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GAS PUMP WITH LIQUID REMOVAL MEANS

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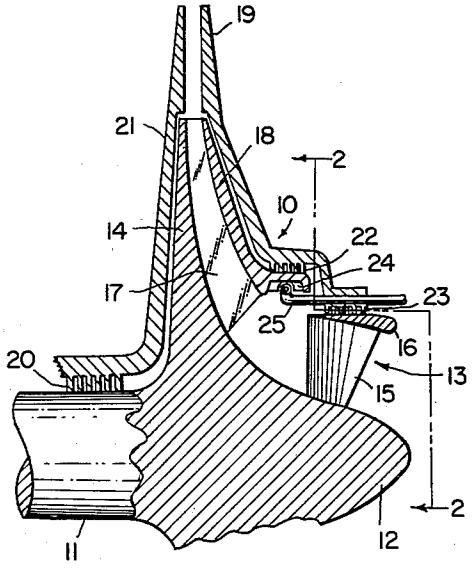

FIG. 1

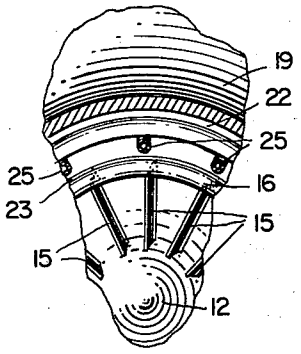

FIG. 2

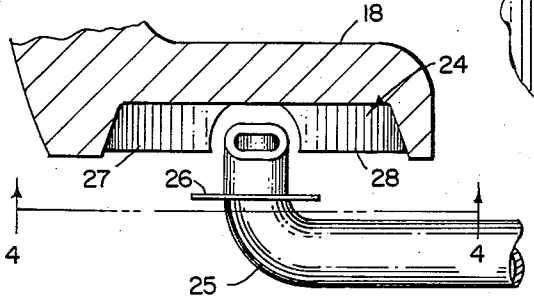

FIG. 3

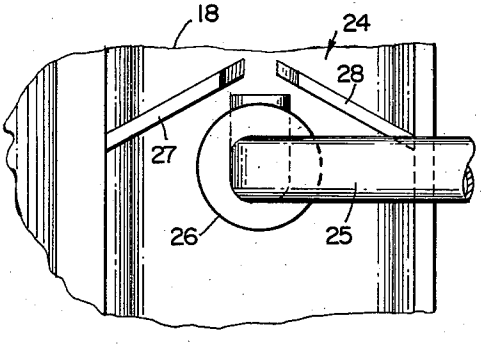

FIG. 4

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GAS PUMP WITH LIQUID REMOVAL MEANS

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This invention relates to a gas pump, and more particularly to a means for removing water or other liquids contained within the gaseous substance being pumped.

Quite often, water or some other liquid finds its way into a gas which is being propelled through a gas handling system and to maintain efficiency of the system, the liquid must be removed. An example would be the operation of an ion exchange membrane type fuel cell which utilizes hydrogen containing material as a fuel. In such an arrangement, water is produced as a by-product of the cell reaction. To maintain adequate cell efficiency any excess water must be removed.

It is an object of this invention to provide a gas pump which will pump a gas and at the same time will remove any liquid entrained within the gas.

Briefly stated, in accordance with one aspect of the invention, a gas pump is provided with a rotating shaft carrying an inducer comprising a plurality of radially extending vanes and an annular shroud circumscribing the outer ends of the vanes. The shaft also carries an impeller having a plurality of radially extending vanes and an annular groove opening inwardly. The shroud on the inducer is inclined with respect to the axis of rotation in order that liquid collecting thereon is centrifuged toward the trailing edge of the shroud. The aforementioned impeller groove is positioned radially outwardly of the inducer shroud so that liquid that is centrifuged off the trailing edge of the inducer shroud enters this groove. The groove thereby receives and collects the liquid by centrifugal force. A liquid removing means extends into the groove and is adapted to scoop out the liquid collected therein and carry it away from the pump.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a sectional view taken axially through a gas pump employing the invention, with certain of the parts shown in elevation;

FIG. 2 is a view of the invention taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged fragmentary view showing one modification of the invention with some parts in section and some in elevation; and

FIG. 4 is a view of the invention taken along line 4—4 of FIG. 3.

Referring to FIGS. 1 and 2, a gas pump 10 is shown. A rotating shaft 11 carries at its end a hub 12. The shaft is supported by suitable bearing means (not shown) and is driven by a suitable power source (not shown). The aforementioned hub 12 is comprised of two major elements; an inducer 13 and an impeller 14.

