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CENTRIFUGAL PUMP HAVING A SHAFTLESS IMPELLER

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Fig. 1.

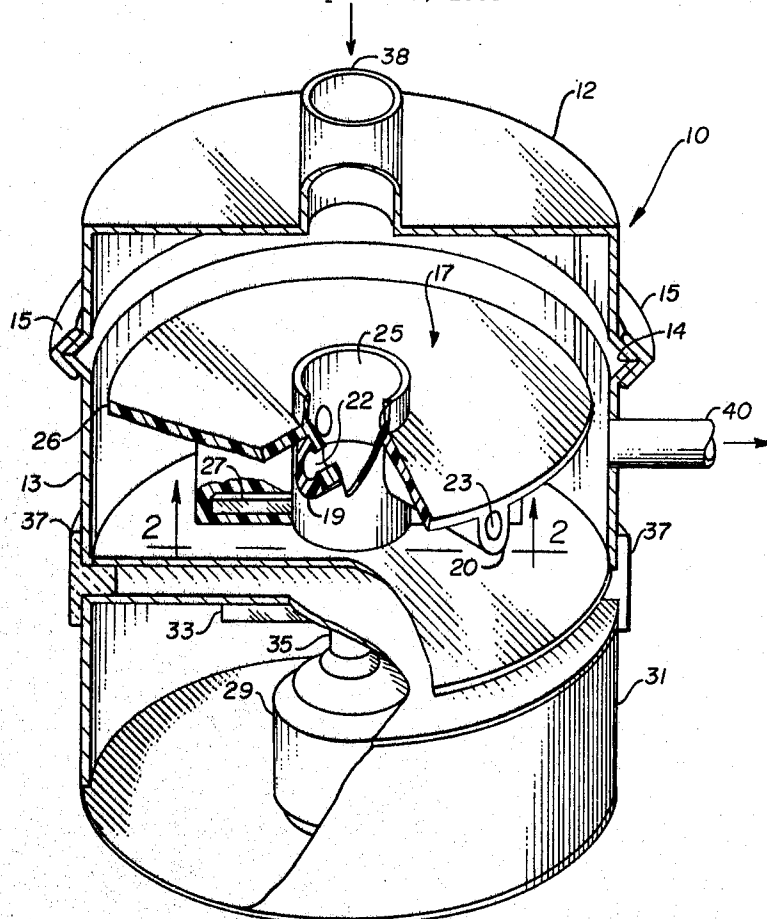
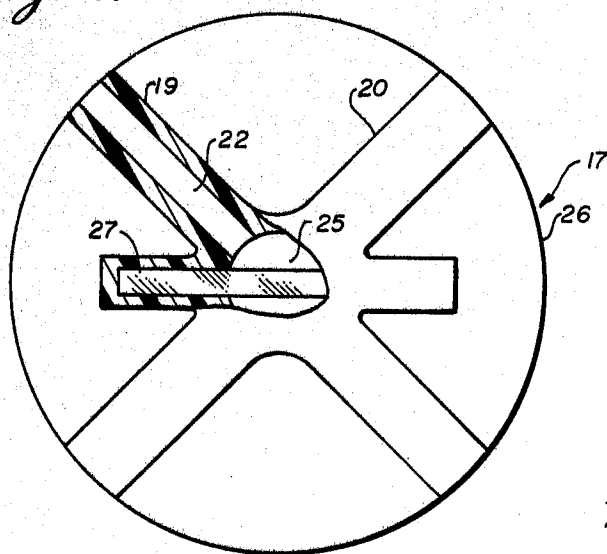


Fig. 2.



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CENTRIFUGAL PUMP HAVING A SHAFTLESS IMPELLER

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7 Claims

ABSTRACT OF THE DISCLOSURE

A centrifugal pump having a lightweight nonmagnetic shaftless impeller in which a bar magnet is embedded for magnetic coupling with a corresponding motor driven bar magnet that is external to the pump housing and that automatically aligns the impeller with the housing. The shape of the impeller is such that upon being rotated a lifting force is created which is balanced by the magnetic coupling force, thereby tending to cause the impeller to float in the fluid being pumped.

BACKGROUND OF THE INVENTION

The invention disclosed herein was made under, or in, the course of Contract No. AT(04-3)-400 with the United States Atomic Energy Commission.

