(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 August 2002 (15.08.2002)

PCT

(10) International Publication Number
WO 02/063166 A1

(51) International Patent Classification[7]: F04B 17/00

(21) International Application Number: PCT/US02/02706

(22) International Filing Date: 30 January 2002 (30.01.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/777,391 5 February 2001 (05.02.2001) US

(71) Applicant: ENGINEERED MACHINED PRODUCTS, INC. [US/US]; 3111 N. 28th Street, P.O. Box 1246, Escanaba, MI 49829 (US).

(72) Inventors: BADER, Mark; 7324 Lake Bluff 0.75 Lane, Gladstone, MI 49837 (US). LASECKI, Michael, P.; 7786 N. Lake Bluff 0.5 Drive, Gladstone, MI 49837 (US). SHIVERSKI, Steven; N 19989 Shiverski Lane, Perronville, MI 49873 (US). DEGRAVE, Kenneth, A.; N14141 County Road 551, Wilson, MI 49896 (US). CARLSON, Jeremy, S.; 7454 S. Lake Bluff 0.5 Drive, Gladstone, MI 49837 (US).

(74) Agents: QUINN, Christopher, W. et al.; Brooks & Kushman, 1000 Town Center, 22nd floor, Southfield, MI 48075 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/063166 A1

(54) Title: ELECTRONIC FLUID PUMP WITH ENCAPSULATED STATOR ASSEMBLY

(57) Abstract: A fluid pump includes a pump housing(12 AND 14) having a housing cavity with an inlet and an outlet. An encapsulated stator assembly (22) is positioned within the housing cavity (15) and at least partially defines a fluid passage from the inlet to the outlet. A seal cartridge assembly (26) provides a frontal seal for the stator assembly, and supports the pump shaft (28b). A polymeric capsule member encloses and seals the encapsulated stator assembly (22), protecting the motor from, and providing heat transfer to, the working fluid. A stator (20) provides a magnetic field which drives a rotor assembly (28). The motor assembly rotates an impeller (16) for pumping fluid from the inlet to the outlet.

ELECTRONIC FLUID PUMP WITH ENCAPSULATED STATOR ASSEMBLY

TECHNICAL FIELD

The present invention relates to a fluid pump containing an encapsulated stator assembly that seals a pump motor and facilitates heat transfer from the motor and the electronics to the working fluid.

BACKGROUND ART

Use of fluid pumps in vehicle engine cooling systems and various industrial applications is well known. However, typical fluid pumps in both of these areas have inherent limitations.

Typically in engine cooling systems, a coolant pump has a pulley keyed to a shaft. The shaft is driven by the engine via a belt and pulley coupling, and rotates an impeller to pump the working fluid. Fluid seals sometimes fail due to the side load from the drive belt, which tends to allow fluid to leak past the seal into the bearing.

U.S. Patent No. 6,056,518, issued on May 2, 2000 to Allen et al., describes one attempt to overcome the shortcomings of prior art vehicle coolant pumps. The '518 patent provides a fluid pump with a switched reluctance motor that is secured to a housing and rotates an impeller for pumping the fluid. This design eliminates the side load problem associated with keyed pulleys, but it is generally not intended for use where larger industrial pumps are required.

Industrial pumps are typically driven by an electric motor connected to the pump via a coupling, the alignment of which is critical. Misalignment of the coupling can result in premature pump failure, which leads to the use of expensive constant velocity couplings to overcome this problem. Moreover, industrial pumps are typically air-cooled, relying on air from the surrounding environment. The cooling air is drawn through the motor leaving airborne dust and other contaminants deposited in the motor. These deposits can contaminate the bearings, causing them to fail, or the deposits can coat the windings, shielding them from the cooling air and causing the windings to overheat and short out.

Accordingly, it is desirable to provide an improved fluid pump which overcomes the above-referenced shortcomings of prior art fluid pumps, while also providing enhanced fluid flow rate and control capability while reducing costs.

DISCLOSURE OF INVENTION

The present invention provides a fluid pump with an encapsulated stator assembly that contains a rotor cavity. A rotor assembly, driven by a stator, is positioned within this cavity and turns an impeller for pumping the working fluid. The encapsulated stator assembly prevents the working fluid from directly contacting the motor. It does, however, have an outside wall that is in contact with the working fluid, thereby facilitating heat transfer from the motor to the fluid.

More specifically, the present invention provides a fluid pump including a housing having a housing cavity therein. An encapsulated stator assembly is positioned within the housing cavity and at least partially defines a boundary for the working fluid. The encapsulated stator assembly contains a rotor cavity in which a rotor assembly is located. The magnetic field generated by a stator drives the rotor assembly, which is connected to an impeller for pumping the fluid.

In a preferred embodiment, the encapsulated stator assembly is a single unit, and is located inside a two-piece housing. A stator comprising steel laminations, windings, and motor power leads, is encapsulated in a thermally conductive, electrically insulative polymeric capsule member. The polymeric capsule member defines a rotor cavity having an opening. The rotor assembly, consists of a rotor with a rotor shaft, the rotor shaft being supported by a front bearing and a rear bearing. Also, in the preferred embodiment, the rear bearing is located within the encapsulated stator assembly, and the front bearing and a seal are positioned within a front cover that plugs the rotor cavity opening.

A diffuser is used to help direct fluid flow and thereby increase the efficiency of the pump. The diffuser comprises an inner wall, an outer wall, and a plurality of diffuser vanes. The diffuser vanes are integrally molded to the outer wall of the encapsulated stator assembly. The polymeric capsule member orients the motor power leads with substantial circumferential symmetry around the diffuser. The motor power leads then interface with a circuit board assembly near the outlet of the pump. The working fluid flows around the outside of the encapsulated stator assembly, thereby encountering the diffuser vanes and allowing heat transfer from the motor to the fluid. The working fluid then encounters the encapsulated motor power leads, thereby cooling both the motor power leads and the circuit board assembly.

In an alternative embodiment, the one piece encapsulated stator assembly is replaced with a one piece stator housing assembly. This change allows for larger motors to be utilized with the pump, and thereby increases the number of applications in which the invention may be used. The stator housing assembly includes an encapsulated stator assembly and a substantially cylindrical metal case which provides an outlet for a single bundle of motor power leads and also contains diffuser vanes that fully define the boundary of the working fluid. The encapsulated stator assembly is enclosed and sealed by a thermally conductive, electrically insulative polymeric capsule member that defines a motor cavity and provides a heat transfer path to the working fluid. As in the preferred embodiment, a rotor with a rotor shaft is located in the motor cavity and is driven by the magnetic field generated by the stator. The motor housing assembly comprises a front cover, a stator housing assembly, and a rear cover.

This alternative embodiment also has a diffuser with diffuser walls and diffuser vanes; however, there are now two sets of diffuser vanes. The front cover is configured with a first set of diffuser vanes and the stator housing assembly is configured with a second set of diffuser vanes. The two covers and the stator housing assembly are joined together and sealed in a manner to prevent the working fluid from entering the motor cavity.

Accordingly, an object of the present invention is to provide a fluid pump with an encapsulated stator assembly, the encapsulated stator assembly orienting the motor components and providing heat transfer between the motor and the working fluid.

Another object of the invention is to provide a fluid pump with an encapsulated stator assembly, the encapsulated stator assembly forming a diffuser, including a plurality of diffuser vanes. The above object and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 shows a longitudinal cross-sectional view of a fluid pump in accordance with the present invention;

FIGURE 2 shows a longitudinal cross-sectional view of an encapsulated stator assembly for use with the pump shown in Figure 1;

FIGURE 3 shows a perspective view of the encapsulated stator assembly, with the motor cavity opening toward the front and the motor power leads toward the back;

FIGURE 4 shows a rear perspective view of an impeller for use with the pump shown in Figure 1;

FIGURE 5 shows a perspective view of a two piece pump housing with an inlet housing toward the front and an outlet housing toward the rear for use with the pump shown in Figure 1;

FIGURE 6 shows a perspective view of the outlet housing corresponding with the embodiment of FIGURE 1;

FIGURE 7 shows a perspective view of the outlet housing of FIGURE 6, with a circuit board assembly attached;

FIGURE 8 shows a side view of a fluid pump in accordance with an alternative embodiment of the invention;

FIGURE 9 shows a longitudinal cross-sectional view of the fluid pump shown in Figure 8;

FIGURE 10 shows a perspective view of the stator housing assembly of the fluid pump of Figure 8;

FIGURE 11 shows a longitudinal cross-sectional view of the stator housing assembly of Figure 10;

FIGURE 12 shows a longitudinal cross-sectional view of a second alternative embodiment of the fluid pump of Figure 1;

FIGURE 13 shows a longitudinal cross-sectional view of a seal cartridge assembly for use with the pump shown in Figure 12;

FIGURE 14 shows a perspective view of the seal cartridge assembly and one end of the rotor shaft with a drive pin for use with the pump shown in Figure 12.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 shows a longitudinal cross-sectional view of a fluid pump 10 in accordance with the present invention. A two-piece pump housing comprises an inlet pump housing 12 and an outlet pump housing 14. The pump housing has a housing cavity 15 therein which contains an encapsulated stator assembly 22.

