

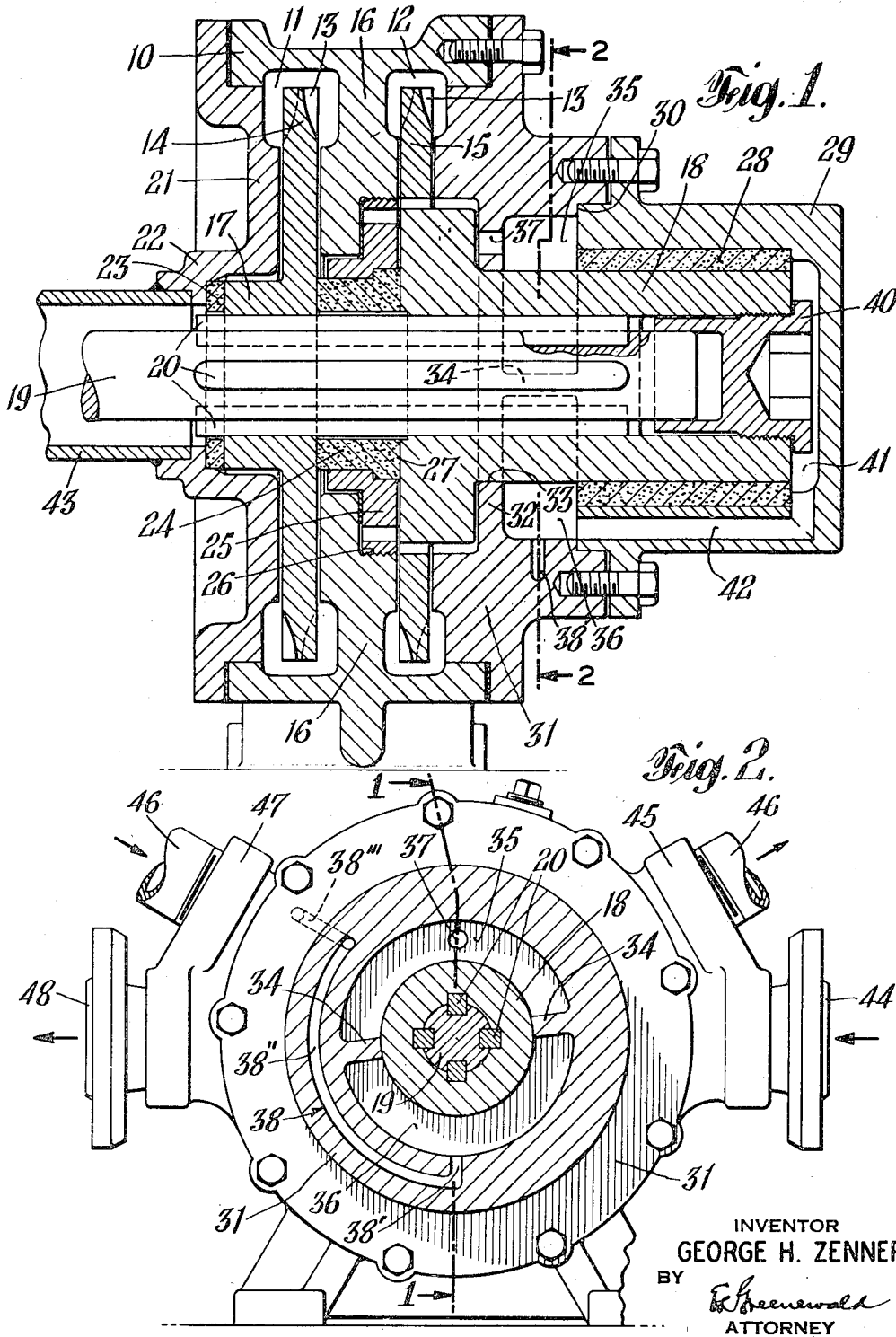
Dec. 7, 1948.

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2,455,460

ROTARY PUMP FOR LIQUEFIED GASES

Filed Feb. 1, 1947



UNITED STATES PATENT OFFICE

2,455,460

ROTARY PUMP FOR LIQUEFIED GASES

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Application February 1, 1947, Serial No. 725,784

6 Claims. (Cl. 103-112)

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This invention relates to rotary pumps for liquefied gases and more particularly to pressure balancing means for relieving bearing pressures in rotary pumps for liquefied gases having boiling points below 133° K. such as liquid oxygen and nitrogen. The problem involved is in part similar to that described in U. S. Patent No. 2,340,787, the present invention including an improved solution of the problem with advantages to be described.

