A rotating radial tube pump has a rotary portion and an extended inlet integral therewith, both of which rotate about a longitudinal axis through the extended inlet. The rotary portion has a traverse passageway with outlet openings at each end and an inlet opening into the transverse passageway. The extended inlet has a passageway traversing between an extended inlet opening and an extended outlet opening at each end of the passageway. The extended outlet opening communicates with the inlet opening of the passageway through the rotary portion. As the extended inlet and the rotary portion are rotated about a longitudinal axis through the extended inlet, the fluid flows into an inlet opening of the passageway traversing the extended inlet and then into the passageway traversing the rotary portion and then is expelled radially outward from outlet openings at each end of the passageway traversing the rotary portion.
FIGURE 3
Spinning Disk Torque and Power

**FIGURE 4**

- **Power, mW**
  - 1.5 mm Disk Thickness
  - 2.0 mm Disk Thickness

- **Torque, μN·m**

- **Rotational Speed, rpm x 1000**

FIGURE 5
ROTATING RADIAL TUBE PUMP

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was made with government support under U.S. Government Contract Number NNC06BA07B awarded by the Administration of NASA. The Government has certain rights in the invention.

FIELD OF THE INVENTION

The present disclosure relates to radial tube pumps for fluids, and more particularly to a rotating radial tube pump for compressible fluids, the pump being of the fully closed design in which the radial flow passages are contained fully within a rotating structure.

BACKGROUND OF THE INVENTION

Centrifugal pumps were invented in France around the middle of the nineteenth century. Before their introduction, only positive displacement pumps were available (i.e., specifically, piston, vane, and gear types) which were costly to manufacture since the machine tool industry was not yet sufficiently developed to the kinds of production standards that enable the tight tolerances that make positive displacement pumps most reliable. Centrifugal pumps, because of their inherent simplicity, durability, and low fabrication cost, quickly replaced the more expensive positive displacement pumps and the bulk of pump research and development throughout the world was slanted to the perfection of the many varieties of centrifugal (a.k.a., velocity) pumps for which markets existed. Centrifugal or velocity pumps are today the most widely used pump type.

Centrifugal pumps can be classified as fully open, semi-open, or fully closed. An example of a semi-open centrifugal pump is the sort used as a compressor in an automotive turbocharger, wherein the radially oriented vanes are affixed to a backing plate, or shroud, that rotates in a unitary way with the vanes. In fact, in this specific example, the vanes and backing plate are manufactured in a single piece, either as a single casting or as machined from a solid block of metal. By contrast, a common example of a fully closed centrifugal pump is the sort used in vacuum cleaners wherein the rotating and radially oriented vanes are positioned between two plates of metal, front plate and backing plate, which move in a unitary way with the vanes contained between them. Such fully closed centrifugal pump impellers are, at least in the case of household vacuum cleaners, produced plastic or from sheet metal such that the impeller vanes are disposed between the front and back shrouds and held in position by rivets or bent metal tabs. Fully enclosed centrifugal pumps can also be produced as castings of metal or plastic, as is commonly found in automotive water pumps. Fully open centrifugal pumps consist of radially oriented vanes that are affixed to the shaft that transmits rotational motion to the system. The vanes rotate in a unitary way within a stationary housing that fits with close tolerances around the rotating members.

Very small centrifugal pumps are rare items having little demand in the realms of industry or consumer products. The smaller a centrifugal pump is, the less flow rate it can deliver. They have to spin at extreme high speeds to achieve a useful pressure differential between the intake and the exhaust. But there are instances where a very low flow and a low pressure differential is exactly what is needed and where space is limited; in such cases it is difficult to impossible to adapt a conventional centrifugal pump design to the intended purpose, and the non-conventional small centrifugal “Rotating Radial Tube Pump” is exactly what is needed.

SUMMARY OF THE DISCLOSURE

The present disclosure reveals a rotating radial tube pump, comprising a rotary portion and a extended inlet integral therewith. The extended inlet and the rotary portion rotate about a longitudinal axis that extends through the major axis of the extended inlet. The rotary portion has a first passageway traversing the rotary portion between first and second outlet openings at each end of the first passageway and a first inlet opening into the first passageway between the first and second outlet openings. The extended inlet has a second passageway traversing the extended inlet between an extended inlet opening and an extended outlet opening at each end of the second passageway, with the extended outlet opening of the second passageway communicating with the first inlet opening of the first passageway in the rotary portion.