Referring to Figure 2, the encapsulated stator assembly 22 defines a rotor cavity 17 with an opening 19. The encapsulated stator assembly 22 comprises a polymeric capsule member 21, that has a plurality of diffuser vanes 18 molded integrally thereon. Polymeric capsule member 21 encloses and seals a motor stator 20 and motor power leads 32. Motor stator 20 comprises a plurality of steel laminations 20a and a plurality of copper windings 20b.

Returning to Figure 1, located within rotor cavity 17 is a rotor assembly 28, consisting of a rotor 28a and a rotor shaft 28b. The rotor shaft 28b is supported by a front bearing 42 and a rear bearing 40. Rear bearing 40 is located within the encapsulated stator assembly 22. Front bearing 42 and seal 44 are located within the front cover 26 that plugs the rotor cavity opening 19.

Figure 3 shows a front perspective view of encapsulated motor assembly 22. In particular, it shows diffuser vanes 18 which are of split construction (but need not be of split construction for this invention), and the motor power leads 32 which are oriented with substantial circumferential symmetry around the longitudinal axis of the encapsulated stator assembly 22. As seen in Figure 1, motor power leads 32 interface with a circuit board assembly 34.

Returning to Figure 1 impeller 16 is slip fit onto the rotor shaft 28b and secured with a buttonhead capscrew 50. A drive pin 30 transversely located through rotor shaft 28b drives impeller 16 via slot 23.

Figure 4 shows impeller 16 with slot 23 configured to receive drive pin 30. Figure 5 shows the inlet pump housing 12 attached to the outlet pump housing 14. Outlet pump housing 14 is again shown in Figure 6, this time with motor power leads 32. Figure 7 shows the outside of pump 10 including the inlet pump housing 12, the outlet pump housing 14, the circuit board assembly 34, and the connection points between circuit board assembly 34 and the motor power leads 32.

Referring to Figure 8, a fluid pump 60 is shown in accordance with one alternative embodiment of the invention. Although similar in function to the preferred embodiment, there are a number of notable differences with regard to form. Rather than a two-piece housing, this embodiment employs a three-piece housing comprising an inlet housing 62, a stator housing assembly 64, and an outlet housing 66, assembled with bolts 68.

The stator housing assembly 64, shown in Figure 10 and sectioned in Figure 11, includes an encapsulated stator assembly 75 and a substantially cylindrical metal case 73 which provides an outlet for a single bundle of motor power leads 92 and diffuser vanes 83 that fully define the boundary of the working fluid. The encapsulated stator assembly 75 includes a plurality of steel laminations 90a, a plurality of windings 90b, and a plurality of motor power leads 92. A polymeric capsule member 77 encloses and seals the stator assembly 90, and also defines a rotor cavity 79.

As shown in Figure 9, a rotor assembly 82, consisting of a rotor 82a and a rotor shaft 82b, is located within rotor cavity 79. Rotor shaft 82b is supported by a rear bearing 96 positioned within the rear cover 74 which plugs the rear opening of the rotor cavity 79, and a front bearing 86 and seals 100 positioned within a front cover 70 which plugs the forward opening of the rotor cavity 79. Drive pin 84 is positioned transversely through rotor shaft 82b and drives impeller 76.

Referring to Figure 9, unlike the preferred embodiment, this alternative embodiment has two separate sets of diffuser vanes, the first set 81 being configured on the front cover 70 and the second set 83 being configured on the stator housing assembly 64.

Figures 10 and 11 clearly show the resultant fluid passage 88 formed between the vanes 83 and the inner and outer walls 73a,73b of the metal case 73.

The encapsulated stator assembly 75 may be manufactured by locating the stator assembly 90 within the substantially cylindrical metal case 73 and temporarily capping the two open ends of the metal case. The stator assembly 90 would then be encapsulated in a polymeric thermally conductive, electrically insulative material 77. The opposing ends of the metal case would be uncapped, and the front and rear covers 70,74 would be attached to the metal case to complete the encapsulated stator assembly 75.

Figure 12 shows a second alternative embodiment of the fluid pump of Figure 1. Seal cartridge assembly 26 plugs opening 19 in rotor cavity 17. Wear sleeve 24 is slip fit over the end of rotor shaft 52b. An impeller 16 is slip fit onto wear sleeve 24 and is secured to rotor shaft 52b with a buttonhead capscrew 50. A drive pin 30 transversely located through rotor shaft 52b and wear sleeve 24 serves multiple functions. The drive pin 30 drives impeller 16 via slot 23 (similarly as shown in Figure 4); it prevents wear sleeve 24 from rotating relative to rotor shaft 52b; it captures axial loads from rotor assembly 52.

Some of the features and components of the seal cartridge assembly 26 are shown in Figures 12 and 13. Body 27 has a wet side 31 in contact with the working fluid, and a dry side 29. The body 27 also contains a plurality of holes 47 for attaching the seal cartridge assembly 26 to the encapsulated stator assembly 57, using bolts 48. A seal 53 is press fit into the body 27 and plugs an opening on the wet side 31.

Referring to Figure 14, the wear sleeve 24 is machined to form an inner diameter and has an axis coaxial to an axis of the body 27. A hole 25 is machined transverse to the wear sleeve axis and is configured to receive drive pin 30. The rotor shaft 52b has a transverse hole 56 that also receives drive pin 30.

Returning to Figure 13, the front bearing 51, being press fit onto the substantially cylindrical wear sleeve 24, plugs an opening on the dry side 29. The bearing 51 and wear sleeve 24 are press-fit into the cartridge body, and the wear sleeve 24 is slip fit over the shaft 52b. The seal cartridge assembly 26 also contains leak detection ports 33, shown in Figure 14, for visual or electronic indication of seal 53 failure.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A fluid pump, comprising:

a housing having a housing cavity therein with an inlet and an outlet;

an encapsulated stator assembly positioned in the housing cavity to cooperate with the housing and to at least partially define a fluid passage from the inlet to the outlet;

wherein the encapsulated stator assembly is enclosed and sealed by a polymeric capsule member and the polymeric capsule member defines a rotor cavity having an opening;

an impeller rotatably positioned at the inlet and having an impeller axis; and

a rotor assembly rotatably located inside the rotor cavity and connected to the impeller for rotating the impeller for pumping fluid through the passage from the inlet to the outlet.

2. The fluid pump of claim 1, wherein the rotor assembly is sealingly protected from the fluid by a seal cartridge assembly, the seal cartridge assembly being positioned within the opening.

3. The fluid pump of claim 1, wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

4. The fluid pump of claim 1, wherein the encapsulated stator assembly comprises a plurality of steel laminations, a plurality of copper windings, and a plurality of motor power leads.

5. The fluid pump of claim 4, wherein the polymeric capsule member orients the motor power leads with substantial circumferential symmetry around the impeller axis.

6. The fluid pump of claim 4, further comprising a circuit board assembly located near the outlet and interfacing with the motor power leads.

7. The fluid pump of claim 1, further comprising a diffuser, wherein the diffuser comprises an inner wall formed by an outer wall of the encapsulated stator assembly, an outer wall formed by an inner wall of the housing, and a plurality of diffuser vanes.

8. The fluid pump of claim 7, wherein the outer wall of the encapsulated stator assembly is configured with the diffuser vanes.