In pumps for low temperature liquefied gases it is found advantageous to use bearings made of solid self-lubricating material inert to the liquefied gas to be pumped. Since such materials tend to wear rapidly it is advantageous to reduce the rate of wear by minimizing the bearing pressures. Also since heat generation in the pump tends to adversely affect the pumping efficiency a reduction of bearing pressures has the further advantage of reducing the generation of frictional heat. According to the aforementioned patent the radial load on an inboard pump bearing may be lightened by providing a radial pressure force counteracting the resultant of radial pressure forces acting on the impeller due to the increase of pressure in the pumping channel from the inlet to the outlet thereof and there is disclosed one arrangement for obtaining such balancing radial force.

According to the present invention there is provided a different and improved arrangement for obtaining a radial balancing force by applying to a cylindrical area of the impeller hub a differential pressure on opposite sides thereof, one pressure being that of a lower pressure region of the impeller channel and the other higher pressure being that of the impeller hub region. Also according to the invention, the axial force acting on the interstage seal of a two-stage pump, which force tends to produce excessive friction and wear of the bearing surfaces of such a seal, is also relieved by reducing the fluid pressure acting against the inboard end of the impeller hub, such pressure relief being preferably accomplished by the passage means employed for providing the lower of the differential pressures acting radially on the impeller hub.

Accordingly, the principal objects of the present invention are to provide improved means and arrangement of parts for reducing radial bearing loads in rotary pumps for liquefied gases; to provide means for reducing excessive axial forces acting on the interstage seal bearing of multi-stage rotary pumps; and to provide an improved pump construction in which the above objects

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are attained with a simple arrangement of pressure equalizing passages.

These and other objects of the invention will be evident from the following description taken with the accompanying drawings, in which:

Fig. 1 is a view of a transverse section of a pump for liquefied gases embodying the principles of the invention; and

Fig. 2 is a view of a section taken along line 2-2 of Fig. 1.

The principles of the invention may be employed in single and multi-stage pumps for liquefied gases, but since the principles are similar in either type of pump and are preferably employed in multi-stage pumps, a two-stage pump is illustrated and described in detail. The pump illustrated is of the turbine type employing bladed impellers revolving in annular pumping channels. In the pump illustrated the casing is shown at 10 having therein two annular pumping channels 11 and 12, the channel 11 being for the low pressure stage and the channel 12 for a second or high pressure stage. Cooperating with the pumping channels 11 and 12 are the bladed ends 13 of low pressure and high pressure impellers 14 and 15, respectively. The casing is also provided with a partition 16 separating the channels 11 and 12. The impellers have hub portions 17 and 18, the hub 17 of impeller 14 extending to the left and the hub portion 18 of the impeller 15 extending to the right, the latter being relatively long. The impeller hubs are mounted slidably on a drive shaft 19 that extends axially into the casing 10 from one side thereof. For driving the impellers the shaft 19 is provided with a set of splines 20 that are set into the shaft and engage corresponding spline ways in the hubs. The low pressure side of the casing 10 is closed by a side cover 21 that has a middle portion 22 extended to form a housing for the hub 17. The middle portion 22 carries internally a thrust bearing 23 positioned to engage the left end of the hub 17 and thus center the impeller 14 in the casing.

The impeller 14 is also positioned by an interstage thrust bearing 24 that engages the right side of the impeller 14 and is mounted within the partition 16 by an externally threaded ring 25 that is threaded into a counterbore 26 in the partition 16. The interstage thrust bearing 24 is also provided with a right end surface 27 that frictionally engages the left side of the impeller 15 to form an interstage seal bearing and to locate the impeller 15 accurately in its pumping channel.

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The right end portion of the hub 18 forms a journal that is rotatably supported within a sleeve bearing 28 mounted within a bearing cap 29 that is mounted on and closes a central opening 30 of the side cover 31 which closes the right side of the pump casing 10. The opening 30 of the side cover 31 extends inwardly for a predetermined distance from the inner end of the bearing 28 to a bottom wall 32 that has a central hole 33 therethrough that fits the hub 18 with a small clearance. The space thus provided around the hub 18 is divided into two chambers by partitions 34 that are seen in transverse section in Fig. 2. The chambers 35 and 36 thus formed are arranged to maintain fluid at higher and lower pressures respectively so as to provide a force acting generally downwardly on the impeller hub 18. A hole 37 through the upper part of the bottom wall 32 provides communication between the high pressure chamber 35 and the hub region of the impeller 15. To obtain a lower pressure in the chamber 36 there is provided a passage 38 connecting the chamber 36 with the pumping channel 12 in a region near its inlet portion. To this end, the passage 38 has a portion 38' extending downwardly to meet an arcuate portion 38'' formed in the side cover 31 and extending clockwise as indicated in Fig. 2 to a portion 38''' at a point opposite the inlet 47 where the portion 38''' enters angularly into the channel 12.

