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Martin

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[54] **IN-LINE PUMP**

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[51] **Int. Cl.** .. **F04d 29/40,** F04d 29/42, F04d 29/62

[58] **Field of Search** 417/424, 360; 415/501, 415/201, 203, 219

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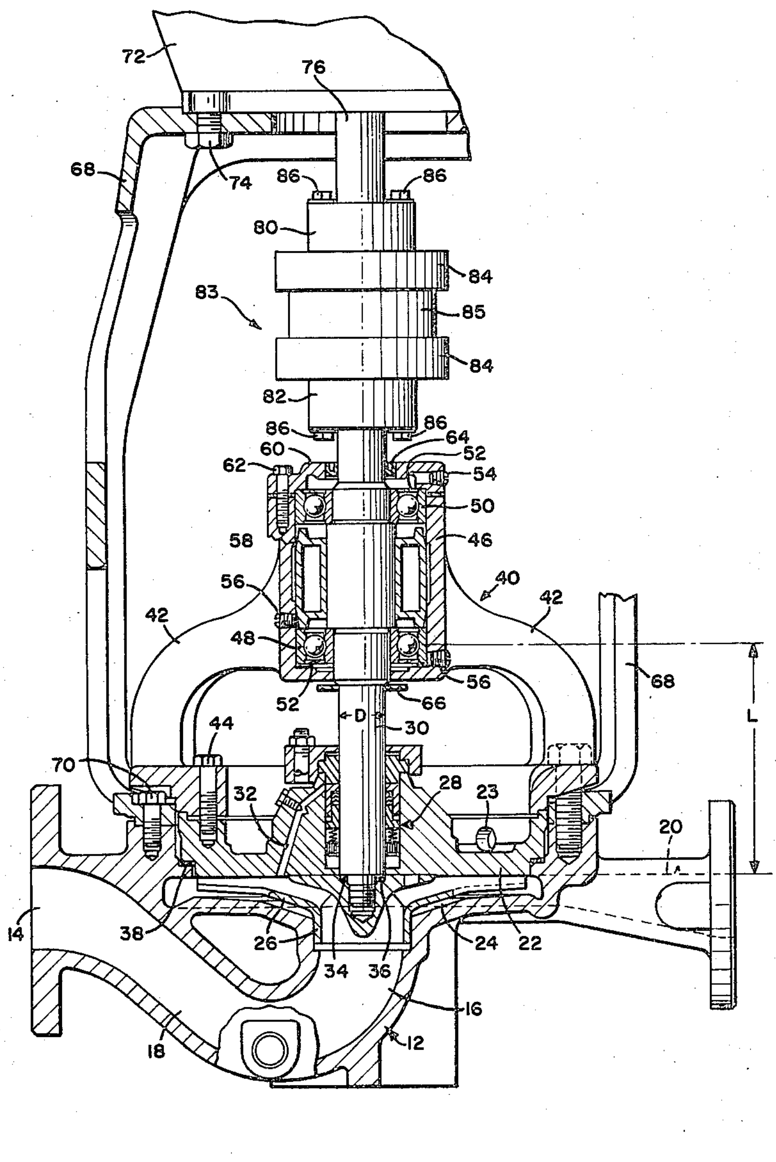
[57] **ABSTRACT**

An in-line pump having a parallel inlet and outlet and an impeller shaft bearing housing carried by the pump housing above the impeller. A motor adapter is also mounted on the pump housing and carries a motor above the bearing housing. The motor shaft extends downwardly in alignment with the impeller shaft and the two shafts are interconnected by a flexible coupling.