9. The fluid pump of claim 1, wherein the rotor assembly consists of a rotor with a rotor shaft.

10. The fluid pump of claim 9, wherein the rotor shaft is supported by a front bearing and a rear bearing.

11. A fluid pump, comprising:

a housing having a housing cavity therein with an inlet and an outlet;

an encapsulated stator assembly enclosed and sealed by a polymeric capsule member, wherein the polymeric capsule member defines a rotor cavity having an opening;

an impeller rotatably positioned at the inlet and having an impeller axis;

a rotor assembly rotatably located inside the rotor cavity and connected to the impeller for rotating the impeller for pumping fluid through the passage from the inlet to the outlet; and

a seal cartridge assembly positioned within the opening for sealing the rotor assembly within the rotor cavity.

12. The fluid pump of claim 11, wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

13. The fluid pump of claim 11, wherein the encapsulated stator assembly comprises a plurality of steel laminations, a plurality of copper windings, and a plurality of motor power leads.

14. The fluid pump of claim 13, wherein the polymeric capsule orients the motor member orients the motor power leads with substantial circumferential symmetry around the impeller axis.

15. The fluid pump of claim 13, further comprising a circuit board assembly located near the outlet and interfacing with the motor power leads.

16. The fluid pump of claim 11, further comprising a diffuser, wherein the diffuser comprises an inner wall formed by an outer wall of the encapsulated stator assembly, an outer wall formed by an inner wall of the housing, and a plurality of diffuser vanes.

17. The fluid pump of claim 16, wherein the outer wall of the encapsulated stator assembly is configured with the diffuser vanes.

18. The fluid pump of claim 11, wherein the rotor assembly consists of a rotor with a rotor shaft.

19. The fluid pump of claim 18, wherein the rotor shaft is supported by a front bearing and a rear bearing.

20. A fluid pump, comprising:

a housing having a housing cavity therein with an inlet and an outlet;

an encapsulated stator assembly positioned in the cavity, wherein an outer wall of the encapsulated stator assembly forms an inner boundary of the fluid flow path and an inner wall of the housing forms an outer boundary of the fluid flow path;

wherein the encapsulated stator assembly is enclosed and sealed by a polymeric capsule member and the polymeric capsule member defines a rotor cavity having an opening;

wherein a plurality of motor power leads are encased in the encapsulated stator assembly; and

wherein the motor power leads are at least partially within the fluid flow path for cooling the motor power leads.

21. The fluid pump of claim 20, wherein the rotor assembly is sealingly protected from the fluid by a seal cartridge assembly, the seal cartridge assembly being positioned within the opening.

22. The fluid pump of claim 20, wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

23. The fluid pump of claim 20, wherein the polymeric capsule member orients the motor power leads with substantial circumferential symmetry around the impeller axis.

24. The fluid pump of claim 20, further comprising a circuit board assembly located near the outlet and interfacing with the motor power leads.

25. The fluid pump of claim 20, further comprising a diffuser, wherein the diffuser comprises an inner wall formed by the outer wall of the encapsulated stator assembly, an outer wall formed by the inner wall of the housing, and a plurality of diffuser vanes.

26. The fluid pump of claim 25, wherein the outer wall of the encapsulated stator assembly is configured with the diffuser vanes.

27. The fluid pump of claim 20, wherein the rotor assembly consists of a rotor with a rotor shaft.

28. The fluid pump of claim 27, wherein the rotor shaft is supported by a front bearing and a rear bearing.

29. A fluid pump, comprising:

a housing having a housing cavity therein with an inlet and an outlet;

an encapsulated stator assembly enclosed and sealed by a polymeric capsule member, wherein the polymeric capsule member defines a rotor cavity having an opening; and

wherein an outer wall of the polymeric capsule member has a plurality of diffuser vanes molded integrally thereon.

30. The fluid pump of claim 29, wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

31. The fluid pump of claim 29, wherein the encapsulated stator assembly comprises a plurality of steel laminations, a plurality of copper windings, and a plurality of motor power leads.

32. The fluid pump of claim 31, wherein the polymeric capsule member orients the motor power leads with substantial circumferential symmetry around the impeller axis.

33. The fluid pump of claim 31, further comprising a circuit board assembly located near the outlet and interfacing with the motor power leads.

34. A method of manufacturing a fluid pump, comprising:

manufacturing a housing;

encapsulating a stator assembly within a polymeric capsule member;

wherein the encapsulating step includes integrally molding a plurality of diffuser vanes with the polymeric capsule member; and

positioning the encapsulated stator assembly within the housing.

35. A fluid pump, comprising:

a housing having a housing cavity therein with an inlet and an outlet;

an encapsulated stator assembly enclosed and sealed by a polymeric capsule member;

wherein the encapsulated stator assembly contains a plurality of motor power leads encased in the polymeric capsule member, the power leads having exposed ends; and

a circuit board assembly positioned near the outlet and interfacing with the ends of the motor power leads.

36. The fluid pump of claim 35, wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

37. The fluid pump of claim 35, wherein the polymeric capsule member orients the motor power leads with substantial circumferential symmetry around the impeller axis.

38. The fluid pump of claim 35 further comprising a diffuser, wherein the diffuser comprises an inner wall formed by the outer wall of the encapsulated stator assembly, an outer wall formed by the inner wall of the housing, and a plurality of diffuser vanes.

39. The fluid pump of claim 38 wherein the outer wall of the encapsulated stator assembly is configured with the diffuser vanes.

40. A fluid pump, comprising:

a housing having a housing cavity therein with an inlet and an outlet;

an encapsulated stator assembly enclosed and sealed by a polymeric capsule member, wherein the polymeric capsule member defines a rotor cavity having an opening; and

wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

41. The fluid pump of claim 40, wherein the encapsulated stator assembly comprises a plurality of steel laminations, a plurality of copper windings, and a plurality of motor power leads.

42. The fluid pump of claim 41, wherein the polymeric capsule member orients the motor power leads with substantial circumferential symmetry around the impeller axis.

43. The fluid pump of claim 41, further comprising a circuit board assembly located near the outlet and interfacing with the motor power leads.

44. The fluid pump of claim 40, further comprising a diffuser, wherein the diffuser comprises an inner wall formed by an outer wall of the encapsulated stator assembly, an outer wall formed by an inner wall of the housing, and a plurality of diffuser vanes.

45. The fluid pump in claim 44, wherein the outer wall of the encapsulated stator assembly is configured with the diffuser vanes.

46. A fluid pump, comprising:

a motor housing assembly having an inlet housing, a stator housing assembly, and an outlet housing;

wherein the stator housing assembly includes a substantially cylindrical metal case and an encapsulated stator assembly enclosed and sealed by a polymeric capsule member, and the polymeric capsule member defines a rotor cavity;

an impeller rotatably positioned in the inlet housing and having an impeller axis; and

a rotor assembly rotatably located inside the rotor cavity and connected to the impeller for rotating the impeller for pumping fluid from the inlet housing to the outlet housing.

47. The fluid pump of claim 46, wherein the inlet housing and outlet housing are bolted together to secure the stator housing assembly therebetween.

48. The fluid pump of claim 46, wherein the substantially cylindrical metal case includes fluid flow passages formed therein by diffuser vanes and inner and outer walls of the metal case, thereby completely defining the fluid flow passages.

49. The fluid pump of claim 46, wherein the polymeric capsule member comprises a thermally conductive, electrically insulative material.

50. The fluid pump of claim 46, further comprising inlet diffuser vanes formed on the front cover.

51. The fluid pump of claim 46 wherein the stator housing assembly further comprises a front cover and a rear cover plugging opposing ends of the rotor cavity.

52. The fluid pump of claim 46, wherein the rotor assembly consists of a rotor with a rotor shaft.

53. The fluid pump of claim 52, wherein the rotor shaft is supported by a front bearing and a rear bearing.

54. The fluid pump of claim 53, wherein the rear cover contains a bearing seat for locating the rear bearing.

55. A method of manufacturing an encapsulated stator assembly, comprising:

providing a front cover and a rear cover;

providing a hollow, substantially cylindrical center metal case with a longitudinal axis and two open ends;

locating a stator assembly within the center metal case;

temporarily capping the two open ends and encapsulating the stator assembly in a polymeric thermally conductive, electrically insulative material; and

uncapping the two ends and attaching the front cover and a rear cover to the center metal case.

56. A seal cartridge assembly for wear protecting and sealingly protecting a pump shaft, comprising:

a body having a wet side and a dry side and a passage therethrough and having a body axis;

wherein the body has a wet-side opening and a dry-side opening;

a seal positioned within the body on the wet side, wherein the seal plugs the wet-side opening;

a bearing positioned within the body on the dry side; and

a substantially cylindrical wear sleeve configured to receive the shaft, positioned inside the bearing and the seal, and having a wear sleeve axis approximately coaxial with the body axis.

