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Carter

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[45] **Nov. 11, 1975**

[54] **PUMP**

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[52] **U.S. Cl.** **417/424;** 415/62; 415/66; 415/68; 417/365

[51] **Int. Cl.**[2] **F04B 17/00**

[58] **Field of Search** 415/60, 143, 62, 66, 68, 415/107; 417/424, 360, 366, 365

[56] **References Cited**

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Primary Examiner—C. J. Husar
Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

Overloading and failures of the lower bearings in submersible electric motor driven centrifugal pumps having inducer impellers ahead of the main centrifugal pumping impeller are avoided by transferring the inducer thrust from the lower bearing to an upper bearing which has ample reserve capacity to accept the added thrust load without redesign of existing pump and bearing assemblies. The transfer of the inducer thrust from the lower to the upper bearing is accomplished by slidably keying the inducer impeller on a hollow motor driven main pump shaft and supporting the inducer impeller on a second shaft extending through the hollow pump shaft and suspended from a top main shaft bearing.

10 Claims, 3 Drawing Figures

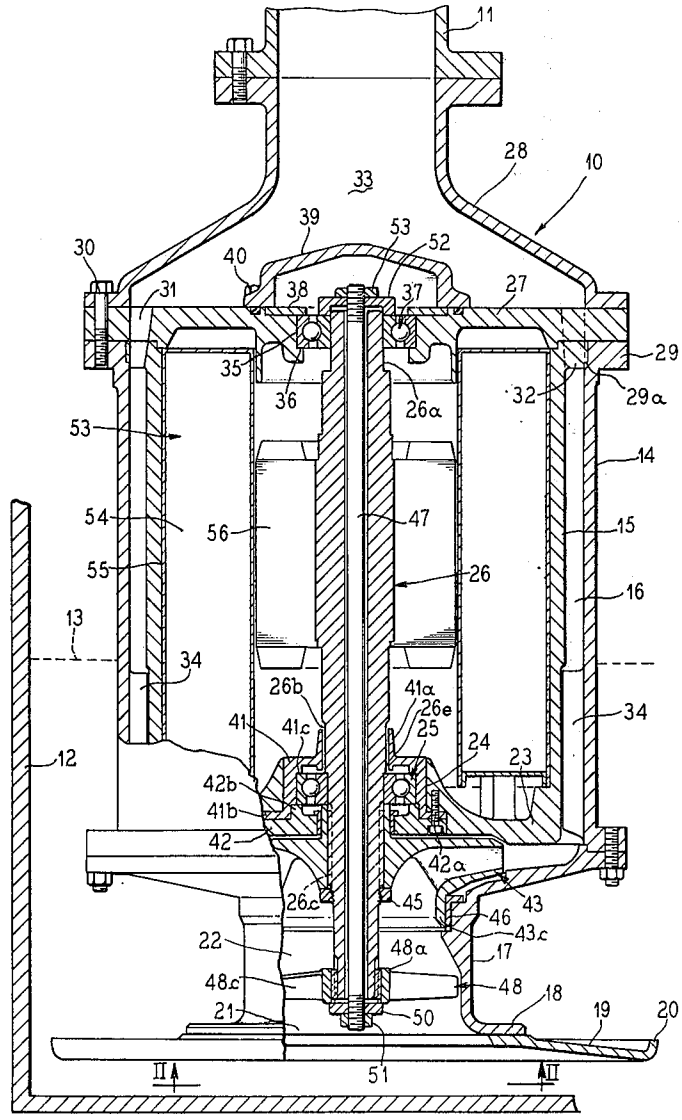
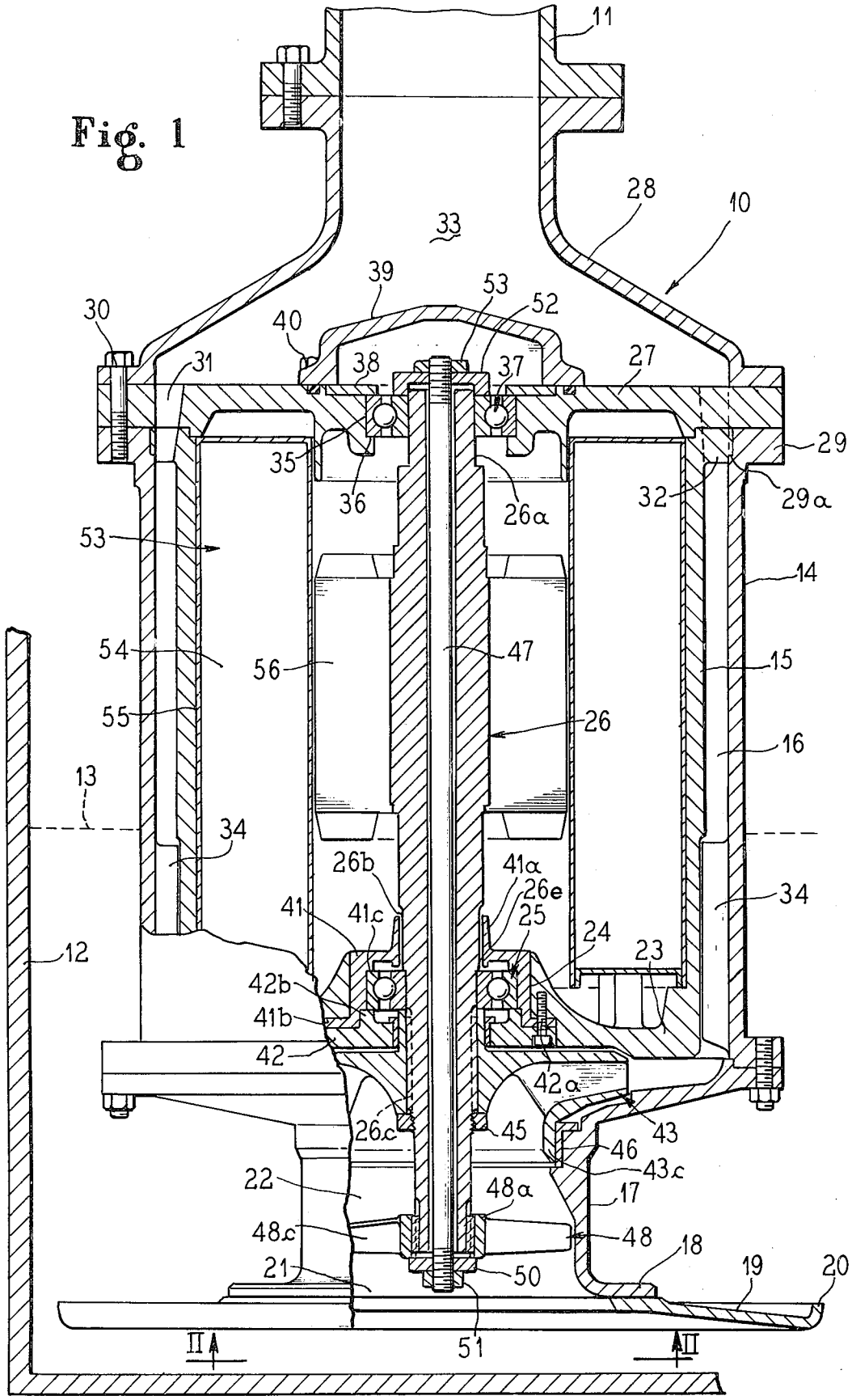