1 Claim, 3 Drawing Figures



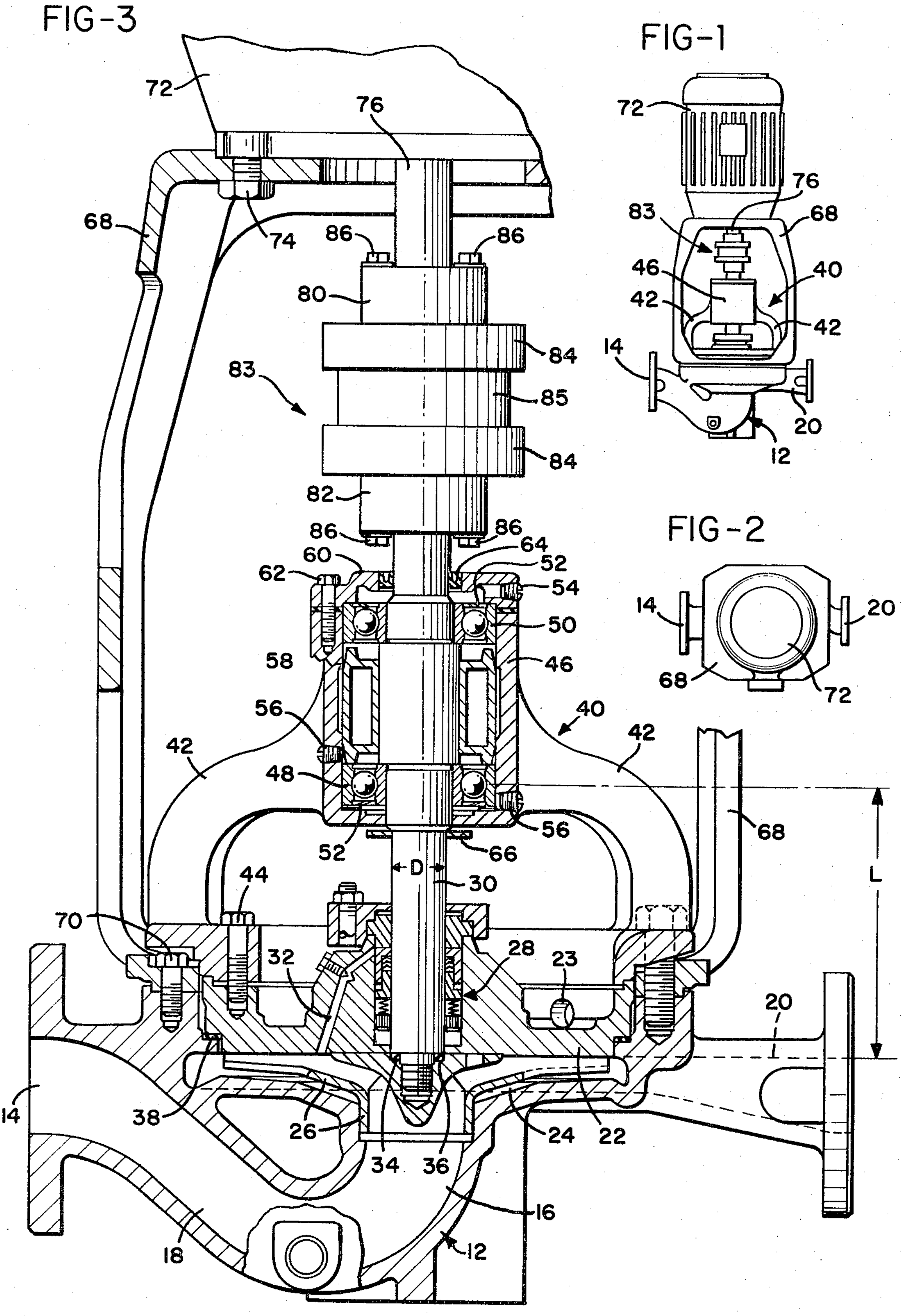


FIG-3
FIG-1
FIG-2
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IN-LINE PUMP

BACKGROUND OF THE INVENTION

The introduction of in-line pumps in place of standard horizontal pumps, particularly for process use in the chemical industry, is a fairly recent development. Although certain disadvantages have been recognized with respect to in-line pumps, it is felt that the advantages of using such pumps will, in most installations, outweigh the disadvantages.

One of the chief advantages of using in-line pumps is the saving in floor space which results from the vertical orientation of in-line pumps. Additionally, because the motor and pump are assembled in the factory the necessity of field alignment of couplings is eliminated. Additionally, modular type construction is becoming increasingly popular and inline pumps are better adapted to this type of construction than are the standard horizontal pump.

However, with the two most common types of in-line pumps there are certain well recognized problems which have tended to reduce the acceptance of these pumps in the industry. Most of these problems have their origin in the imposition of the pump loads on the motor bearings and the inability of motor manufacturers to design and build an economical motor which will operate under load within generally accepted specifications for shaft deflection, end play and bearing life.

