May 30, 1972 E. H. PRIEST ET AL 3,666,375

PUMPING A HIGH OR LOW TEMPERATURE FLUID

Filed Aug. 26, 1969 2 Sheets-Sheet 1

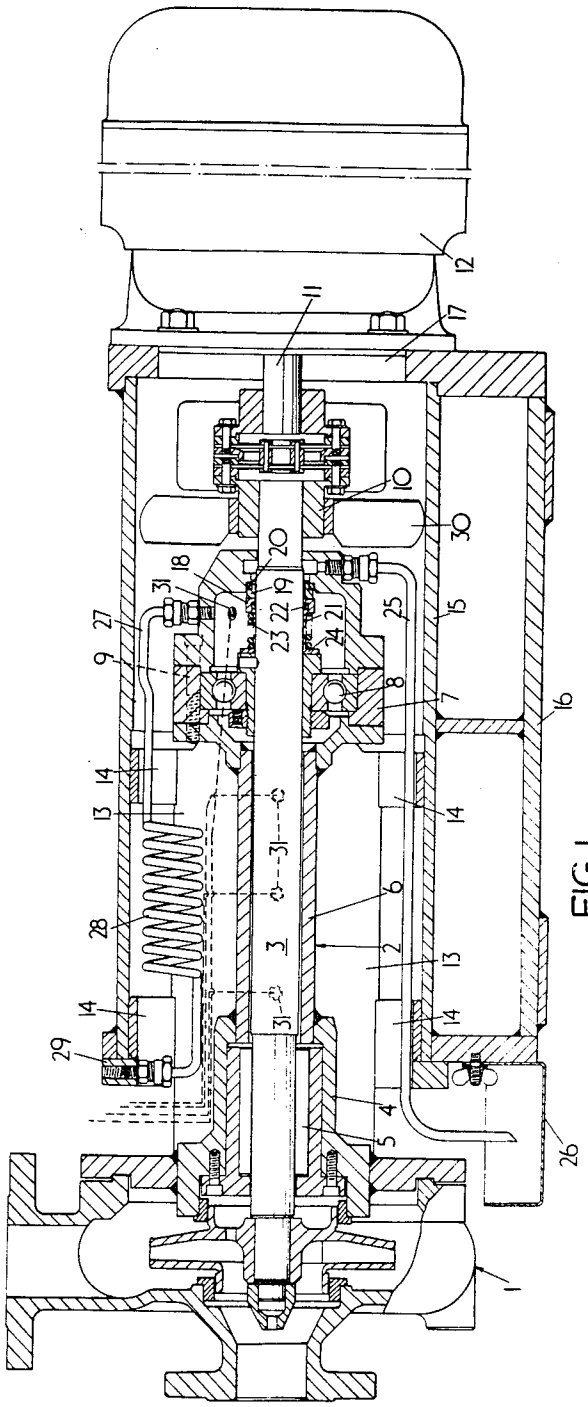


FIG. 1.

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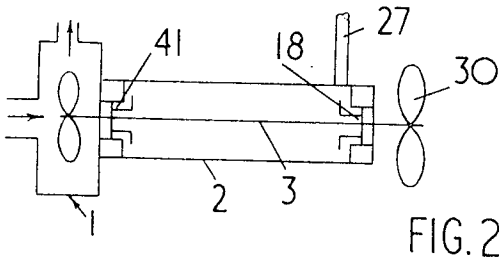


FIG. 2

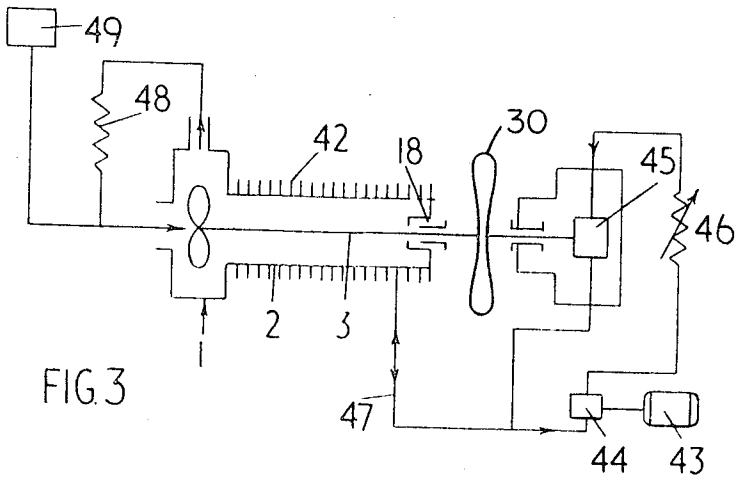


FIG. 3

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PUMPING A HIGH OR LOW TEMPERATURE FLUID

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U.S. Cl. 415—112 3 Claims

ABSTRACT OF THE DISCLOSURE

Heat-transfer systems using oxidizable heat-transfer fluids have oxidation problems around the pump shaft seal. According to this invention, the problem is solved by having the seal at the remote end of a barrier section connected to the casing of the pump so that the barrier section can be cooled to keep the seal cool enough.