Fig. 1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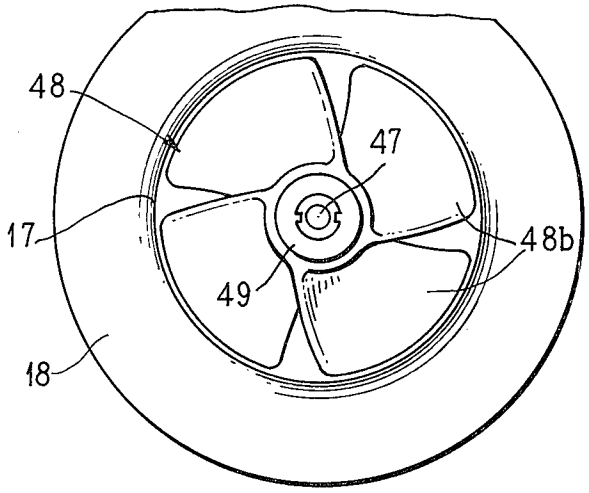
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Fig. 2

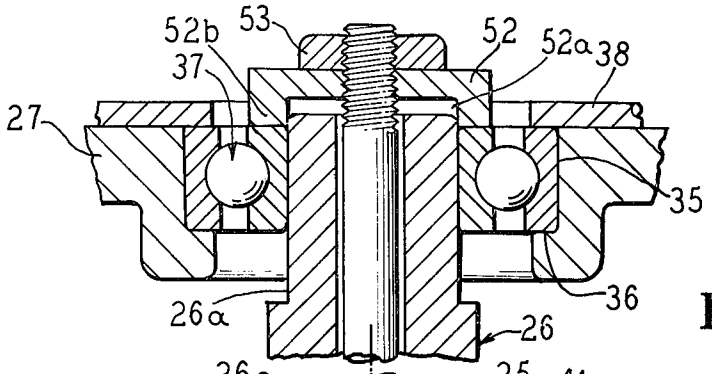
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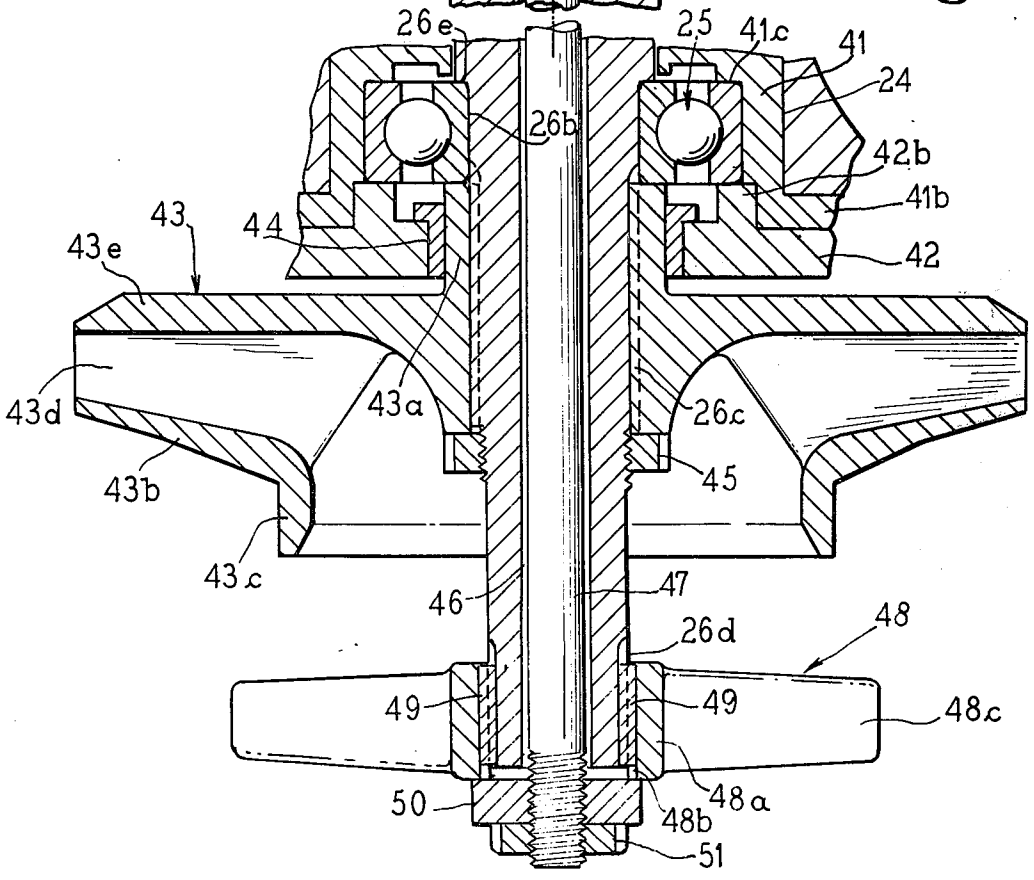
Fig. 3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PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the art of submersible electric motor driven inducer equipped centrifugal pump units especially suitable as cargo pumps for tanker ships and storage tanks and capable of pumping cargo such as cryogenic fluids or fluids at their boiling points. Particularly, the invention deals with the relieving of inducer thrust loads from the lower main pump shaft bearing.