The two design elements which most critically affect shaft deflection are the distance from the radial bearing to the center line of the impeller, or shaft overhang, and the diameter of the shaft. Shaft deflection is directly proportional to the cube of the shaft overhang and inversely proportional to the diameter of the shaft raised to the fourth power. It will be seen, therefore, that a seemingly small reduction in shaft diameter and/or a small increase in shaft overhang can result in a marked increase in shaft deflection.

One method of combining both of these critical factors into a single figure is the Index of Deflection, which is arrived at by dividing the cube of the shaft overhang by the fourth power of the shaft diameter. This is expressed $I = L^3/D^4$.

In an attempt to minimize shaft deflection in one conventional design the motor shaft has been extended and the impeller for the pump mounted directly on the motor shaft to reduce shaft overhang. This type of construction, generally referred to as Extended Motor Shaft Design, will typically have a shaft overhang of 8.5 to 10.75 inches and a shaft diameter of 1.375 inches, resulting in an Index of Deflection of approximately 172–348.

With this type of construction, it will be apparent that reliance is made on the capacity of the motor bearings to carry all of the pump thrust loads as well as the motor loads. Unfortunately this often results in motor bearing failure.

Additionally, the seals about the impeller shaft must be replaced fairly frequently with most types of in-line pumps. Where the impeller is mounted directly on the motor shaft, it will be seen that the motor must be removed before access can be had to the seals about the shaft. Thus, although seals must be replaced fairly frequently, access to the seals is difficult.

In the environments in which in-line pumps are commonly used the liquids being pumped are often at relatively high temperature and corrosive fumes are often

generated which tend to escape from the pump stuffing box. Where the impeller is mounted directly on the motor shaft it will be apparent that the motor is fairly close to the pump and is likely to be affected by the heat associated with the high temperature liquids passing through the pump as well as the corrosive fumes from the pump stuffing box which can be drawn through the motor by its fan.

In a second type of commercially available in-line pump, commonly referred to as a Rigid Coupling Design, the motor is spaced from the pump and the pump impeller is provided with a separate impeller shaft. The ends of the motor shaft and the impeller shaft are joined by a very precisely machined coupling to provide a rigid connection between the two shafts. This permits easier access to the pump seals. However, the pump loads are again carried by the motor bearings and again, the result is often motor bearing failure.

A second disadvantage appears when either the rigid coupling or one of the shafts becomes damaged or worn. Under this condition, it will be almost impossible to recouple the shafts and keep them in alignment.

Additionally, the shaft overhang is increased considerably over the shaft overhang found in the Extended Motor Shaft Design. In a typical Rigid Coupling Design the shaft overhang may be from 14.5 to 18 inches with a shaft diameter of 1.625 inches, resulting in an Index of Deflection of approximately 437–836.

It will be seen, therefore, that despite the advantages offered by the use of in-line pumps, several disadvantages exist which have reduced the acceptance of these pumps, particularly for process use in the chemical industry.

SUMMARY OF THE INVENTION

An in-line pump in accordance with the present invention includes a horizontally oriented inlet and outlet and its own bearing system. With this construction the motor for the pump may be connected to the pump shaft by means of a relatively inexpensive flexible coupling and needs to supply only rotational force.

The pump bearing housing is supported by upwardly and inwardly extending legs attached to the upper surface of the pump housing and carries two, single row, deep grooved, double shielded bearings that are preloaded by a load spring in the housing. Preloading the bearings insures contact between all of the balls and the ball races and produces smoother and quieter operation.

With this type construction, a typical shaft overhang will be approximately 6.75 inches, so that with a shaft diameter of 1.5 inches the Index of Deflection is reduced to well below 100, down to approximately 60. At the same time, the motor is spaced from the impeller such that operation of the pump with high temperature liquids will not affect the motor nor will corrosive fumes from the pump stuffing box be drawn into the motor by its fan.