The inducer 13 includes a plurality of airfoil type vanes 15 which extend radially outward from the hub portion 12. The outer ends of the vanes 15 are circumscribed by an inducer shroud 16 which takes the form of an annulus. The shroud 16 is preferably streamlined to avoid obstruction of the gas being drawn into the pump. Furthermore, the inducer shroud 16 is inclined with respect to the shaft axis, i.e., the circle defined by the trailing edge of the inducer shroud 16 is greater than that of the circle

defined by the leading edge of the induced shroud. The purpose for inclining the inducer shroud 16 will hereinafter be more fully discussed.

The impeller 14 includes a plurality of essentially radially extending vanes 17 and an impeller shroud 18. A vaneless diffuser 19 is provided at the outer ends of the impeller vanes.

Sealing means are provided at various points between the stationary and the rotating members to prevent leakage of the gas being pumped. Such sealing means are shown in the drawing at 20 between the shaft 11 and the diffuser housing 21, at 22 between the impeller shroud 18 and the diffuser housing 21, and at 23 between the diffuser housing 21 and the inducer shroud 16.

Alternative configurations are of course possible. For example, the pump of the present invention could be designed with a rotatable housing having the vanes carried thereon.

The device as thus far described, however, is a conventional radial compressor or gas pump wherein air is drawn in axially by means of the inducer vanes 15. The inducer 13 propels the gas axially and outwardly to the impeller vanes 17, whereupon it is compressed and accelerated radially out through the vaneless diffuser 19.

In some applications of a blower or gas pump as just described, the gas being handled has undesired liquid entrained therein. In accordance with the invention, to remove this liquid an annular groove 24 is provided in the impeller shroud 18. As can be seen from the drawing, the groove 24 is of greater diameter than the trailing edge of the inducer shroud 16. Moreover, the groove 24 is positioned so that a portion of it lies in a common plane, normal to the axis of shaft 11, with the trailing edge of the inducer shroud 16.

Particles of liquid which are entrained in the gas passing through the blower are trapped in the inducer vanes 15 and are centrifuged radially outward until they contact the inducer shroud 16. Since the inducer shroud 16 is inclined with respect to the shaft axis, as mentioned above, liquid accumulating on the inducer shroud 16 is further centrifuged toward the trailing edge of the shroud. As the liquid reaches the trailing edge of the inducer shroud 16, it separates from the shroud and enters the collector groove 24 where it is collected by further centrifugal action. Liquid removal means, such as Pitot tube 25, extends into the groove 24 to remove the liquid therefrom. The liquid removal means is arranged so that its open end faces the oncoming liquid as the liquid rotates with the impeller shroud 18. Liquid which enters the tube 25 is carried away from the pump to a suitable disposal means (not shown). Obviously, a plurality of liquid removal means, such as tube 25, could be angularly spaced about the groove to increase the liquid removing capacity of the invention. This may be desirable if the gas being pumped has an extremely large quantity of liquid entrained therein. Since the aforementioned space between the inducer shroud 16 and the impeller shroud 19 is an unbroken annulus, there would be no problem in so providing a plurality of liquid removal means such as tube 25. Furthermore the tube 25 may assume various configurations, e.g., round as in FIG. 1 or flattened as in FIG. 2. In addition, a deflector 26 may be used to improve the scavenging ability of the tube by preventing leakage of the liquid past the tube orifice back into the gas stream.

As will be noted in FIG. 1, the inducer vanes 15 are axially spaced from the impeller vanes 17. This spacing allows the particles of liquid to enter the liquid collecting groove 24 with limited opportunity of being carried on into the impeller vanes 17 which would result in the liquid particles being reentrained within the gas stream.

Furthermore, the inducer shroud **16** is radially spaced from the impeller shroud **18** which extends axially upstream beyond the lowermost extremity of the impeller vanes. The liquid collecting groove is formed in this axial extension as shown in FIG. 1. The radial spacing between the inducer shroud **16** and the impeller shroud **18** provides an annular area which accommodates one or more liquid removing means **25**.