The present disclosure also reveals a method of pumping fluid with a rotating radial tube pump. The method comprises the following steps: providing a rotary portion having a extended inlet integral therewith; rotating the extended inlet and the rotary portion about a longitudinal axis through the extended inlet; moving the fluid into an inlet opening of a second passageway traversing the extended inlet and into a first passageway traversing the rotary portion; and expelling the fluid radially outward from outlet openings at each end of the first passageway.

BRIEF DESCRIPTION OF THE DRAWINGS

The structure, operation, and advantages of the present invention will become further apparent upon consideration of the following description taken in conjunction with the accompanying figures (FIGs.). The figures are intended to be illustrative, not limiting.

Certain elements in some of the figures may be omitted, or illustrated not-to-scale, for illustrative clarity. The cross-sectional views may be in the form of “slices”, or “nearsighted” cross-sectional views, omitting certain background lines which would otherwise be visible in a “true” cross-sectional view, for illustrative clarity.

Often, similar elements may be referred to by similar numbers in various figures (FIGs) of the drawing, in which case typically the last two significant digits may be the same, the most significant digit being the number of the drawing figure (FIG).

FIG. 1A is an oblique see-through view of a first embodiment of a rotating radial tube pump, according to the present invention.

FIG. 1B is an oblique view of a second embodiment of a rotating radial tube pump, according to the present invention.

FIG. 1C is a series of the cross-sectional views of various cylindrical shapes of the rotating part of the second embodiment of a rotating radial tube pump, according to the present invention.

FIG. 1D shows the rotating part of the first embodiment in cross-sectional view plus a series of cut-away views of fluid passageways, according several embodiments of the present invention.
FIG. 1E is an oblique view of a third embodiment derivative of the second embodiment of a rotating radial tube pump, according to the present invention.

FIG. 2A is an oblique view of the first embodiment disposed upon and through the wall of a plenum chamber, according to the present invention.

FIG. 2B is an orthogonal cross-sectional view of the plenum chamber deployment of FIG. 2A, according to the present invention.

FIG. 3 shows three sets of curves displaying the design characteristics of the two embodiments of the pump, according to the present invention.

FIG. 4 shows three sets of curves displaying the torque and power requirements of the two embodiments of the pump, according to the present invention.

FIG. 5 shows two sets of curves displaying the pump performance map, according to the first and second embodiments of the invention.

The present disclosure relates to a rotating radial tube pump 10 designed for use with an optical airborne particle counter (not shown in any of the FIGURES). While the pump 10 is described as being used with fluid, it is within the terms of the invention to use the pump 10 with any gas or liquid. The overall characteristic dimension of a typical pump 10 is the order of 20 mm. The pump 10 is adapted to pull air through a particle counter (not shown). The dimensions of the airborne particles can be in the range of 300 nm (nanometers) to 10 micrometers.

Since the pump 10 can be an integral part of the particle counter, in a preferred embodiment, the pump is small and able to meet its basic performance requirements as well as have long life, emit low noise and operate satisfactorily at very low Reynolds Numbers, on the order of 90. The pressure differential that pump 10 can produce is on the order of 45 Pa (Pascals). The embodiment shown in FIG. 2A moves air from inside of a plenum chamber to the outside air, as discussed in more detail herein.