A further advantage is readily apparent in the motor adapter. In the other units, this casting must be designed to withstand not only the weight of the motor and the torsional forces, but also the forces and moments developed by the impeller and transmitted to the motor through the shaft. In this design the same forces and moments are transmitted to the bearing housing and immediately back down to the casing. This allows the motor adapter to be designed for only motor torque and weight.

Additionally, replacement of pump seals is relatively simple. All that is necessary is that the flexible coupling be removed, after which the rear cover of the pump housing can be unbolted from the pump casing. The entire power end of the pump comprising the shaft, bearing housing, bearings, rear cover, and impeller, can then be easily removed through the openings in the motor adapter. After a new seal has been installed the rear cover is once again bolted to the pump casing, reestablishing pump and motor shaft alignment. Thus, it is unnecessary to remove the motor to gain access to the pump seals or to realign the motor and pump shaft.

It will be seen, therefore, that with the pump of the present invention shaft overhang and the resultant Index of Deflection are drastically reduced, pump thrust loads are carried by pump bearings rather than the motor bearings, the motor is positioned remotely from the pump away from the harmful effects of high temperature fluids and corrosive fumes, and ready access to the pump seals for replacement is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view of a pump in accordance with the present invention,

FIG. **2** is a plan view thereof, and

FIG. **3** is an enlarged view of a portion of the pump with parts in section.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As seen in FIG. **1** of the drawings, a pump in accordance with the present invention includes a pump casing **12** having an inlet, the upstream end **14** of which is substantially horizontally disposed and connected to the downstream end **16** thereof by means of a smoothly curved elbow **18.** The casing also includes an outlet **20** which, as in the case of the upstream end **14** of the inlet, is substantially horizontally disposed, and as best seen in FIGS. **2** and **3**, aligned with the upstream end of the inlet.

Bolted to the casing **12** is a rear cover plate **22** having drainage means **23**, the cover plate **22** and casing **12** forming a pump housing and defining an impeller chamber **24.** Received in the impeller chamber **24** is an impeller **26** which, preferably, is of the type shown in U.S. Pat. No. 3,169,486, although it will be apparent that other types of impellers may be used.

A stuffing box **28** is mounted in the rear cover plate **22** and carries seals for the impeller shaft **30** which is attached to and extends upwardly from the impeller **26.** Preferably the cover plate will also be provided with an internal bypass **32** to lubricate, cool and flush the seal faces. An impeller gasket **34** is received in a groove **36** and is preferably formed of a material such as TFE encased Silicone rubber to provide a positive corrosion resistant seal. Additionally, a gasket **38** will also be clamped between the casing **12** and the rear cover plate **22.**

A pump bearing support **40,** consisting of a plurality of legs **42** extending upwardly and inwardly, is mounted on the pump housing by means of bolts or the like **44.** At their upper ends the legs **42** carry a pump bearing housing **46** which contains a pair of vertically spaced bearings **48** and **50.** Bearings **48** and **50** are preferably single row, deep groove, double shield bearings that are spring loaded by means of a wavy washer **52.**

This construction insures contact between all of the balls and the ball races and results in smoother, quieter operation. Preloading in this manner also eliminates end play and reduces radial play so that radial shaft movement is greatly reduced. The spring **52** which loads the bearings is selected such that its tension exceeds the opposing weight of the rotating element, plus the thrust created by operating the pump with a suction pressure equal to full vacuum. This construction locates the shaft axially in relation to the other parts of the pump.

Ordinarily bearings **48** and **50** will be permanently lubricated. However, plugged openings, as at **54** and **56,** are provided to permit relubrication if necessary or desired. In addition, a spacer **58** is interposed between bearings **48** and **50** to fill the space therebetween and prevent grease from building up inside the bearing housing. A cap **60** is attached to the housing **46** by bolts or the like **62** and a seal **64** is provided at the upper end thereof. Additionally, a deflector **66** is mounted on the shaft **30** beneath the housing **46** to spin with the shaft and throw off any liquid tending to climb upwardly along the shaft.

A motor adapter **68** is also mounted on the pump housing by means of bolts or the like **70** and extends upwardly from the pump housing outwardly of the pump bearing housing support **40.** At its upper end the adapter **68** carries a motor **72** bolted thereto, as at **74,** and having a downwardly extending motor shaft **76.** The impeller shaft **30** and the motor shaft **76** are aligned in the factory at the time of assembly to eliminate field alignment and are joined to each other by a resilient coupling.