BACKGROUND OF THE INVENTION

This invention relates to an arrangement for pumping fluid, e.g. a heat-transfer fluid, whose temperature differs substantially from the ambient temperature.

The pumping of fluids (liquids or gases) which can cause a hazard if they leak from the glands of a pump, requires special methods to prevent any leakage and the word "pump" as used herein includes pumps for liquids or compressors for gases.

Some type of sealing arrangement must be used to prevent leakage of the fluid. One alternative is to enclose the pump and its driving motor in a sealed system. A second alternative is to enclose the pump alone in a sealed system and drive it magnetically. A third alternative is to use a mechanical seal around the driving shaft of the pump.

A mechanical seal can give difficulty both with high temperature fluids and with low temperature fluids. Thus high temperature mineral oils and organic liquids may oxidize as soon as the liquid comes in contact with air, coating the seal with an oxidized product which can flake off and cause leakage, and which also impairs the lubrication of the seal surfaces. Low temperature liquids or gases may cause freezing of atmospheric moisture around the seal.

According to a first aspect of the present invention, there is provided an arrangement for pumping a fluid whose temperature differs substantially from the ambient temperature, the arrangement including

SUMMARY OF THE INVENTION

A pump for pumping the fluid,

A driving shaft for driving the pump,

A barrier section, sealed to the casing of the pump, and surrounding the driving shaft,

A seal around the driving shaft at the end portion of the barrier section remote from the pump,

The barrier section being arranged so that said seal will be in communication either directly or through another fluid with the working fluid being pumped and will seal the working fluid against egress, and

Means driven by the driving shaft for forcing a cooling or heating medium in heat exchange relationship with the fluid in the barrier section, to reduce the heat transferred between the pump and said seal, or vice versa, and for arranging that the temperature of said seal will not

be too hot or too cold for the effective operation of said seal.

In the arrangement of the invention, most of the heat transferred between the pump and said seal is transferred by conduction through the driving shaft; the driving shaft however transmits heat to, or absorbs heat from, the surrounding fluid in the barrier section, and this fluid can be cooled or heated as appropriate. As most of the heat is transferred through the driving shaft, the cross-sectional area of the driving shaft is one parameter determining the amount of heat transferred. The length of the barrier section is preferably over four times, and suitably about nine times, the average diameter of the portion of the driving shaft lying between the pump and said seal.

Due to the manner in which the seal is protected, any suitable motor may be used to drive the working pump; thus an electric motor may be used or alternatively a high starting torque can be provided by using a pressure-fluid-operated motor; in the latter case, the prime mover may be electric motor. The driving motor speed can be arranged to be variable, and the arrangement can be such that the capacity or pressure of the system in which the fluid is being pumped can be altered.

Though the invention has been developed principally for high or low temperature heat-transfer systems, where the leakage of heat-transferred liquid (the fluid being pumped) could be dangerous to personnel, the invention is not limited to liquid heat-transfer systems, but can be used on any fluid system, e.g. one using a pneumatic driving pump (compressor) and a motor operated by gas. As examples, the fluid being pumped may be a high temperature heat-transfer medium or a sub-zero temperature fluid, and in both cases said seal can be kept at a suitable temperature for its effective operation, for instance above room temperature.

If desired, the barrier section may contain a fluid different from the fluid being pumped provided the interchange between the two fluids is not detrimental; in this arrangement, said seal will still be in communication with the fluid being pumped, but by way of the intermediate fluid, and will seal the fluid being pumped against egress through the seal. Alternatively, the arrangement can be modified by having a seal between the barrier section and the pump and arranging that there is no gross communication between the fluid in the barrier section and the fluid being pumped; it is possible to arrange that there is no communication at all, but this is usually expensive because most commercial seals leave a small leak path which can have a substantial effect if there is no flow through the seal but only pressure balance on either side of the seal.

If desired, once the barrier section has been filled with fluid, the fluid in the barrier section need not be changed. When pumping a liquid, no recourse need be made to an air cushion for protecting said seal even where the arrangement is used with the driving shaft vertical.