The end of the hub 18 is preferably closed by a plug 40 that is arranged to permit relative axial movement between the end of the shaft 19 and the hub 18. In previous pumps of this character the impeller hub pressure would act toward the left on the impeller 15 because of the lower pressure at the hub portion of the low pressure impeller 14. Such pressure difference applies considerable force between the impeller 15 and the seal bearing surface 27. According to the present invention this is relieved by providing a pressure communication between the chamber 41, between the end of the hub 18 and the bearing cap 29, and a point of lower pressure, preferably that of the pumping channel 12 in the region of its inlet. This is conveniently effected by a passage 42 extending in the cap 29 from the chamber 41 to the low pressure chamber 36. The diameter of the impeller hub 18 should be adjusted so that all of the axial force tending to move the impeller 15 toward the left is not counterbalanced because it is desirable that a relatively small resultant axial force be provided to maintain the sealing surfaces of the seal bearing surface 27 and the impeller 15 in contact.

In Fig. 1 is shown a portion of a tubular housing 43 that encloses the outwardly extending portion of the shaft 19. The housing 43 is welded to the portion 22 of the end cover 21 and is provided at its outer end with the customary type of shaft seal which is not shown in the drawing as it forms no part of the present invention. The shaft seal and outboard bearing for the outer end of the shaft 19 may be similar on construction to that shown in the aforementioned Patent No. 2,340,787. The inlets and outlets of the two pumping channels may also be similar to those shown in said patent. In Fig. 2, 44 indicates the main inlet to the first stage channel 11, 45 indicates the outlet from the first stage channel which is connected by a pipe 46 (partly broken away) to the inlet 47 of the high pressure stage channel 12, and 48 indicates the final outlet from the high pressure stage channel 12.

It will be seen that the provision of the opposed

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chambers 35 and 36 about the cylindrical portion of the hub 18 between the inner end of bearing 28 and the wall 32 and the maintenance of a difference of pressure in these chambers will provide a resultant force urging the impeller toward the chamber having the lower fluid pressure. The pressure in the pumping channel 12 increases from an intermediate value in the region of its inlet 47 to a maximum value in the region of its outlet 48, which pressure change creates a generally upwardly acting resultant force on the impeller 15. Such force is only partly counteracted by a similar resultant radial force acting generally downwardly on the first stage impeller 14 so that additional counterbalancing is preferable. Such additional downward counterbalancing force is herein obtained by having the chamber 35 in communication through hole 37 with the impeller hub region so that it has a fluid pressure intermediate in value between that of the inlet and outlet of the second stage pumping channel 12 and having chamber 36 communicate through passage 38 with the front region of pumping channel 12 which provides a lower fluid pressure therein so that a downwardly acting resultant balancing force is provided.

The pressure acting on the left side of impeller 15 is substantially that of the hub region of the first stage impeller 14 and such pressure is slightly less than the discharge pressure of the first stage pumping channel. It is also considerably less than the hub pressure acting to urge the impeller 15 to the left. The inlet pressure of the second stage pumping channel is only slightly higher than the hub pressure of the first stage and is, according to the invention, applied to the right side of the hub 18. The transverse area of the hub 18 is proportioned to the pressure difference so that the axial forces acting on the impeller 15 are balanced to the degree desired. It is found preferable, especially in a two-stage pump, that the axial force be not entirely balanced in order that a small resultant force will urge the impeller 15 toward the left to maintain contact at the seal surface 27 so that the sealing action is maintained without excessive friction.

In a single stage pump the arrangement for the single pumping channel and impeller may be similar to that of the second stage illustrated herein. In such case the interstage seal would be replaced by a thrust bearing but the means for balancing radial and axial forces would be similar to that herein described, although preferably the total area and/or the ratio of the areas of the impeller hub exposed in the balancing chambers 35 and 36 would be adjusted and correlated to the ratio of the pressures to provide a greater radial balancing force that might be required because there would be no partial balancing force obtained from a first pressure stage. For example if the partition 34 is diametral so that the area of hub 18 exposed in the chamber 35 is equal to the area exposed in chamber 36 and if the length of the hub so exposed is such that the exposed area in each chamber is 1 square inch and, assuming further for the purpose of illustration, that the pressure in chamber 35 is 20 pounds per square inch and that in chamber 36 is 10 pounds per square inch, the net downward force will be 10 pounds. If now the length of hub exposed in the chambers is increased so that 2 square inches is exposed in each chamber, the ratio of areas is still 1 but the net downward force is increased to 20 pounds. The ratio of the exposed areas can be changed

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a limited amount by shifting the partition 34 away from the diametral position. A downward shift of the partition 34 will increase the area exposed in chamber 35 and decrease the area exposed in chamber 36 so that the ratio could be 1.25 to 1 for example to increase the net downward force accordingly. The pressure ratio can also be selected within limits by choosing the point where the passage portion 38''' connects into the pumping channel 12. However the location of the passage portion 38''' close to the inlet as shown provides the largest differential of pressure, thus permitting the use of the least total exposed area in the chambers 35 and 36 to provide the desired net balancing force.