The coupling, preferably an elastomeric spacer coupling of conventional design, consists of a motor hub **80,** a pump hub **82** and a spacer assembly **83** that fits between them. The spacer **83** is made up of two cast iron flanges **84** and a flexible rubber sleeve **85** which has teeth on its outer diameter to transmit torque from one flange to the other. The entire assembly is then held together by two sets of bolts **86,** with one set joining motor hub **80** and upper flange **84** and the other set joining pump hub **82** and lower flange **84.**

With the above construction it will be seen that the liquid being pumped is received in the upstream end **14** of the pump inlet and is directed toward the downstream end thereof by the streamlined elbow **18** which eliminates turbulence and reduces the net positive suction head (NPSH) requirement. The fluid is then directed into the impeller through the downstream end **16** of the inlet and pumped outwardly through the outlet **20** in the manner described in detail in the above noted U.S. Pat. No. 3,169,486. Because the pump is provided with its own bearings none of the impeller thrust loads are imposed on the motor bearings and the motor bearings need only support the motor shaft for motor loads.

At the same time, it will be seen that the pump overhang, noted by the dimension L is kept relatively low, on the order of 6.75 inches. With the impeller shaft having a diameter D of 1.5 inches this provides an Index of Deflection of approximately 60. Since shaft deflection is directly proportional to the Index of Deflection, it will be seen that an in-line pump in accordance with the present invention keeps shaft deflection to a minimum.

Despite the fact that shaft overhang is kept at a minimum the motor **72** is still positioned remotely from the pump housing. As a result, operation of the pump at high temperatures has little effect on the motor and the tendency for corrosive fumes to be drawn into the motor is markedly reduced.

When it becomes necessary to replace the seals in the pump, the spacer **83** is removed, allowing the entire rotatable assembly of the pump to be unbolted from the pump casing **12.** This exposes the impeller and rear cover for further disassembly. The impeller is then unscrewed from the shaft and the rear cover plate is unbolted and removed. With the rear cover removed the seal is fully exposed and can be easily replaced. After new seals have been installed the rear cover and impeller are reassembled, reestablishing the pump and motor shaft alignment, with no further alignment being required.

It will be seen, therefore, that the present invention provides an in-line pump having its own bearing system, yet designed to position the motor remotely spaced from the pump while minimizing shaft deflection and facilitating replacement of pump seals.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention.

What is claimed is:

1. An in-line pump comprising:

a. a main casing having an inlet and an outlet formed integrally therewith,

b. said inlet having a substantially horizontal upstream end and a substantially vertical downstream end joined by a smoothly curved elbow,

c. said outlet being substantially aligned to said upstream end of said inlet,

d. a cover plate mounted on an upper surface of said casing and defining therewith an impeller chamber,

e. an impeller received in said impeller chamber for rotation about a substantially vertical axis,

f. said cover plate having a diameter no smaller then the diameter of said impeller, thereby allowing said impeller to be removed from said impeller chamber when said cover plate is removed from said casing,

g. an impeller shaft fixed to and extending upwardly from said impeller,

h. a stuffing box integral with said cover plate and rotatably receiving said impeller shaft,

i. a bearing housing support including a plurality of upwardly and inwardly curved legs mounted on an upper surface of said cover plate and carrying a bearing housing at their upper ends,

j. a pair of vertically spaced bearings positioned in said bearing housing and rotatably receiving said impeller shaft,

k. the impeller shaft overhang and diameter thereof being such that the Index of Deflection of said pump is substantially less than 100,

l. a motor adapter mounted on said casing separately from said bearing housing support and extending upwardly about said bearing housing spaced outwardly of said bearing housing support,

m. a motor mounted on said adapter and having a downwardly extending motor shaft aligned with said impeller shaft,

n. an elastomer coupling interconnecting adjacent ends of said aligned impeller and motor shafts, and

o. said adapter being of openwork construction and having an inner dimension greater than said diameter of said cover plate, providing access to and permitting removal of said coupling, bearings and bearing housing support, cover plate, impeller and impeller shaft while said motor and motor adapter remain fixed in place with respect to said main casing.

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