2. Prior Art

Submersible electric motor driven cargo pumps for the pumping of cryogenic fluids or fluids at their boiling points have heretofore had the inducer impeller mounted on and driven by the main pump shaft in the pump inlet ahead of the main pump impeller as, for example, in my prior U.S. Pat. Nos. **3,304,877** issued Feb. **21, 1967; 3,369,715** issued Feb. **20, 1968;** and **3,764,236** issued Oct. **9, 1973.** In these units the pump shaft was supported in bearings at the top and bottom of the motor with the bottom bearing carrying the thrust loads of both the main pump impeller and the inducer impeller while the top bearing functioned as a radial bearing for the pump shaft. Failures of the lower bearing after short periods of operation because of excessive thrusts, have been experienced in a number of cargo pump installations. Reduction of the thrust on the lower bearing by removing some of the blades of the inducer impeller and by a lift drum feature as in my U.S. Pat. No. **3,652,186** issued Mar. **28, 1972** have been attempted but reduction of inducer blades has lessened inducer capacity and decreased the efficiency of the pump while the lift drum feature of my prior patent is costly, requires recirculation of pumpage.

SUMMARY OF THIS INVENTION

According to this invention the inducer thrust is removed from the main pump shaft bearing and transferred to an existing separate bearing in submersible electric motor driven centrifugal pump units which has adequate reserve capacity to accept the thrust loads without redesign or overloading. This is accomplished by slidably keying the inducer impeller on a hollow motor driven main pump shaft supported on a main pump bearing at the bottom of the motor and a top bearing at the top of the motor, and then supporting the inducer impeller on a second shaft extending through the hollow shaft and suspended from the top bearing. The inventive feature is easily applied to existing submersible electric motor driven centrifugal cargo pump units because the top bearings of such units have ample reserve capacity to carry the inducer thrust loads.

The top bearing not only provides radial bearing support for the main pump shaft, but all of the thrust load of the inducer impeller supporting shaft.

It is then an object of this invention to increase the wear life of the bearings of inducer impeller equipped centrifugal pumps by relieving inducer impeller thrust loads from the main pump bearing.

Another object of the invention is to provide electric motor driven centrifugal impeller equipped cargo pumps with top bearings supporting the thrust loads of the inducer impeller.

A specific object of the invention is to provide a submersible electric motor driven centrifugal cargo pump with an inducer impeller in the pump inlet driven by the main pump shaft but suspended from a bearing at the top of the motor.

Another specific object of the invention is to provide a submersible electric motor driven inducer impeller equipped cargo pump suitable for pumping cryogenic fluids and fluids at their boiling points wherein the main pump shaft is hollow, drives both the main centrifugal impeller and the inducer impeller, receives an inducer impeller supporting shaft therethrough and has a top bearing suspending the inducer impeller shaft to relieve inducer impeller thrust loads from the main shaft.

Another object of the invention is to relieve inducer impeller thrust loads from the main bearing of a centrifugal pump by slidably keying the inducer impeller on the main bearing supported pump shaft and suspending the inducer impeller from a second bearing to carry the thrust loads.

Other and further objects of this invention will become apparent to those skilled in this art from the following detailed description of the annexed sheets of drawings which, by way of a preferred example, illustrate one embodiment of the invention.

IN THE DRAWINGS

FIG. **1** is a vertical cross sectional view of a submersible electric motor driven inducer impeller equipped centrifugal cargo pump according to this invention;

FIG. **2** is a plan view of the pump inlet along the line II—II of FIG. **1**; and

FIG. **3** is a broken partial vertical cross sectional view of the bearing and shaft assembly for the inducer impeller and main centrifugal impeller of the cargo pump of FIG. **1.**

AS SHOWN ON THE DRAWINGS

In FIG. **1** the reference numeral **10** designates generally a submersible electric motor driven inducer impeller equipped centrifugal cargo pump according to this invention suspended from a vertical discharge pipe **11** in the bottom of a tank **12** containing cargo **13** such as cryogenic fluids or fluids at their boiling point including for example, ammonia, liquefied natural gas, propane, and the like. Such fluids are frequently stored in land based storage tanks or in the holds of tanker ships and the tank **12** is representative of such storage means. The pipe **11** suspends the unit **10** in the tank **12** so that its bottom inlet will be close to the bottom of the tank and it will be understood that the pipe **11** delivers the fluids from the top of the unit **10** to the top of the storage means. The unit **10** can be mounted as disclosed in any of my aforesaid U.S. Pat. Nos. **3,304,877; 3,369,715; 3,652,186;** and **3,764,236.**

The unit **10** has a generally cylindrical outer casing **14** and a concentric inner casing **15** spaced therefrom to provide an annular passage **16** therebetween. The bottom of the casing **14** has a reduced diameter depending neck portion **17** with an outwardly flared bottom flange **18** carrying a downwardly dished plate **19** with an upturned peripheral rim **20** spaced above the bottom of the tank **12.** This plate **19** directs fluids to the bottom opening inlet mouth **21** into a chamber **22** provided by the neck **17** in the bottom of the unit.