Referring to FIG. 1A, there is illustrated a first embodiment of the present rotating radial tube pump 10, consisting of a rotary portion 12 and an extended inlet portion 14 integral therewith. The pump 10 rotates about a longitudinal axis A-A' axis of rotation. In this first embodiment shown in FIG. 1A, the rotary portion 12 is shown as a flat disk having a diameter D. The flat disk rotary portion 12 is disposed perpendicular to the axis or rotation A-A'. The rotary portion, or disk portion, 12, in FIG. 1A, has a first passageway 16 traversing the rotary portion between first outlet openings 16a, 16b at each and for a first inlet opening 16c to the first passageway between the first outlet openings. The passageway 16 is disposed midway between faces 12' and 12" of rotating disk portion 12. The extended inlet portion 14 has a second passageway 18 disposed coaxially with axis A-A' traversing the extended inlet between an extended inlet opening 18a and an extended outlet opening 18b at each end of the second passageway and wherein the extended outlet opening of the second passageway communicates with the first inlet opening 16c of the first passageway 16 in the rotary portion 12. The first passageway 16 and the second passageway 18 are disposed perpendicular to each other, and the second passageway bisects the first passageway. The second passageway 18 bisects the first passageway 16 in the rotary portion 12; the first and second passageways are disposed perpendicular to each other; and the first passageway is coaxial with diametrical axis Y-Y' of the rotary portion and the second passageway is coaxial with longitudinal axis A-A' through the extended inlet 14. The rotating radial tube pump 10 can be thought of as having a rotating portion 12 that is a rotating flat disk which is disposed perpendicular to the extended inlet 14 and centered on the extended inlet so as to rotate about the longitudinal axis A-A' of the extended inlet. The first passageway 16 and the second passageway 18 each has a circular cross section, or, conceivably, at least one of the first passageway and the second passageway has a noncircular cross section. Yet further in this regard, at least one or both of the first passageway 16 and the second passageway 18 can have a variable cross-sectional area, as illustrated in view (d) showing passageway 66 in FIG. 1D. The second passageway 18 bisects the first passageway 16 of the rotary portion 12. At least one of the first passageway 16 and the second passageway 18 has a circular cross section. It is also within the terms of a preferred embodiment that either the first passageway 16 and/or the second passageway 18 has a non circular cross section.

While not shown in the drawings, bearings can be provided that support the pump assembly 10 and the disk 12.

Even though the rotational speed of the pump 10 can be relatively high at 15,000 rpm, the tangential speed of the perimeter 17 of the disk portion 12 is very low as a result of the disk having a small diameter which reduces the level of the noise being generated so that a low noise design requirement can be achieved.

The extended inlet portion 14 of rotating radial tube pump 10, as shown in FIG. 1A, can have a length of about 6.0 mm, but the length is dependent on the application and therefore any desired length can be used.

As can be readily understood by those skilled in the art, when the rotor 12 rotates in either direction, about the axis A-A' as indicated in arbitrary direction by arrow 22, air or other fluid that is contained within the passageway 16 in the disk 12 experiences a centrifugal force that propels it to the perimeter 17 of the disk, thereby producing a low pressure region in the passageway near the axis of rotation A-A'. Because the passageway 18 in the extended inlet communicates with the passageway 16 at its central region near the axis of rotation A-A', air or generally, fluid moves into the passageway 18 in the direction indicated by arrows 20 and is thence expelled into passageway 16 and radially outward through openings 16a and 16b in the directions indicated by the arrows 21.

Referring now to FIG. 1B there is illustrated a second embodiment of a rotating radial tube pump 30 wherein the rotary portion 32 is a first elongated cylindrical portion with a first passageway 36 therethrough which is disposed perpendicular to a second passageway 38 through the extended inlet 34 and centered on the extended inlet so as to rotate about a longitudinal axis B-B' through the extended inlet.

The pump 30 rotates about the axis B-B' that is concentric with the extended inlet portion 34 and a passageway 38 which extends between the inlet opening 38a to the outlet opening 38b.

A passageway 36 transverses the length L of the elongated cylindrical portion 32, and has an outlet opening 36a at end 32a, an outlet opening 36b at end 32b, and an inlet
opening 36c which communicates with the outlet opening 38b of second passageway 38 which extends through the extended inlet 34.

[0031] The extended inlet portion 34 of pump 30 has an outlet opening 38b disposed coaxially with the extended inlet. The outlet opening 38b of passageway 38 communicates with the inlet opening 36c of passageway 36 in the cylindrical portion 32. Bearings that support the pump 30 assembly are not shown herein.