Although a preferred embodiment of the invention in a two stage pump has been described in detail, it is contemplated that modifications of the construction may be made and that some features may be employed without others without departing from the spirit and scope of the invention. For example, in certain instances either the radial balancing means or the axial force compensating means may be employed alone without the other.

What is claimed is:

1. In a rotary pump having a casing with an annular pumping channel, a rotary impeller operating in said pumping channel, and a drive shaft for said impeller, the pumping action causing an increasing fluid pressure in said channel from the inlet to the outlet thereof, which pressure increase produces a net radial force acting on said impeller in a certain direction; a radial bearing in said casing for the inboard end of said shaft; and means for balancing said radial force comprising a cylindrical surface rotatable with said shaft, chambers in said casing about said cylindrical surface, said chambers being substantially on opposite sides and extending peripherally about said cylindrical surface for a portion only of the circumference, a fluid passage connecting one of said chambers to a lower pressure region of said pumping channel, and a passage connecting the other of said chambers to a region of higher fluid pressure in the casing adjacent said impeller, the areas of said surface exposed in the chambers and the relation of such areas being correlated with the pressures in the chambers to provide a resultant radial force substantially balancing said net radial force acting on the impeller.

2. A rotary pump according to claim 1 in which said fluid passage connecting one of said chambers to said pumping channel enters said pumping channel at its inlet portion.

3. In a rotary pump having a casing with an annular pumping channel, a rotary impeller operating in said pumping channel, said impeller having a laterally extending hub portion, the pumping action causing an increasing fluid pressure in said channel from the inlet to the outlet thereof, which pressure increase produces a net radial force acting on said impeller in a certain direction; a radial bearing in said casing in which said hub portion is journaled; and means for balancing said radial force comprising a cylindrical surface on said hub portion, chambers in said casing about said cylindrical surface, said

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chambers being substantially on opposite sides and extending peripherally about said cylindrical surface for a portion only of the circumference, a fluid passage connecting one of said chambers to a lower pressure region of said pumping channel, and a passage connecting the other of said chambers to a region of higher fluid pressure in the casing adjacent said impeller, the areas of said surface exposed in the chambers and the relation of such areas being correlated with the pressures in the chambers to provide a resultant radial force substantially balancing said net radial force acting on the impeller.

4. In a rotary pump having a casing with an annular pumping channel, said channel having inlet and outlet portions, a rotary impeller operating in said pumping channel, said impeller having a laterally extending hub portion journaled in a sleeve bearing mounted in said casing; a combined thrust bearing and seal mounted in said casing in frictional contact with a surface on a hub portion of said impeller on the side of the impeller opposite said sleeve bearing; and means for reducing the axial force tending to push said impeller toward the thrust bearing comprising a chamber enclosing the end of said laterally extending hub portion, and a passage connecting said chamber with a lower pressure region of said pumping channel.

5. A rotary pump according to claim 4 in which said pump is a multi-stage pump and said thrust bearing seal is mounted in a partition portion of the casing between said impeller and a lower pressure stage.

6. In a rotary pump having a casing with an annular pumping channel, a rotary impeller operating in said pumping channel, said impeller having a laterally extending hub portion, the pumping action causing an increasing fluid pressure in said channel from the inlet to the outlet thereof, which pressure increase produces a net radial force acting on said impeller in a certain direction; a radial bearing in said casing in which said hub portion is journaled; means for balancing said radial force comprising a cylindrical surface on said hub portion, chambers in said casing about said cylindrical surface, said chambers being substantially on opposite sides and extending peripherally about said cylindrical surface for a portion only of the circumference, a fluid passage connecting one of said chambers to a lower pressure region of said pumping channel, and a passage connecting the other of said chambers to a region of higher fluid pressure in the casing adjacent said impeller, the areas of said surface exposed in the chambers and the relation of such areas being correlated with the pressures in the chambers to provide a resultant radial force substantially balancing said net radial force acting on the impeller; a combined thrust bearing and seal mounted in said casing cooperating with the impeller side opposite said sleeve bearing; a chamber enclosing the end of said laterally extending hub portion; and a passage between said last-mentioned chamber and said passage connecting to the lower pressure region of said pumping channel.

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No references cited.