Nonetheless, any variation in the volume of fluid in the barrier section, caused by changing temperature conditions (for instance during raising the temperature of the fluid being pumped), can be taken up by the system in which the fluid is being pumped. In general, the barrier section can be arranged to be suitable for a stable process condition or to be suitable for variable process conditions, e.g. fluctuating temperatures or pressures in the

fluid being pumped. As a general preferred feature, there may be no seal between the interior of the barrier section and the fluid in the pump; nonetheless, it should be noted that where there is a seal between the barrier section and the fluid in the pump, there will be fluid on each side of the seal and this seal will be protected while the seal effectively sealing the pump against egress of fluid will still be the barrier section seal remote from the pump. It will be noted that where a seal is provided between the barrier section and the pump, some fluid communication must be provided between the barrier section and the interior of the pump either by way of a leak path through the seal or by way of a by-pass connection. The seal between the barrier section and the pump may be, for instance, a gland packing or a labyrinth seal.

The working pump in the arrangement of this invention can be of any suitable type.

The arrangement of the present invention is preferably such that the cooling or heating medium is air.

Preferably, said forcing means is mounted on the driving shaft, and said forcing means may be a fan or propeller blade for passing the medium longitudinally over the outside of the barrier section, and in general, it is preferred to pass the cooling or heating medium longitudinally over the outside of the barrier section as this normally gives a longer sweep of the cooling or heating medium over the barrier section and the barrier section can have longitudinal fins to improve the heat exchange efficiency. The forcing means may be mounted on the driving shaft just outside said seal remote from the pump (i.e. between the seal and a driving motor).

In a convenient construction, there are two bearings between the pump and said seal remote from the pump, with one bearing being at the pump end portion of the barrier section and the other bearing being at the other end portion of the barrier section.

There may be a duct communicating with the barrier section, preferably adjacent said seal remote from the pump. Such a duct may be used for various purposes, as indicated below.

First, the duct may be used for purging air from the barrier section on start-up, normally by allowing the fluid being pumped to enter from the other end of the barrier section.

Secondly, the duct may be used to purge the fluid in the barrier section if the fluid has become dirty during use.

Thirdly, the duct may be used continuously during pumping if, for instance, the fluid being pumped contains an abrasive filler which may damage the driving shaft bearings mounted in the barrier section; in this case, the purging fluid will be passed in through the duct, and may, for instance, be passed in at a rate of up to ten gallons per hour, depending on factors such as viscosity, bearing clearances and wear at the bearings. As an example, the arrangement of the invention may be used to pump mineral oil which contains fuller's earth for decolorizing and deodorizing the oil. The fluid passed in through the duct need only be compatible with the fluid being pumped, and need not be the same as the fluid being pumped. However, it is often useful to use say a hot fluid being pumped as a purging fluid (though not in cases where the fluid contains an abrasive filler), and in such circumstances, said forcing means may be arranged to pass the cooling or heating medium over a portion of the duct to cool or heat fluid in the duct; to this end, the duct may include a coil.

The arrangement of the invention preferably includes an inner casing sealed to the pump casing and forming the outer wall of the barrier section, and an outer casing providing a mount for the inner casing and forming the outer wall of a duct for the cooling or heating medium. Thus, the outer casing may be secured to the casing of a driving motor. A coupling may be provided outside said seal for coupling the driving shaft to the driving motor shaft, with the coupling being enclosed by the outer casing. The arrangement is preferably such that the cooling or heating medium is passed down the whole length of the outer casing, for efficient cooling or heating.

According to a second aspect of the invention, there is provided a method of pumping a fluid by a pumping arrangement of the first aspect of the invention, the fluid having a temperature substantially different from the ambient temperature, with said seal being in contact with fluid in the interior of the barrier section and said forcing means being operated so that the temperature of said seal is not too hot or too cold for the effective operation of said seal.

According to a third aspect of the present invention, there is provided a heat-transfer system arranged to use an oxidizable heat-transfer fluid whose temperature is substantially above the ambient temperature, and including:

A working pump for pumping the heat-transfer fluid,

A driving shaft for driving the pump,

A temperature barrier section casing of substantial length sealed to a casing of the pump and surrounding the driving shaft,

And a seal around the driving shaft at the end portion of the barrier section remote from the pump, to seal the heat-transfer fluid against egress.

The barrier section being arranged so that said seal will be in communication with the heat-transfer fluid either directly, or indirectly through another oxidizable fluid, and being arranged so that heat can be transferred from the barrier section so that the temperature of said seal will not to too hot for the effective operation of said seal.