57. A method of manufacturing a seal cartridge assembly for mounting onto a pump shaft, comprising:

providing a cartridge body;

pressing a seal into the cartridge body;

machining a wear sleeve with an inner diameter along an axis;

machining a hole in the wear sleeve transverse to the axis;

pressing a bearing onto the wear sleeve;

pressing the bearing and wear sleeve assembly into the cartridge body;

slip fitting the wear sleeve over the pump shaft; and

securing the wear sleeve to the pump shaft with a drive pin.

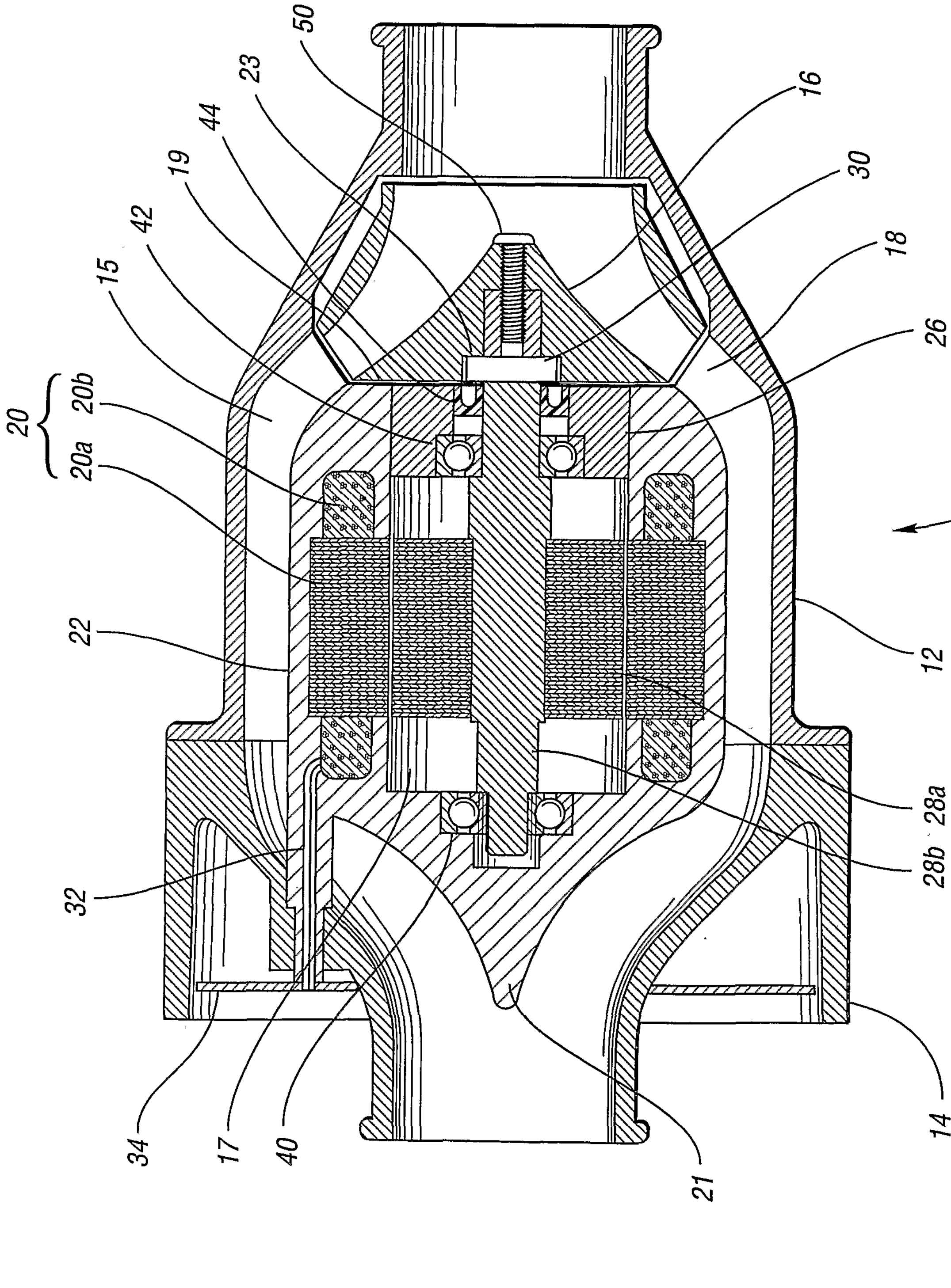
50
23
44
19
42
15
20
20b
20a
22
32
34
17
40
21
14
28b
28a
28
12
10
26
18
30
16