The present invention relates to centrifugal pumps, and more particularly, it pertains to a centrifugal pump in which no bearings or shafts are required whereby it is especially useful as a liquid cryogen pump since introduction of heat into the pump is minimized.

One persistent problem in the design of pumps for liquids cryogen is to effectively minimize the introduction of heat into the pump to prevent boiling and flushing of the liquid cryogen from the pump. A conventional impeller type centrifugal pump used as a cryogenic pump permits heat to be introduced by conduction through the impeller driving shaft to the impeller and interior of the pump housing. One technique for blocking heat introduced in this manner is to embed a magnet in the impeller and then couple it to a corresponding magnet external to the pump housing. The external magnet may be mounted on the shaft of a motor and the impeller thereby driven through the magnetic coupling between the two magnets. Since the pump is mechanically isolated from the driving motor, it may be easily mounted in a vacuum for effectively insulating the pump and the cryogen therein against introduction of heat. Another source of heat leakage into a cryogenic pump is that generated in the impeller bearings. To minimize this effect special care can be taken to align all bearing surfaces. Such alignment, however, is tedious and once the bearings are aligned they are difficult to maintain in alignment. This is especially true for cryogenic pumps where it is desirable to maintain the pump and motor housings separate.

SUMMARY OF THE INVENTION

In brief, the invention pertains to a centrifugal pump having a shaftless impeller that tends to float in the fluid being pumped. The impeller is driven through a magnetic coupling between magnetic material integral with the impeller and magnetic driving means external to the housing. The impeller is made in a shape such that a lifting force is created upon rotation of the impeller. This force moves the impeller slightly away from the housing during operation of the pump, and is balanced by the axial force of the magnetic coupling to maintain the impeller in a floating axially aligned op-

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erating position. Transverse alignment of the impeller with the housing is also accomplished through the magnetic coupling. Both axial and transverse alignment of the impeller with its housing is thereby automatically obtained. The isolation of the pump from its driving source and the tendency of the impeller to be rotated clear of the pump housing or any other bearing surfaces thereby results in a simplified, reliable, centrifugal pump in which the introduction of heat is minimized.

It is an object of the invention to minimize the introduction of heat into a cryogenic pump.

Another object is to drive a pump impeller clear of any bearing surfaces.

Another object is to automatically align the impeller of a centrifugal pump.

Other objects and advantageous features of the invention will be apparent in a description of a specific embodiment thereof, given by way of example only, to enable one skilled in the art to readily practice the invention, and described hereinafter with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a front view of a centrifugal pump and driving motor partially in cross section and with portions broken away, according to the invention.

FIGURE 2 is a bottom view of the impeller of the pump of FIGURE 1 taken in the direction of the arrows 2—2 and with portions broken away.

DESCRIPTION OF AN EMBODIMENT

Referring to the drawing, there is shown in FIGURE 1 a centrifugal pump 10 comprising a cylindrical housing including an upper nonmagnetic housing portion 12 and a lower nonmagnetic housing portion 13. A metal seal 14 is provided between the housing portions which are held together by means of a V-clamp 15. A generally cylindrical impeller 17 is mounted for rotation within the lower housing portion. The impeller is formed to have a pair of cross vanes 19 and 20 with intersecting passages 22 and 23 respectively provided there-through. The passages meet at the center of the impeller where they are connected with a central axial passage 25 which opens into the interior of the upper housing portion 12. The upper sides of the vanes 19 and 20 are interconnected with a thin web 26. Magnetic material in the form of a permanent bar magnet 27 is embedded in the lower part of the impeller, close to the end of the housing portion 13.

Driving means, such as a motor 29, may be mounted in a nonmagnetic housing 31 that is external to the pump housing. The driving means also includes a bar magnet 33 mounted on a shaft 35 of the motor 29 for magnetically coupling the motor to the bar magnet 27 of the impeller 17. The magnet 33 is mounted next to the upper end of the housing 31, in proximity to the magnet 27 for good magnetic coupling. The pump and/or motor housings or motor may be adjusted to transversely align the impeller 17 within the housing 31 through the magnetic coupling of the bar magnets. Thereafter, the impeller is maintained automatically in alignment through the magnetic coupling. If desired, the pump and motor housings may be made an integral unit by means of interconnection with heat insulating support blocks 37. Once the impeller and driving means are transversely aligned, any slight relative shifts therebetween will not cause added transverse pressure on bearings with resultant heating as would occur in conventional pumps with shaft mounted impellers.