The invention will be further described, by way of example, with reference to the accompanying drawings, of which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view, mainly in axial section, of a pumping arrangement in accordance with this invention connected to a motor;

FIG. 2 is a schematic drawing showing a modification to the arrangement of FIG. 1; and

FIG. 3 is a schematic drawing showing another modification to the arrangement of FIG. 1, and also showing a possible circulatory heat-transfer system and the hydraulic circuit of the motor.

DETAILED DESCRIPTION OF THE DRAWINGS

The arrangement of FIG. 1 has a pump **1** which may be any suitable type. The pump is secured to a cylindrical casing **2** which surrounds pump driving shaft **3** and forms a barrier section. The cylindrical casing **2** has three parts, a front part **4** surrounding a plain bearing **5**, a center part **6** closely embracing the shaft **3** and a rear part **7** surrounding an antifriction bearing **8**. For assembly, the rear part **7** is itself made up of three components secured together by bolts **9**. The casing **2** is fixed only at its left-hand end (as seen in FIG. 1).

A sleeve **10** is secured to the rear end of the shaft **3**, and is coupled to a driving shaft **11** of a motor **12**. The motor **12** may be of any suitable type, for instance an electric motor or a hydraulic motor.

The inner casing **2** has longitudinal fins **13** to which are connected radial webs **14** for mounting the inner casing in a cylindrical outer casing **15** in such a manner as to allow an air current to pass down the interior of the outer casing **15**. The outer casing **15** is carried on a support **16** and is bolted to the casing of the motor **12** in such a way as to leave entry passages **17** for air entering the outer casing **15**.

There is a small but definite clearance between the bearing **5** and the shaft **3**, and a larger clearance between the center part **6** of the barrier section and the shaft **3**, leading to the space enclosed by the rear part **7**. In this manner, the space enclosed by the rear part **7** is subject

to the fluid pressure generally on the axis of the pump **1**, and a mechanical seal **18** seals the rear of the rear part **7** to the shaft **3** where the shaft **3** exits from the barrier section. The length of the finned part of the inner casing **2** (the effective barrier section) is above nine times the average diameter of the section of the driving shaft **11** lying between the pump **1** and the seal **18**.

The mechanical seal **18** is of a conventional type, having a sleeve **19** sealed to the rear part **7** by an O-ring **20** and a second sleeve **21** sealed to the shaft **3** by an O-ring **22**, with the second sleeve **21** being sprung against the first sleeve **19** by a helical compression spring **23** whose front end bears against the bearing **8** with the interposition of a collar **24**.

A leak pipe **25** leads from an annular space adjacent the bearing **18** to a leak check tray **26** secured to the support **16**, for checking leakage through the seal **18**.

A purging pipe **27** leads from the rear of the interior of the rear part **7**, through a helical coil **28** mounted in the space between the inner and outer casings **2**, **15** to a connector **29**.

Fan blades **30** are mounted on the sleeve **10** and rotate with the driving shaft **3**, with the fan blades **30** being profiled to draw a flow of air from right to left through the whole length of the outer casing **15** and over the inner casing **2** and cooling fins **13**.

Though not used on a production model, thermocouple probes **31** are indicated spaced along the length of the barrier section to test the temperature in the barrier section and adjacent the bearing **18**.

The arrangement shown in the drawing is designed for pumping a hot liquid, though it may alternatively be designed for pumping a hot gas or a sub zero liquid or gas. If the liquid being pumped has a temperature of about 400° C., the temperature adjacent the seal **18** can be maintained at a value of about 100° C., which is low enough to prevent oxidation of say an organic heat transfer fluid at the outer surfaces of the seal **18**. The heat transferred down the driving shaft **3** and down the casing **2** is to a substantial extent withdrawn by the air blown by the fan blades **30**.

As explained in more detail above, the purging pipe **27** has three functions, namely to provide an initial air bleed on start-up, to provide an occasional purge of the liquid within the barrier section if this liquid becomes dirty or, if necessary, to provide a continuous slow purge if a liquid containing an abrasive filler is being pumped.

If the liquid used for the continuous purge is hot (or very cold), the coil **28** will ensure that its temperature is fairly close to ambient temperature when it reaches the area around the seal **18**. The slow purge will prevent any abrasive filler penetrating into the bearing **5**.