Fig. 1

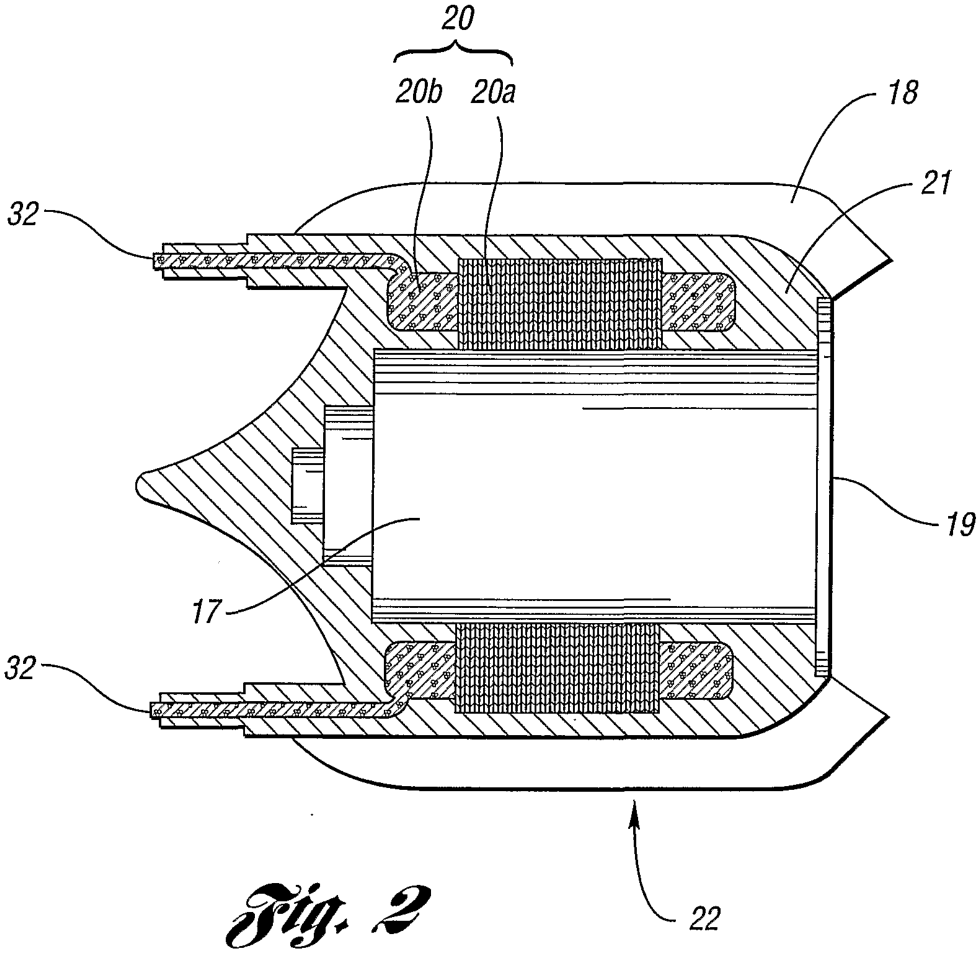

Fig. 2

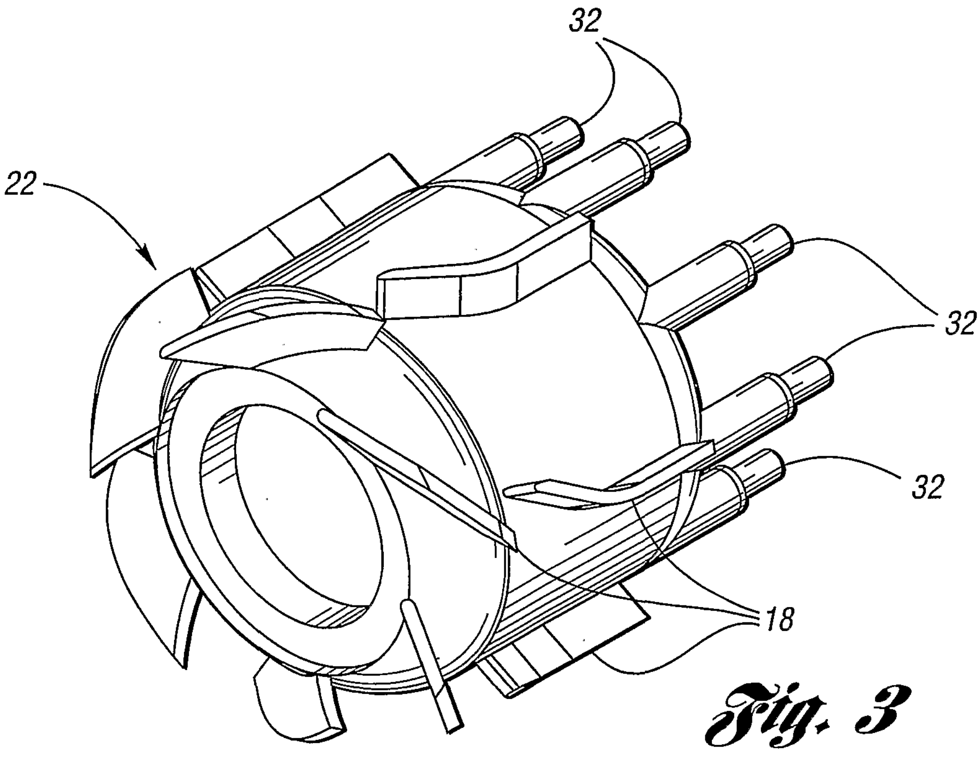

Fig. 3

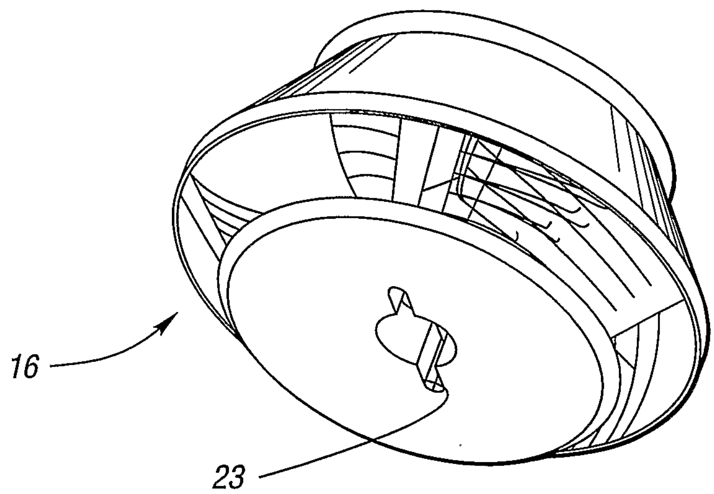

Fig. 4

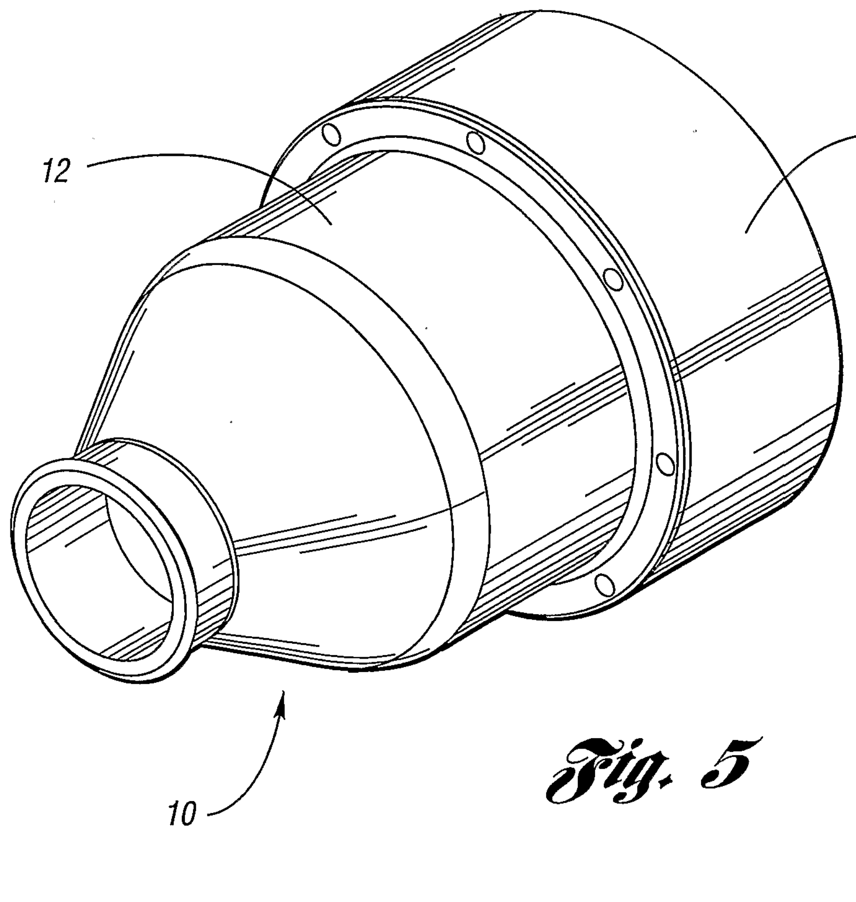

Fig. 5

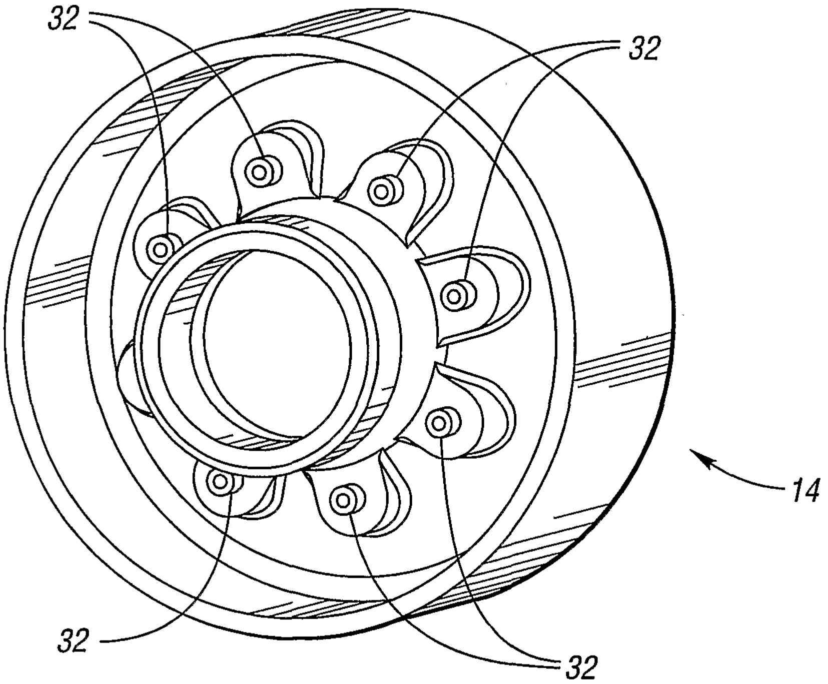

