are included primarily for purposes of orienting cross sectional views **14**K, **14**L and **14**M. FIG. **14**K illustrates convergence of passageways **284**, **286** and **288** at the downstream end of section **274**. Threaded apertures **282** are also depicted along with threaded apertures **276** for engagement by screws or bolts **278** to secure housing **90** to section **274**. FIG. **14**L is an end view of section **274** and depicts final convergence of passageways **284**, **286** and **288**.

FIG. **14**M is a cross sectional view of motor mount assembly **270** and illustrates bearing **300** disposed within bearing block **302** mounted on a corresponding cylindrical section **304** within the motor mount assembly. The bearing block is pressed in place. As depicted in FIG. **14**N, the bearing block may include a plurality of arcuate passageways **306**, **308** and **310** for wiring passageway to motor **136**.

FIG. **15** illustrates mounting of stator **132** within sleeve **264** of motor mount assembly **270**. In particular, it illustrates routing of multiple conductors **262** through a passageway **314** extending through bearing block **302** and through central passageway **316** extending through section **274**. Thereafter, these conductors are conveyed upwardly through conduit **32**. This figure also illustrates mounting of cylinder **120** supporting vanes **122** upon sleeve **264**. Vanes **122** mounted upon cylinder **120** are shown with respect to their orientation more clearly in FIGS. **15**A, **15**B, **15**C and **15**D. In particular, the vanes are formed as three sets of vanes **320**, **322** and **324** with each set of vanes having a different angular orientation to counter the rotary motion of the product flowing into the annular passageway. To prevent rotation of cylinder **120**, it may include a key way **326** for engagement by a spring loaded key **328**.

FIG. **16** illustrates journal bearing **102** disposed at the lower end of shaft **100**.

FIGS. **17**A and **17**B illustrate two end views of bearing block **302** supporting bearing **300** (depicted as **138** in FIG. **4**). As depicted, more than one wiring passageway **306**, **308** and **310** may be incorporated.

FIG. **18** illustrates an apertured disc **340**. This disc includes apertures **342**, **344** and **346** penetrably receiving selected ones of electrical conductors **262**. Thus, it serves in the manner of a spacer for the electrical conductors. The disc may be mounted in passageway **316** of section **274** at the upper end thereof, as illustrated in FIG. **15**.

FIGS. **19**A and **19**B illustrate tube holder **92**. This tube holder includes the earlier described hollow boss **168** for penetrable insertion within passageway **316** of block **274** in the motor mount assembly. Each of channels **170** about the hollow boss may include an o-ring to achieve sealed engagement with passageway **316**. As particularly shown in FIG. **19**B, the tube holder defines outlets **164** of arcuate passageways **284**, **286** and **288** disposed about conduit **32** extending from threaded engagement with a spider-like support **350**. As described earlier, tube holder includes threads **174** for threaded engagement with the end of conduit **32** and threads **178** for threaded engagement with pipe **30**.

We claim:

1. In a fuel delivery assembly having a storage tank for the fuel, a superstructure mounted upon the storage tank, a leak detector for receiving fuel to be dispensed from a chamber in the superstructure, the improvement comprising:

a) an in-line motor and pump assembly for pumping fuel from the storage tank to the chamber, said in-line motor and pump assembly including a brushless direct current motor;

b) a pipe and an internal conduit defining a first annular passageway for conveying the fuel from said in-line motor and pump assembly to the chamber;

c) said in-line motor and pump assembly including a common shaft and upper and lower journal bearings for supporting the rotor of said motor and an impeller of said pump;

d) an inlet section upstream of said impeller, said lower journal bearing and a thrust bearing for supporting a lower end of said shaft and at least one passageway for conveying fuel into said inlet section via said lower journal bearing and said thrust bearing to lubricate and cool said lower journal bearing and said thrust bearing;

e) a throat unit defining a throat adapted in configuration to said impeller for conveying the fuel in response to rotation of said impeller;

f) a motor mount assembly for mounting the stator of said motor;

g) a housing in combination with said motor mount assembly for defining a second annular passageway to receive fuel from said throat and convey the fuel adjacent said stator to draw heat from said stator to cool said motor and through said lower journal bearings for purposes of lubrication and cooling; and

h) a tube holder attached to said motor mount assembly for channeling flow of fuel from said second annular passageway to said first annular passageway.

2. A fuel delivery assembly as set forth in claim **1**, said motor mount assembly including three converging arcuate passageways for conveying fuel from said second annular passageway to said tube holder.

3. A fuel delivery assembly as set forth in claim **1**, including a plurality of vanes disposed in said second annular passageway for urging the flow of fuel therein into an axial flow.

4. A fuel delivery assembly as set forth in claim **1**, including an inlet section disposed at the lower end of said motor and pump assembly for introducing fuel, said inlet section including a plurality of inlets and a screen for filtering the fuel flowing into said inlets.

5. A fuel delivery assembly as set forth in claim **4**, wherein said screen is a sleeve encircling said inlet section.

6. A fuel delivery assembly as set forth in claim **1**, including an electrical control circuit and a plurality of electrical conductors disposed within said conduit and interconnecting said control circuit with said motor.

7. A fuel delivery assembly as set forth in claim 1, wherein said pipe and said conduit are threadedly detachably attachable to said motor and pump assembly and to the superstructure.

8. A method for drawing fluid from a tank with a submerged brushless direct current motor and pump assembly, said method comprising the steps of:

a) transmitting power to the motor through conductors interconnecting the motor and a control circuit;

b) drawing a fluid from the tank with an impeller of the pump rotationally mounted within a throat unit, a low pressure inlet section for introducing fluid to the impeller and further drawing fluid into the inlet section adjacent the lower journal bearing and a thrust bearing supporting the shaft to lubricate and cool the lower journal bearing and the thrust bearing;

c) directing the fluid to upper and lower journal bearings supporting a shaft common to the impeller and the rotor of the motor to lubricate and cool the upper and lower journal bearings;

d) further directing the fluid adjacent the stator of the motor to cool the motor;

e) channeling the fluid to an outlet subsequent to exercise of said steps of further directing; and

f) further conveying the fluid from the outlet into a pipe for discharge external of the tank, including a conduit disposed within the pipe for housing the electrical conductors and directing the flow of fluid from the outlet into the space intermediate the pipe and the conduit.

9. A method for drawing fluid from a tank as set forth in claim 8, wherein said steps of channeling includes the steps of directing the fluid from the annular passageway into passageways converging at the outlet.

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