[0032] Even though the rotational speed of the pump 30 can be relatively high, for example 15,000 rpm, the tangential speed of the two ends 32a, 32b of the cylindrical portion 37 can be very low as a result of the small length l of the rotating elongated cylindrical portion 32. The result is that very low noise is generated so that a low noise design requirement can be achieved.

[0033] The passageway 36 through the elongated cylindrical portion 32 and the passageway 38 through extended inlet portion 34, respectively, can each have a circular cross section, and/or a variable cross-sectional area. Once again, as can be readily imagined by those skilled in the art, when the assembly 30 rotates in either direction about the axis B-B', as indicated in arbitrary direction by arrow 35, fluid that is contained within the passageway 36 in the cylindrical portion 32 experiences a centripetal force that propels it to the two outlet openings 36a, 36b of the passageway 36 which thereby produces a low pressure region in the passageway in the region of the axis of rotation B-B'. Because the outlet 38b of passageway 38 in the extended inlet 34 communicates with the inlet opening 36c of passageway 36 at its central region near the axis of rotation B-B', fluid moves axially into the extended inlet in the direction indicated by arrows 40 and is then hurled radially outward from the outlet openings 36a and 36b at ends 32a, 32b, respectively in the directions indicated by the arrows 41.

[0034] While the cylindrical portion 32, as described above in relation to FIG. 1B, is shown with a circular cross section, it may also be shaped in ways so as to streamline its motion and thereby reduce the noise of operation which is one of the design criteria.

[0035] Referring to FIG. 1C there are shown three cross-sectional designs of the cylindrical portion 32 of the pump embodiment 30 in FIG. 1B. Note that the term “cylindrical,” as used in common parlance, implies “circularly, cylindrical.” In strict mathematical terms, “cylindrical” refers to linear body elements that are parallel to a central axis. For example, FIG. 1B shows an axis X-X' of the circular cylindrical element 32 that rotates about the axis B-B’, with dotted line 37 on the outer surface of the circular cylindrical element being parallel to said axis and all such mathematical lines defining the circular shape of the cylinder being likewise parallel to one another and to the axis X-X'. FIG. 1C shows, in cross-sectional view in diagram (a), the circular shape 32a of the circular cylindrical element 32 of FIG. 1B. The other two views, (b) and (c), show alternative cylindrical cross-sectional shapes. View (b) in FIG. 1C shows an elliptical cylindrical shape 32b, with a central passageway and gas conduit 36b, and view (c) shows and stream-lined cylindrical cross-sectional shape 32c with a central gas conduit 36c projecting there through. Velocity (i.e., motion) vectors are for clarity of view, the vector v representing the motion of the circular cylindrical cross section 32a, vector v' representing the motion of the elliptical cylindrical cross section 32b, and v'' representing the motion of the stream-line cylindrical cross section 32c. It will be obvious to those skilled in the art that the respective velocity vectors could as well be pointing in the opposite directions and that the lengths of the vectors would, in actuality, represent velocity magnitudes that would be a function of rotational speed and distance from the axis of rotation, i.e., axis B-B' in FIG. 1B.

[0036] Another embodiment of the portion 32 in FIG. 1B and the two non-circular variant displayed in FIG. 1C need not be a constraining design criterion. The rotating element 32 might also conveniently be constructed so as to have non-cylindrical shape.

[0037] The inventor further contemplates a rotating radial tube pump 10 having both a first passageway 64 and a third passageway 65, both of which are disposed within the rotating flat disk 12 as per view (c) of FIG. 1D. In this arrangement, the third passageway 65 intersects the first passageway 64 and the second passageway 18 (as shown in FIG. 1A). The third passageway 65 has an inlet opening 65a coincident with the first inlet opening 64a of the first passageway 64 as shown in view (c) of FIG. 1D.