Fig. 6

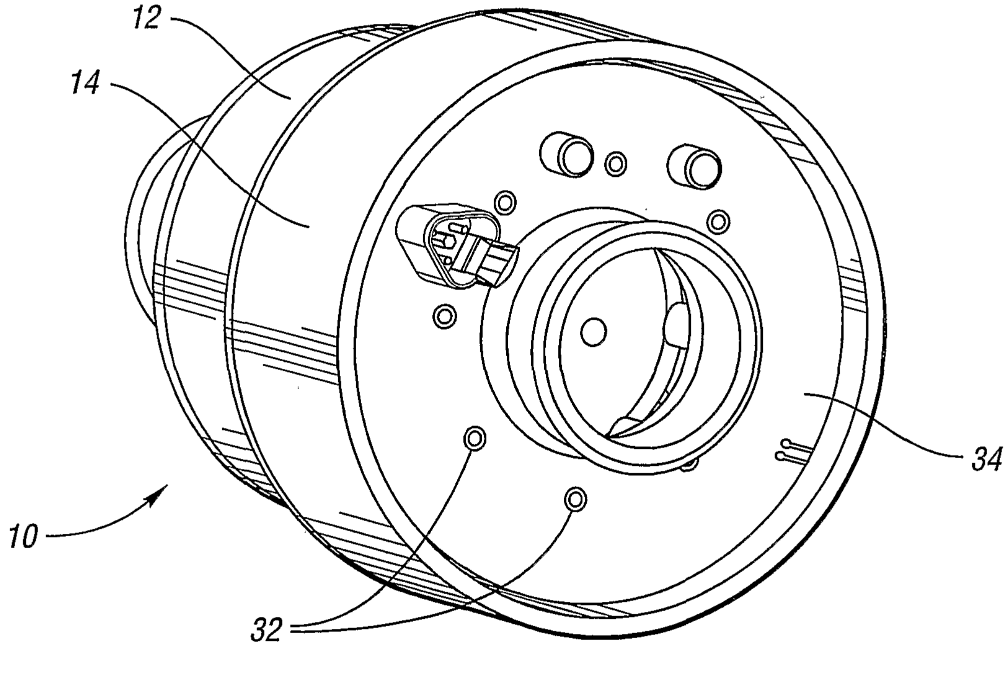

Fig. 7

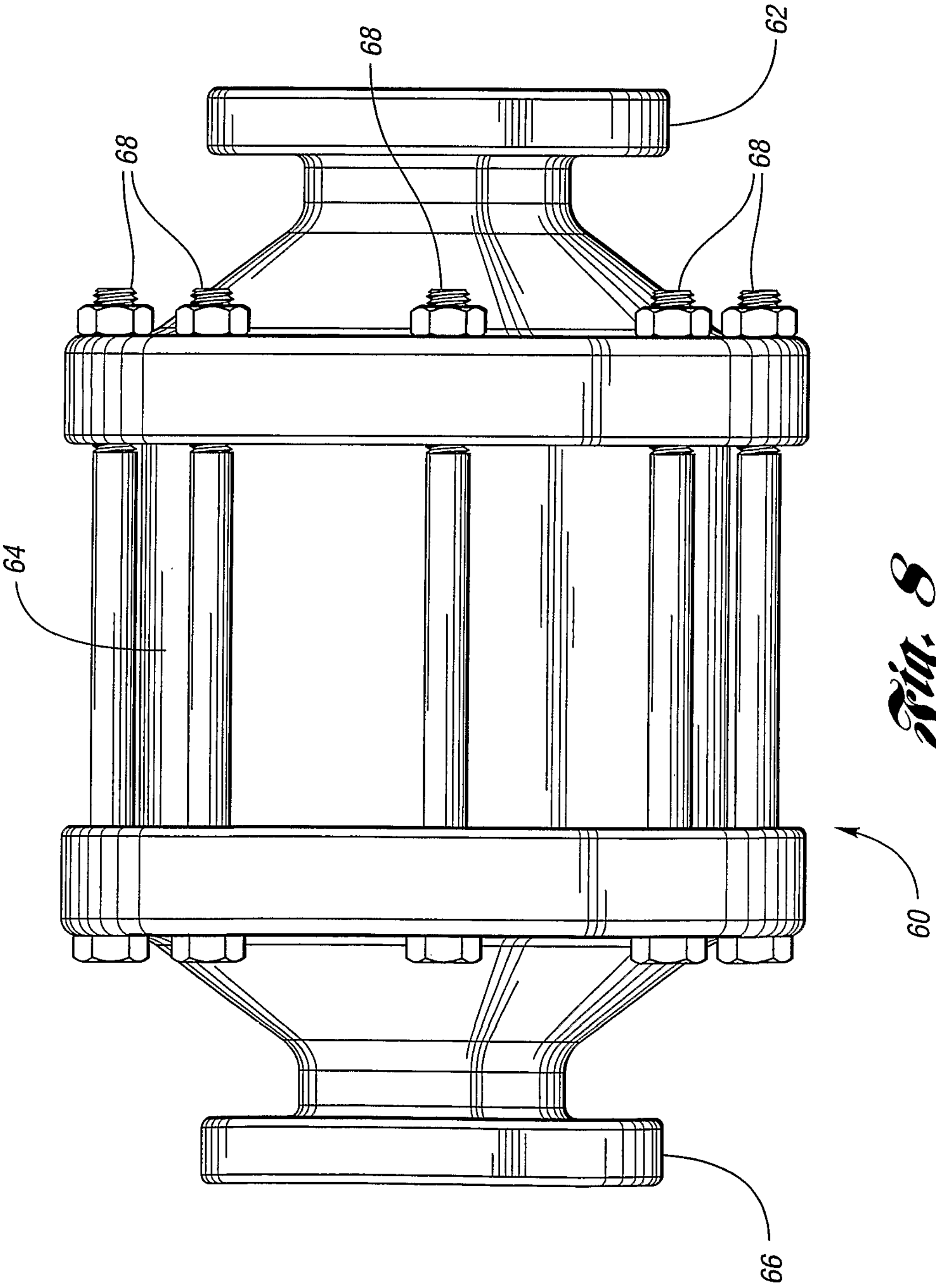

Fig. 8

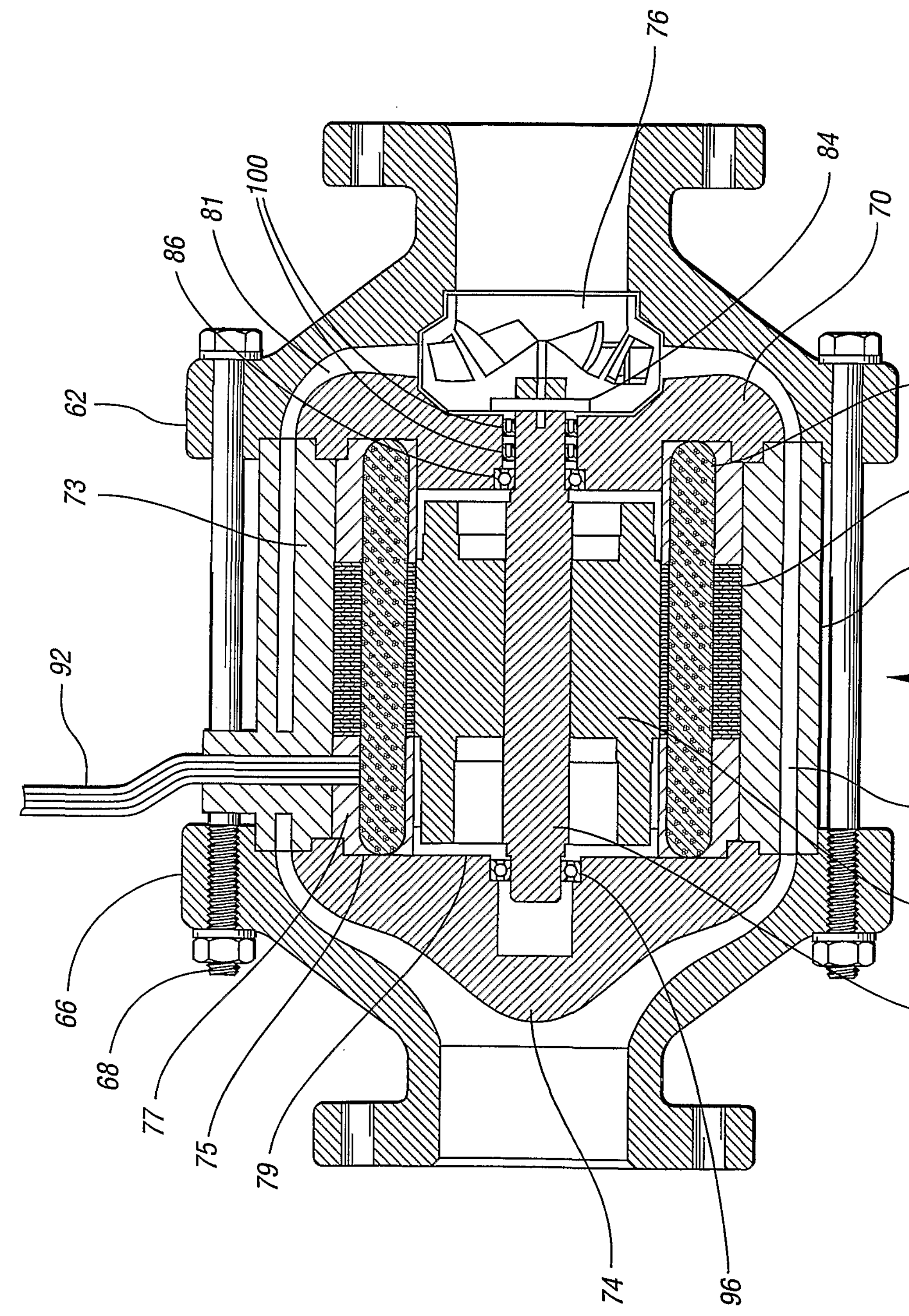
76
100
81
86
84
70
62
90b
90
90a
73
64
92
60
83
82a
82
82b
66
68
77
75
79
74
96