The inner casing **15** has a bottom end wall **23** with a central hub portion **24** carrying a bottom or main ball bearing assembly **25** for the main pump shaft **26.** A flat plate cover **27** overlies the casings **14** and **15** and is

clamped between a conical head or dome **28** and a peripheral flange **29** around the casing **14** by bolts such as **30**. Slots **31** through this cover **27** and through an outturned flange **32** at the top end of the inner casing **15** resting on a shoulder **29***a* of the outer casing **14** connect the annular passage **16** with an outlet passage **33** to the pipe **11**. The bottom end of the casing **15** slidably fits in a ring of vanes **34** extending inwardly from the outer casing **14** to direct fluid from the main impeller of the pump axially into the passageway **16**.

The cover **27** has a central hub **35** with an inturned shoulder **36** receiving and supporting a top bearing assembly **37** for the shaft **26**. The outer race ring of the bearing **37** is bottomed on the shoulder **36** and clamped thereagainst by a cover plate **38** underlying a cap **39** which is bolted to the cover plate **27** by bolts such as **40**. The bearing **37** is thus locked against axial shifting in the hub **35**. However, the top end of the shaft **26** has a reduced diameter cylindrical portion **26***a* which is slidable through the inner race ring of the bearing **37**. Thus, this bearing **37** is not subjected to axial thrust loads of the shaft **26** and only provides radial bearing support for the shaft.

The bottom bearing **25** has its outer race ring mounted in an inverted cap **41** in the hub **24** with a hollow neck **41***a* freely receiving the shaft **26** therethrough and an outturned flange **41***b* underlying the hub and clamped against the bottom of the hub by a bottom plate **42** which is bolted to the hub by bolts **42***a*. The closure plate **42** has a rim portion **42***b* clamping the outer race ring of the bearing **25** against an internal shoulder **41***c* of the cap **41**. Thus, the bearing **25** is held against axial shifting in the hub **24**.

The shaft **26** has a reduced diameter portion **26***b* fitting through the inner race of the bearing **25** and providing a shoulder **26***e* which is bottomed on top of this inner race. The lower end of the reduced diameter portion **26***b* has splines or keyways **26***c*.

The main centrifugal pump impeller **43** of the unit **10** has a central hub **43***a* splined or keyed on the portion **26***c* of the shaft **26** and extending through a sleeve **44** carried by the plate **42** to bottom against the inner race ring of the bearing **25**. A nut **45** threaded on the shaft portion **26***b* below the splines **26***c* thrusts against the bottom of the hub **43***a* to clamp the hub against the inner race ring of the bearing.

The impeller **43** has a shroud **43***b* with a collar **43***c* riding in a bearing sleeve **46** carried in the neck portion **17** of the bottom casing and a plurality of centrifugal pumping vanes **43***d* are provided between the shroud **43***b* and a flat base plate **43***e* of the impeller. These vanes centrifugally discharge the fluid from the inlet chamber **22** to the annular chamber **16** for flow therethrough to the outlet pipe **11**.

Since the outer race ring of the bearing **25** is clamped relative to the hub **24** and since the inner race ring of this bearing **25** is clamped between the impeller and the shoulder **26***e* of the pump shaft **26**, the bearing **25** not only cooperates with the bearing **37** to provide radial support for the shaft **26** but also carries all of the axial thrust load imposed by the impeller **43** on the shaft.

In accordance with this invention, the shaft **26** is hollow with a bore **46** therethrough freely receiving a solid shaft **47**. The bottom end of the shaft **26** is key slotted as at **26***d* to slidably receive an inducer impeller **48** with a central hub **48***a* having internal key slots **48***b* mating with the slots **26***d* of the shaft and receiving keys **49** to slidably key the shaft and impeller while allowing axial shifting of the impeller on the shaft. Four blades **48***c* extend from the hub **48***a* into close running clearance relation with the internal wall of the neck **17**.

A nut **50** is threaded on the bottom end of the solid shaft **47** and locked thereon by a cap nut **51** to support the hub **48***a* of the impeller **48**.

The top end of the shaft **47** has a cap member **52** threaded thereon with a recess **52***a* slidably receiving the top end portion **26***a* of the hollow shaft **26** and surrounded by a rim **52***b* bottomed on the inner race ring of the bearing **37**. A nut **53** is also threaded on the shaft **47** and tightened against the cap **52** to lock the assembly on the shaft.