[0038] Referring now to FIG. 1D, there is shown in view (a) an edge-on view of the pump 10 of FIG. 1A, showing the passageway 16 within the rotary portion 12 as well as the respective openings 16a, 16b. The remaining views (b), (c), (d), and (e) show in cutaway view in accordance with the view V-V' various alternative shapes and arrangements of internal passageways. View (b) in FIG. 1D, shows the same arrangement as in FIG. 1A, wherein the first passageway 16 progresses diametrically across the disk 12. View (c) shows two diametrically disposed passageways 64, 65 which, though shown as perpendicular to one another need not be so arranged to be within the spirit of this disclosure. View (d) shows a passageway 66 that widens toward the exit ends 66a and 66b, though, depending on design requirements, could as well become narrower, with smaller cross-sectional areas towards the exit ends. Finally, in view (e), there is shown a passageway 68 which follows a non-linear pathway from the central region 69 to the exit ends 68a, 68b. It is within the spirit and scope of this disclosure that any combination of passageway designs and numbers of passageways could be used. The arrows 75 are intended to show rotation, albeit with at most arbitrary reference to specific rotational direction.

[0039] FIG. 1E is an oblique view of another embodiment 80 of the rotating radial tube pump embodiment 30 that is illustrated in FIG. 1B. In this embodiment 80, the rotary portion has a first elongated cylindrical portion 82 and a second elongated cylindrical portion 84, the latter having a third passageway 92 therethrough which is disposed perpendicular to a second passageway 88 through the extended inlet 86 and centered on the extended inlet so as to rotate about the longitudinal axis C-C' of the extended inlet. That is to say, the rotating radial tube pump 80 has two rotating elongated cylindrical portions 82, 84, each disposed perpendicular to and bisected by an extended inlet portion 86 so as to rotate about a longitudinal axis C-C'. The respective rotating elongated cylindrical portions 82, 84 might or might not be perpendicular to one another. Each of the respective elongated cylindrical portions 82, 84 has a passageway 90, 92 respectively, extending therethrough. That is, the passageway 90 extends from end 84a to end 84b of the rotating cylindrical portion 84, and the passageway 90 extends from end 82a to end 82b of the cylindrical portion 82. Arrow 85 indicates rotation about axis C-C', that is concentric with an extended inlet portion 86, which has a passageway 88 extending between the inlet open-
In order to be consistent with other descriptions above, the passageway 90 in the cylindrical portion 82 comprises a first passageway, while the passageway 88 in the extended inlet portion 86 is herein referred to as a second passageway, and the passageway 92 in the cylindrical portion 84 comprises a third passageway. In a preferred embodiment, the first and third passageways 90 and 92 in the elongated cylindrical portions 82, 84, and also the second passageway 88 of the extended inlet 86, can each have a circular cross section with diameters 0.40 mm, 0.44 mm, and 0.60 mm respectively. However, the size of the first and third passageways 90 and 92 in the elongated cylindrical portions 82, 84, and also the second passageway 88 of the extended inlet 86 can be of any desired diameter and non-circular and of a variable cross-sectional area.

Yet again, as can be readily imagined by those skilled in the art, when the assembly 80 rotates in either direction about the axis C-C', as indicated in arbitrary direction by arrow 85, fluid that is contained within the passageways 90, 92 in the circular cylindrical portions 82, 84 experiences a centrifugal force that propels it to the outlet openings in the respective ends 82a, 82b, 84a, 84b which thereby produces a low pressure region in all the passageways in the region of the axis of rotation C-C' such that air or, more generally, fluid, as indicated by the arrows 94 gets drawn into the passageway 88 at its opening 88a which communicates with the passageways 90, 92 so as to be expelled in the radial directions indicated by the arrows 96.

While the rotary cylindrical portions 82, 84, as described above in relation to FIG. 1E, are illustrated with a circular cross section, the cross-sections might also be such as to streamline its motion and thereby reduce the noise of operation which is one of the design criteria, in accordance with the cross-sectional views that are illustrated in FIG. 1C in relation to the rotating tube pump embodiment 30 shown in FIG. 1B.

The design of rotating radial tube pump embodiments 10, 30 and the other variations described herein are such that neither the flat disk embodiment 10 shown in FIG. 1A nor the circular cylindrical cross-sectional embodiment 30 in FIG. 1B has a casing to receive fluid that is discharged radially from the passageways 16 and 36 respectively in the two embodiments. This is because the air is discharged directly to the atmosphere. In service, however, a casing or cover, not shown, might be employed to protect the pump rotor 12 from damage.