Fig. 9

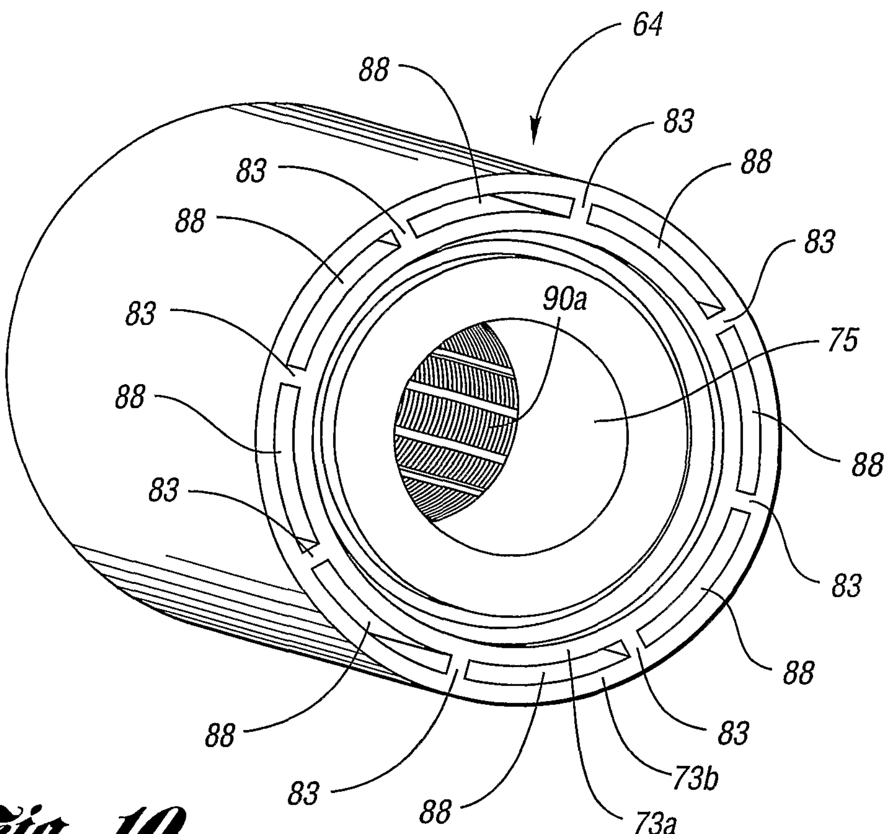
64
88
83
83
88
88
83
83
90a
75
88
88
83
83
88
88
83
83
88
73b
73a