FIGS. 3 and 4 illustrate a modification of the present invention wherein a plurality of vanes **27** and **28** are provided in the groove **24**. It has been discovered that some liquids, after being collected in the groove **24** tend to divide into two pools, one on each side of the liquid removing means **27**. This situation is partially caused by a cutting action of the liquid removing means **25** as the liquid is rotated past the liquid removing means **25**. This may result in an inefficiency of removing the liquid and in gas entering the liquid handling system which may be undesirable depending upon the exact liquid handling system employed. The vanes **27** and **28** are essentially identical in size and configuration and as can be seen in FIG. 4, the vanes **27** and **28** may be angled with respect to the sides of the groove. This angling of these vanes is not imperative but it does urge the liquid toward the center of the groove **24** and thereby aligns it with the inlet of the liquid removing means **25**. The inner end of each vane **27** and **28** is given the same curvature as the outer diameter of the liquid removing means **25** to provide a closer clearance between the liquid removing means **25** and the individual vanes **27** and **28**. Any number of vanes **27** and **28** may be spaced about the axis of the groove **24**.

As will be evident from the foregoing description, certain aspects of the invention are not limited to the particular details of construction of example illustrated, and it is contemplated that various and other modifications or applications will occur to those skilled in the art. It is therefore intended that the appended claims shall cover such modifications and applications as do not depart from the true spirit and scope of the invention.

Having thus described the invention, what is claimed is:

1. A gas pump comprising:
(*a*) a rotating inducer,
(*b*) a rotating impeller,
(*c*) said rotating inducer having a plurality of radially extending vanes and an annular shroud circumscribing the ends of said vanes,
(*d*) said rotating impeller having an annular groove adapted to receive and collect liquid which is centrifuged from said shroud, and
(*e*) means for removing liquid from said annular groove.

2. The invention as defined in claim 1 wherein said liquid removing means comprises a tube extending into said annular groove.

3. A gas pump comprising:
(*a*) a rotating inducer,
(*b*) a rotating impeller,
(*c*) said rotating inducer having a plurality of radially extending vanes and an annular shroud circumscribing the outer ends of said vanes,
(*d*) said rotating impeller having an annular groove adapted to receive and collect liquid which is centrifuged from said shroud,
(*e*) said annular groove being spaced from said annular shroud, and
(*f*) means for removing liquid from said annular groove.

4. The invention as defined in claim 3, wherein said liquid removing means includes a conduit extending between said annular shroud and said annular groove for conveying the liquid away from the pump.

5. A gas pump comprising:
(*a*) a rotating shaft,

(*b*) an inducer carried by said shaft and having a plurality of radially extending vanes,
(*c*) an annular shroud circumscribing the outer ends of said inducer vanes,
(*d*) said shroud having a leading edge and a trailing edge,
(*e*) said trailing edge defining a circle larger than that defined by said leading edge,
(*f*) an impeller carried by said shaft and having a plurality of radially extending vanes,
(*g*) said impeller having an annular liquid collecting groove opening radially inward,
(*h*) said annular groove and said trailing edge lying in a common plane normal to the axis of said shaft,
(*i*) said annular groove being adapted to receive and collect liquid centrifuged from the trailing edge of said shroud, and
(*j*) liquid removing means for removing liquid from said annular groove.

6. The invention as defined in claim 5 wherein said annular groove is spaced from said trailing edge.

7. The invention as defined in claim 6 wherein said liquid removing means includes a conduit extending between said annular shroud and said annular groove for conveying the liquid away from the pump.

8. A gas pump comprising:
(*a*) a rotating inducer,
(*b*) a rotating impeller,
(*c*) said rotating inducer having a plurality of radially extending vanes and an annular shroud circumscribing the ends of said vanes,
(*d*) said rotating impeller having a plurality of radially extending vanes and an annular groove adapted to receive and collect liquid which is centrifuged from said shroud,
(*e*) said rotating inducer vanes being spaced from said rotating impeller vanes, and
(*f*) means for removing liquid from said annular groove.

9. A gas pump comprising:
(*a*) a rotating inducer,
(*b*) a rotating impeller,
(*c*) said rotating inducer having a plurality of radially extending vanes and an annular shroud circumscribing the ends of said vanes,
(*d*) said rotating impeller having an annular groove adapted to receive and collect liquid which is centrifuged from said shroud,
(*e*) means for removing liquid from said annular groove comprising a tube extending into said groove, and
(*f*) a plurality of vanes disposed within said annular groove to urge the liquid collected in the groove toward the liquid removing means.

10. A gas pump comprising:
(*a*) a rotating inducer,
(*b*) a rotating impeller,
(*c*) liquid collecting means comprising an annular groove on said rotating impeller, and
(*d*) means for removing liquid from said collecting means.

11. The invention as defined in claim 10 wherein said means for removing liquid comprises a tube extending into said annular groove.

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