FIG. 2A schematically illustrates the type of arrangement, with a flat disk portion 50 of a type of rotating radial tube pump 40 of the sort illustrated as 12 in FIG. 1A being shown in oblique view on and through a wall 42 of a plenum chamber 44 containing a plenum volume 46. Opening 48 in the plenum chamber 44 connects to another volume, not shown, from which air is moved into the plenum 46 and thence through the rotating radial tube pump 40 to the outside air. That is to say, the plenum chamber 44 connects to such a thing as an airborne particle counter of the sort for which this rotating radial tube pump was intended and designed. Only one air conduit passageway 47 is visible in the oblique view of FIG. 2A.

FIG. 2B is an exemplary cross-sectional view of the rotating radial tube pump 40 of FIG. 2A in relation to the wall 42 of plenum chamber 44. The flat disk portion 50 is integral with the extended inlet 52 in the way described in relation to FIG. 1A. FIG. 2B shows a nipple 54 situated within, and extending through, the wall 42 of the plenum chamber 44, such that the nipple is stationary within the wall. The extended inlet 52 receives fluid, as shown by arrow 59, from the nipple 54. A circular seal 56 surrounds the nipple 54 and the extended inlet 52. The circular seal 56 is affixed to either the nipple 54, in which case it does not move, or to the extended inlet 52, with which it would rotate.

Were the present disclosed idea to be presented in terms of being a method of pumping, moving or drawing air, it could be said that the present disclosure relates to a method of pumping air or, more generally, fluid, with a rotating radial tube pump 10, 30, and that the method consists of providing a rotary portion 12, 32 having a extended inlet 14, 34 integral therewith. Then, by rotating the extended inlet 14, 34 and the rotary portion 10, 34 about a longitudinal axis (A-A', B-B') through the extended inlet, the result is, to speak generally, the moving or drawing of the fluid into an inlet opening 16a, 38a of a second passageway 18, 38 that is traversing the extended inlet and into a first passageway 16, 36 traversing the rotary portion and then expelling the fluid radially outward from outlet openings 16a, 16b, 36a, 36b at each end of the first passageway.

A motor, not illustrated, drives the rotating radial tube pump 40 by way of the rotating disk portion 40, such as by means of a belt (not shown) or direct drive to the disk portion.

Analysis

One embodiment of pump 10 was developed to meet the following specifications:

- Working fluid (e.g., air) density $\rho = 1.225$ kg/m$^3$
- Volumetric flow rate $Q = 0.401$ cm$^3$/s
- Inlet total pressure $P_{in} = 45$ Pa (gage)
- Inlet tube inside diameter $d = 0.40$ mm
- Maximum pump diameter $2R = 20$ mm
- Maximum rotational speed, $N = 15,000$ rpm

Referring to FIG. 1A, the pump 10 is supposed to generate the specified suction at its inlet 18 while discharging into ambient air at its exit passageways 16. The maximum rotational speed is a soft limit which may be exceeded if deemed necessary or advantageous.

Specific speed, defined as $NQ^{1/2}(\Delta p/\rho)^{1/4}$, is a dimensionless parameter for turbo-machine pumps. For the stated specifications, using 45 Pa as the total-pressure rise and 15,000 rpm as the rotational speed, the calculated value is 0.067, which is relatively low and suggests a rotating radial tube pump with a large exit-to-inlet radius ratio. In general, low specific speed indicates a relatively high pressure rise for the associated flow rate and rotational speed.

The pipe Reynolds number for the inlet tube is 87.4 at the specified flow rate. This value is also very low and indicates that the flow will be laminar everywhere inside the pump 10.

The present rotating radial tube pump 10 is a geometrically simple device, which appears to be highly suitable for meeting the design objectives and allows for a fairly accurate determination of the pressure (head) loss in the pump, especially with the low Reynolds numbers. For the given specifications, pump rotational speed $\Omega$ can be calculated as a function of pump radius $R$, radial-tube inside diam-
eter \(d_i\) and inlet-tube length \(l_i\). Assuming a value of 1.5 mm for \(d_i\), several characteristics were computed and graphed, and are shown here in FIG. 3. The “*” symbol in FIG. 3, corresponding to a pump diameter of 15.0 mm, a radial-tube inside diameter of 0.60 mm, a rotational speed of 14,288 rpm, and a hydraulic efficiency of 0.794, indicates the preliminary design, which is offered as a recommendation that reflects a balanced tradeoff between pump diameter and rotational speed.