Fig. 10

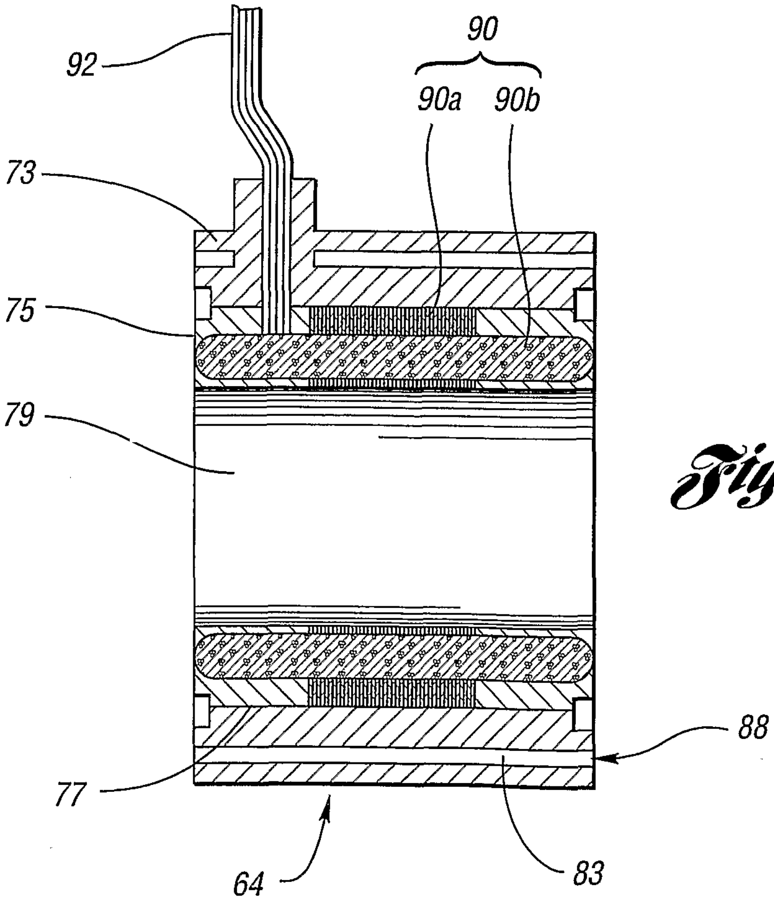
92
90
90a
90b
73
75
79
88
77
64
83

Fig. 11

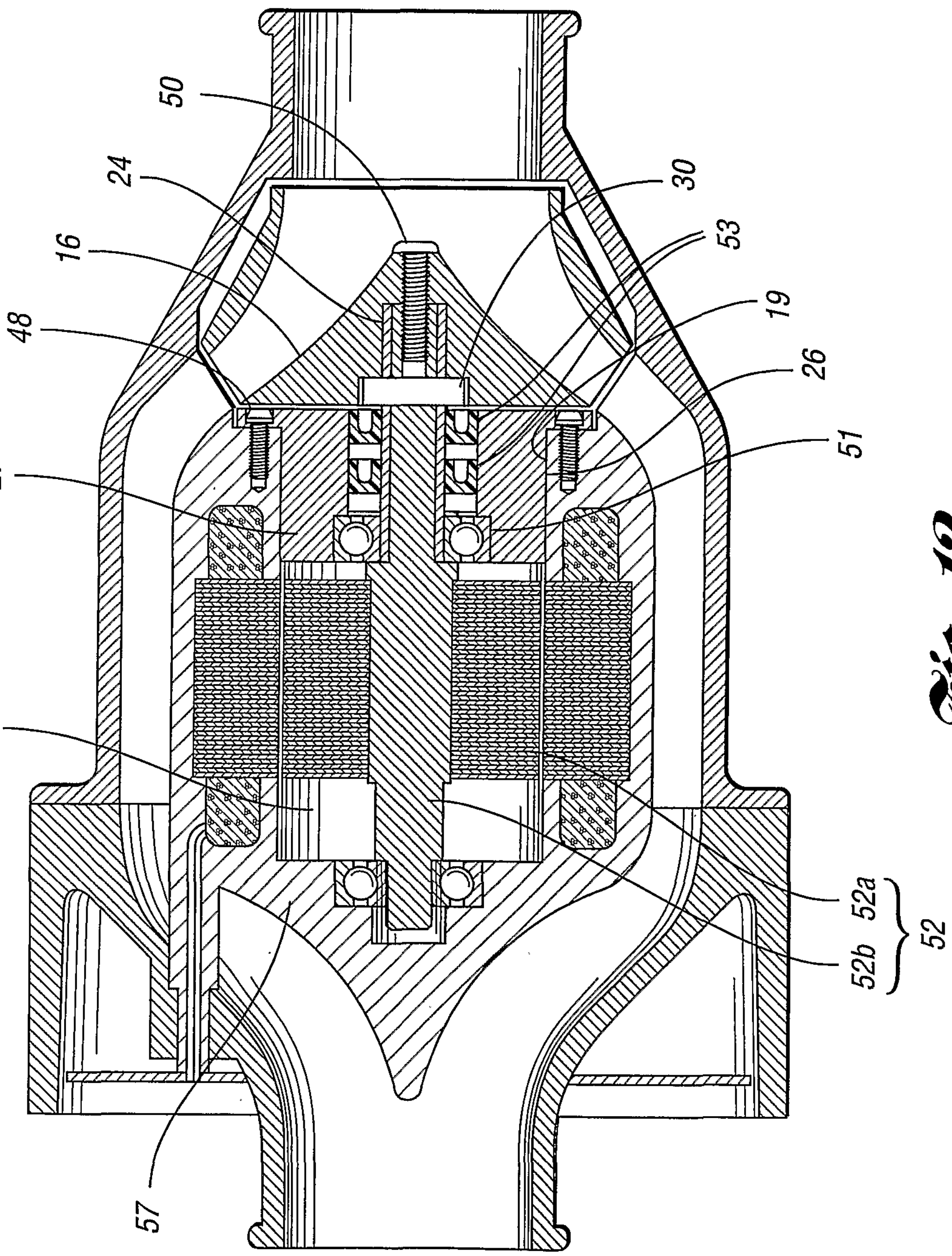

Fig. 12

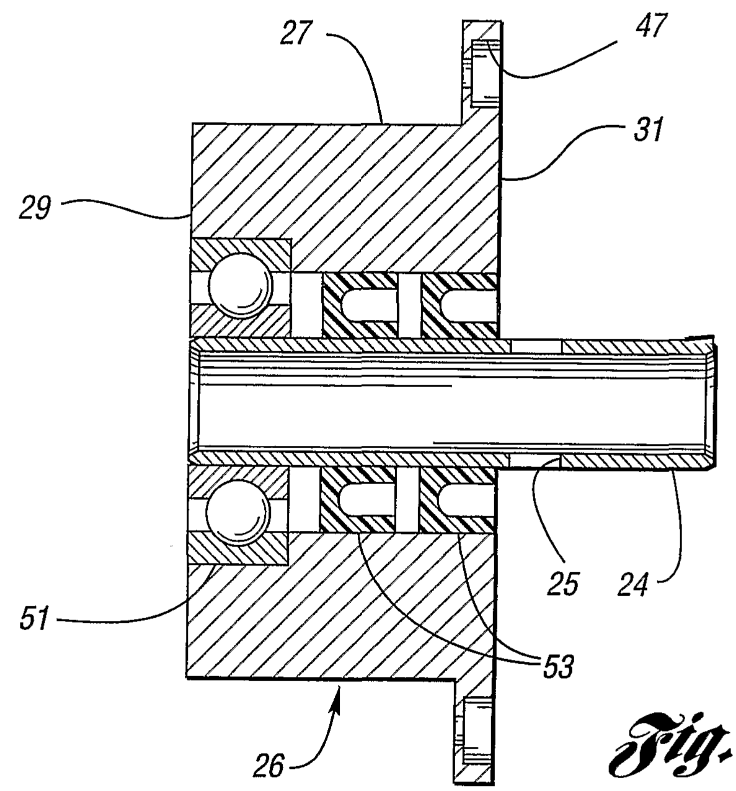

Fig. 13

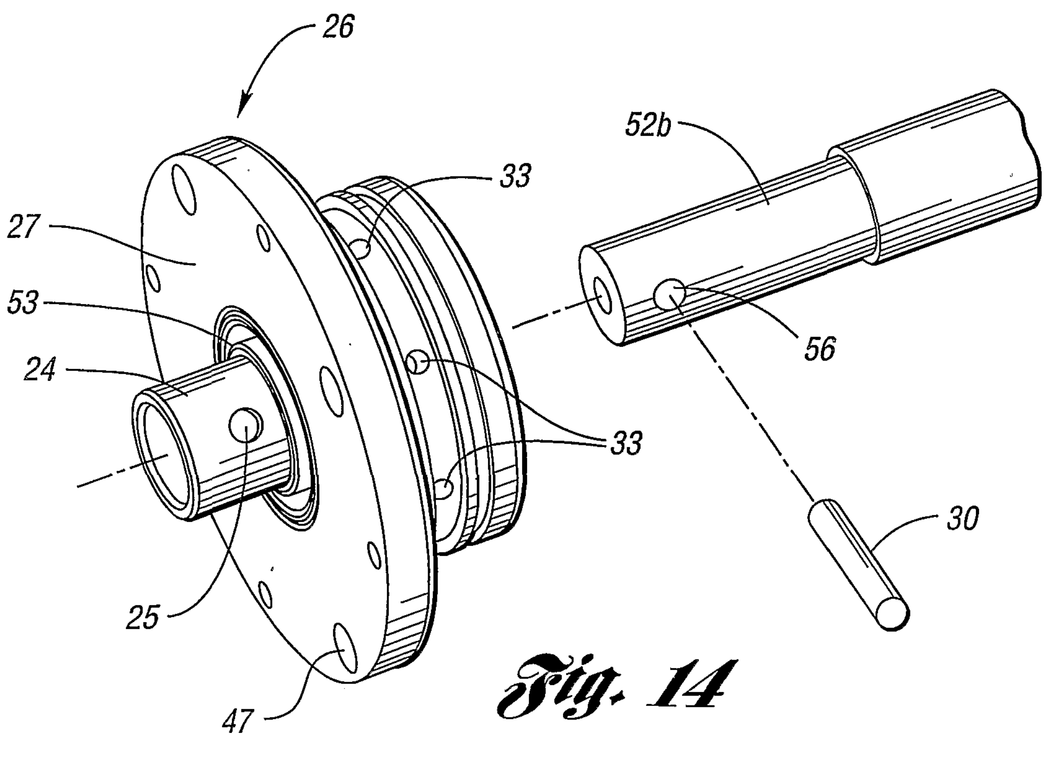

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/02706

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : F 04 B 17/00

US CL : 417/366, 423.1, 423.7, 423.14; 415/211.2, 208.2, 226, 206

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 417/366, 423.1, 423.7, 423.14; 415/211.2, 208.2, 226, 206; 277/500; 29/888.3, 888.02

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,129,525 A (WOOLLENWEBER et. al.) 10 January 2000 (10.10.2000), Column 4, lines 24-67, Column 5, lines 1-36, Prior Art Figure 1, Figure 3.	1-5, 7-12, 16, 18, 19-23, 25-29, 30, 34, 40, 44, 46-49, 51-54
Y,P	US 6,288,470 B1 (BREIT) 11 September 2001 (11.09.2001), Column 3 lines 35-47, Column 6 lines 62-67, Column 7 lines 1-22.	1-5, 7-12, 16, 18, 19, 29, 30, 34, 40, 44, 46-49, 51-55
Y	US 5,096,390 A (SEVRAIN et. al.) 17 March 1992 (17.03.1992), Column 3 lines 44-49, Figure 3.	4, 5, 13, 14, 20-23, 25-28, 31, 32, 41, 42
Y	US 5,511,942 A (MEIER) 30 April 1996 (30.04.1996), Figure 1.	8, 17, 21-23, 25-28, 45
Y	US 3,559,539 A (NAGY) 02 February 1971 (02.02.1971), Figure 1.	56, 57
Y	US 5,639,227 A (MILLS) 17 June 1977 (17.06.1977), Figure 1.	56, 57
Y	US 3,863,935 A (BATCH) 04 Feb 1975 (04.02.1975), Column 2, Line 46, Figure 1.	57

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 April 2002 (01.04.2002)	20 MAY 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Y. Hurley for Timothy Thorpe Telephone No. (703)308-0861

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/02706

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,344,515 A (CHENOCK JR.) 06 September 1994 (06.11.1994), see whole reference, pertains to method of making pump housing.	34
A	US 6,131,267 A (VAN DEN BERG) 17 October 2000 (17.10.2000), see whole reference, pertains to encapsulation method.	55
A	US 3,932,930 A (DOTCHTERMAN) 20 January 1976 (20.01.1976), see whole reference, pertains to metal manufacturing methods.	57
Y	US 5,401,146 A (MORIYA et. al.) 28 March 1995 (28.03.1995), Figure 17, Column 12 lines 40-44.	50