Thus, the inducer impeller **48** is rotated by the shaft **26** but is suspended through the shaft **47** from the top bearing **37** and thrust loads of this impeller are relieved from the bottom main bearing **25** which carries the thrust loads of the main impeller **43**.

An electric motor **53** is mounted in the inner casing **15** and includes a stator **54** mounted in a sealed annular container **55** in the casing **15** and a rotor or armature **56** secured around the intermediate portion of the shaft **26**.

OPERATION

From the above descriptions it will be understood that the pump unit **10** of this invention has its main centrifugal impeller **43** driven by the electric motor **53** from a main shaft **26** which is supported radially by two axially spaced bearings **25** and **37** but is only supported axially by the bearing **25**. This main shaft **26** is hollow and also drives an inducer impeller **48** in the pump inlet ahead of the main centrifugal impeller **43**. The inducer impeller has blades **48***c* which exert downward thrust loads when propelling fluid and developing a head pressure in the pump inlet. However, thrust loads of this inducer impeller **48** are supported by the top bearing **37** through a shaft **47** which extends through the hollow main shaft **26**. In this manner, excessive loads on the main pump bearing **25** are relieved and heretofore encountered bearing failures are avoided.

Fluids to be pumped enter the bottom of a pump unit **10** through the bottom opening **21** and are immediately acted upon by the blades **48***c* of the inducer **48** to feed the fluid through a chamber **22** to the inlet of the main centrifugal impeller **43**. This impeller **43** centrifugally discharges the fluids into the annular chamber **16** between the casings **14** and **15**. Vanes **34** in this chamber diffuse the rotating fluid from the discharge of the impeller **43** into an axial flow. The fluid flows through the annular passage **16**, through slots **31** at the top of the annular passage **16** into an outlet **33** from which the fluids are discharged to the outlet pipe **11**. The vanes **48***c* of the impeller **48** can be as numerous as desired to provide desired inlet head pressures for the main pump impeller since heavy thrust loads on the inducer will not have any effect on the main pump bearing **25**.

I claim as my invention:

1. In a pump and motor unit having a main pump impeller and an inducer impeller ahead of the main pump impeller driven by the same motor from a hollow main drive shaft supported in axially spaced bearings in the unit, one of which is adjacent the main pump impeller and the other of which is remote from the main pump impeller, the improvement which comprises a second shaft extending through the hollow main shaft sus-

pended from the remote bearing and supporting the inducer impeller to relieve the other bearing from thrust loads developed by the inducer impeller.

2. The improvement of claim **1** wherein the inducer impeller is slidably keyed on the hollow main shaft and is free to slide axially on the main shaft.

3. The improvement of claim **1** wherein the bearings are respectively at the bottom and top of the motor.

4. The improvement of claim **1** wherein the bearings are ball bearings.

5. A submersible electric motor driven centrifugal pump adapted for pumping cryogenic fluids and fluids at their boiling points which comprises a casing adapted to be mounted in the bottom of a tank and having a bottom inlet and a top outlet, an electric motor in the casing, a hollow shaft driven by said motor, a centrifugal impeller mounted on said shaft for corotation therewith receiving fluid from said inlet and discharging fluid through the casing to the top outlet, a second shaft extending through said hollow shaft, an inducer impeller slidably keyed on said hollow shaft in said pump inlet, means suspending said second shaft from the top of said casing, and means axially supporting said inducer impeller on said second shaft.

6. The pump of claim **4** wherein the casing has a main antifriction bearing supporting the hollow shaft radially and axially and a top antifriction bearing radially supporting said shaft and axially suspending said second shaft.

7. The pump of claim **4** including a first antifriction bearing radially and axially supporting the hollow shaft and a second antifriction bearing spaced from the first bearing also radially supporting the hollow shaft and radially and axially supporting the second shaft.

8. The pump of claim **4** wherein the second shaft is suspended from a top antifriction bearing in the top of the casing.

9. The pump of claim **4** wherein a ball bearing in the casing at bottom end of the motor carries thrust and radial loads of the hollow shaft and a second ball bearing in the casing at the top end of the motor suspends the second shaft.

10. The pump of claim **4** wherein the inducer impeller has a hub slidably keyed on the bottom end of the hollow shaft and four blades extend from the hub across the pump inlet to develop inlet head pressure for the centrifugal impeller.

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