In the modification of FIG. 2, a seal **41** is provided between the pump **1** and the barrier section, i.e. at the other end of the barrier section to the seal **18**. If desired, though not shown, the seal **41** may be associated with a bearing. The barrier section is filled with a liquid compatible with the liquid being pumped by the pump **1**, and the pipe **27** can be used to top up the liquid in the barrier section or to allow for its expansion.

The seal **41** prevents any gross communication between the liquid being pumped and the liquid in the barrier section, though a small leak path may be present through the seal **41** if it is too expensive to provide a seal which is completely effective. As there will be liquid on each side of the seal **41**, there can be no oxidation at the seal **41**, and hence no scaling. The seal **18** will be considerably cooler than the seal **41**, and sufficiently cool for no oxidation to occur at the outside of the seal **18**.

In the modification of FIG. 3, the fan blades **30** are shown, but although they are advantageous, they may be omitted. Fins **42** on the casing **2** are transverse so that natural convection can be used to cool (or warm) the sleeve **2**. The outer casing **15** of FIG. 1 can be omitted. In another alternative, a cooling (or heating) liquid may be passed through a heat-exchange jacket surrounding the casing **2**.

The hydraulic circuit and heat transfer system shown in FIG. 3 could be applied to either FIG. 1 or FIG. 2. The hydraulic circuit has a motor **43** (e.g. an electric motor) connected to a hydraulic pump **44** which is in hydraulic circuit with a hydraulic motor **45**, the hydraulic circuit including an external heater or cooler **46** to maintain the temperature of the hydraulic fluid at any desired value. The hydraulic motor **45** is connected to the working (or process) pump **1** by the driving shaft **3**. The hydraulic fluid may either return straight from the hydraulic motor **45** (as shown in FIG. 3) or may return by way of the barrier section (which arrangement is not shown).

The volume of the hydraulic circuit is constant (except when the temperature or pressure fluctuate), and the circuit does not need to draw any fresh supply from, or pass any discharge to, the heat-transfer system; thus the bulk of the liquid contained in the casing **2** will remain relatively stagnant and, particularly in the system of FIG. 3, the only movement within the casing **2** is due to temperature conduction or due to differential pressure, and this movement can be prevented or reduced if desired by the seal **41** (FIG. 2) or the purging pipe **27** (FIG. 1). Nonetheless, a transfer pipe **47** is provided connecting the interior of the barrier section with the hydraulic circuit so that any expansion or contraction of the hydraulic fluid can be accommodated by the heat transfer system.

The hydraulic fluid used for powering the motor **3** is preferably the heat-transfer liquid, though, as indicated above, this former liquid need not be the same as the heat-transfer liquid provided interchange between the two liquids is not detrimental. Furthermore, with suitable modification, a gas may be used instead of the heat-transfer liquid and a compressed gas used to power the motor **45**.

The working (or process) pump **1** circulates oxidizable heat-transfer oil through a circulatory heat-transfer system having a heater **48**, and any variations in volume are accommodated in an expansion tank **49**.

The term "heat-transfer system" as used herein is a circulatory system for transferring heat from one location to another location remote from the first location by heating a heat-transfer fluid at the first location, pumping the fluid along a duct (such as a pipe) to the other location, abstracting the heat by heat exchange at the other location, and returning the fluid along a duct to the first location.

We claim:

1. A heat-transfer system arranged to use high temperature mineral oils and organic liquids and whose temperature is substantially above the ambient temperature, including a working pump for pumping the liquids, a pump casing, a driving shaft operably connected to and driving the pump, a temperature barrier section casing sealed to the casing of the pump and surrounding the driving shaft, a second casing surrounding and spaced from the barrier section casing to provide a space therebetween, said barrier section casing having longitudinally extending fins, radial webs connected to the fins, with said radial webs mounting the barrier section casing in the second casing, a seal around the driving shaft at the end portion of the barrier section casing remote from the pump, to seal the liquid against egress, said barrier section casing providing a fluid communication means for placing the seal in fluid communication with the pumped liquid, means driven by the driving shaft for forcing air through the space between the barrier section casing and second casing and over the barrier section casing and fins whereby heat transferred down the driving shaft and down the barrier section casing is substantially withdrawn by the air forced by said means driven by the driving shaft, said temperature barrier section casing and seal preventing contact between said air and said liquid, and the length of the temperature barrier section casing having the fins being about nine times the average diameter of the portion of the driving shaft lying between the pump and the seal.

2. The system as claimed in claim 1, wherein a means is provided communicating with the barrier section, for purging fluid from the barrier section.

3. The system as claimed in claim 1, wherein a means is provided communicating with the barrier section for passing fluid into the barrier section during pumping.

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