In operation, the fluid to be pumped, such as a liquid cryogen, is supplied through an inlet 38 into the interior

of the housing portion 12 for transfer through the central axial passage 25 to the vane passages 19 and 20. The interior of the housing portion 12 is made relatively large to provide space for damping and subsidence of any turbulence of the incoming fluid. Rotation of the motor shaft 35 causes the magnet 33 and therefore the magnet 27 to rotate in unison. The impeller 17 also is thereby rotated, causing the fluid in the housing portion 12 to flow through the passage 25 to be centrifugally forced through the vane passages 22 and 23. This causes an increased fluid pressure to build up between the housing portion 13 and the impeller 17, around the periphery of the impeller and between the end of the housing portion 13 and the web 26. The fluid is thus forced by the pump through an outlet 40 at a raised pressure. The pressure between the housing portion 13 and web tends to move or "lift" the impeller away from the housing, while the magnetic coupling between the magnets 27 and 33 opposes this movement. Friction between the impeller and housing is minimized by the lift; and with a proper balancing of lift and axial magnetic coupling forces, the impeller may be floated to entirely eliminate friction and resultant heating of the fluid. To minimize starting friction, the impeller and housing may be made of a slick plastic, or alternatively they may be coated with a slick plastic. The slick plastic also minimizes friction in the event the lift and axial magnetic coupling forces are not sufficiently balanced to float the impeller.

A model exemplifying the invention was constructed wherein the pump and motor housing were made of stainless steel, and the impeller was made of polytetrafluoroethylene. The surface of the pump housing 13 adjacent the impeller was coated with polytetrafluoroethylene. The inner diameter of the pump housing was 3.875 inches and the vane passages 22 and 23 had a diameter of 0.25 inch. The impeller web 26 was 0.375 inch thick. The fluid pumped was liquid nitrogen, and it was pumped at rates of 0, 16, and 42 liters/hour at differential pressures of 7½", 5½", and 2½" respectively, without any flushing or boiling of the fluid. The pump was found to be operable in any position from horizontal to vertical.

While an embodiment of the invention has been shown and described, further embodiments or combinations of those described herein will be apparent to those skilled in the art without departing from the spirit of the invention or from the scope of the appended claims.

What is claimed is:

1. A centrifugal pump for pumping a fluid, comprising:
 - (a) a cylindrical housing having an inlet and an outlet;
 - (b) an impeller mounted for rotation within said housing in a plane that is orthogonal to the central axis of said cylindrical housing for moving said fluid from said inlet to said outlet, said impeller including vanes for moving said fluid centrifugally and

creating a high pressure area between said impeller and housing for forcing said fluid through said outlet;

- (c) magnetic material integral with said impeller for magnetic coupling to an external driving means; and
- (d) means integral with said impeller for providing an axial lift of said impeller away from said housing upon rotation of said impeller by said driving means, said integral means including a web interconnecting said vanes and in a position to separate said inlet from said outlet whereby said high pressure area is created between said web and said housing, thereby tending to move said impeller away from said housing.

2. A centrifugal pump according to claim 1, wherein said impeller defines a central axial passage, and said vanes define a plurality of passages which are orthogonal to said central axial passage and which connect said central axial passage to said outlet.

3. A centrifugal pump according to claim 1, wherein said magnetic material is a first magnet integral with said impeller, and

further including a driving means external to said housing and comprising a motor, a shaft driven thereby, and a second magnet mounted on said shaft for cooperation with said first magnet.

4. A centrifugal pump according to claim 3, wherein said impeller is made of a lightweight material having a negligible mass, and

the axial coupling force between said magnets is equal to the force of said lift but in the opposite direction thereto when said impeller is rotating clear of said housing.

5. A centrifugal pump according to claim 3, wherein said first and second magnets are permanent bar magnets.

6. A centrifugal pump according to claim 1, wherein said housing defines a space between said inlet and said impeller sufficiently large to dampen any turbulence of the fluid as it flows into the space.

7. A centrifugal pump according to claim 1, wherein said impeller is made of a slick plastic, and further including a slick plastic coating on the interior surfaces of said housing adjacent said impeller.

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