[0060] Calculated curves for the (windage) torque and power needed to rotate such a disk are shown in FIG. 4. Comparing the torque needed to rotate the disk with that needed to pump the fluid reveals that the former is over 50 times greater. For the recommended preliminary design, the torque and power needed to pump the fluid are 0.0414 \(\eta\)N-m and 0.0619 mW, respectively, and the corresponding values to spin a 1.5 mm-thick disk are 2.32 \(\mu\)N-m and 3.48 mW, respectively. Use of the circular cylindrical configuration shown in FIG. 1B would decrease the windage torque by a factor somewhere around 1.5, maybe even 2.0, but the potential for noise generation would greatly increase. A more streamlined shape for the pipe exterior could be used, possibly decreasing the windage torque by another factor of 2.5 while also reducing the noise, as discussed above, but at the added cost of increased fabrication complexity. Regardless of configuration type, however, disk or pipe, the time and cost associated with mechanical design and fabrication are expected to be relatively small.

[0061] Documentation of the Faulhaber 0.023 mN-m brushless DC micromotor was included as part of the information package containing the pump design specifications, indicating that the Faulhaber motor is a likely candidate for driving the pump. The maximum torque and power of the Faulhaber motor, 23 \(\mu\)N-m and 40 mW, respectively, are about 10 times greater than the largest values discussed above for the pump, suggesting that the torque and power needed by the pump may be small enough to be considered relatively insignificant. If that is the case, the disk configuration would be a good option since it is expected to be virtually silent, and the inertia of the disk might be beneficial for speed control and stability.

[0062] A predicted performance map for the recommended preliminary design has been calculated and is shown in FIG. 5.

[0063] The uniqueness of the rotating radial tube concept of the preferred embodiment is that the desired flow area can be maintained as the diameter is increased from the inlet to the exit of the small rotating radial tube fluid pump disclosed herein.

[0064] Advantages of the preferred embodiment include: 1. Performance can be reliably predicted since the losses associated with tube flow is well documented; 2. Manufacturing is relatively simple and inexpensive; and 3. Design trades between size and rotational speed are very easy to make.

[0065] Although the invention has been shown and described with respect to a certain preferred embodiment or embodiments, certain equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular regard to the various functions performed by the above described components (assemblies, devices, etc.) the terms (including a reference to a “means”) used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (i.e., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary embodiments of the invention. In addition, while a particular feature of the invention may have been disclosed with respect to only one of several embodiments, such feature may be combined with one or more features of the other embodiments as may be desired and advantageous for any given or particular application.

1. A rotating radial tube pump, comprising:
a rotary portion and a extended inlet integral therewith;
the extended inlet and the rotary portion rotate about a longitudinal axis through the extended inlet;
the rotary portion having a first passageway traversing the rotary portion between first and second outlet openings at each end of the first passageway and a first inlet opening into the first passageway between the first and second outlet openings; and
the extended inlet having a second passageway traversing the extended inlet between an extended inlet opening and an extended outlet opening at each end of the second passageway and wherein the extended outlet opening of the second passageway communicates with the first inlet opening of the first passageway in the rotary portion.

2. The rotating radial tube pump of claim 1 wherein the second passageway bisects the first passageway in the rotary portion.

3. The rotating radial tube pump of claim 2 wherein the first and second passageways are disposed perpendicular to each other.

4. The rotating radial tube pump of claim 1 wherein the first passageway is coaxial with a diametrical axis of the rotary portion and the second passageway is coaxial with the longitudinal axis through the extended inlet.

5. The rotating radial tube pump of claim 4 wherein the diametrical axis of the rotary portion is bisected by the longitudinal axis through the extended inlet.

6. The rotating radial tube pump of claim 1 wherein at least one of the first passageway and the second passageway has a circular cross section.

7. The rotating radial tube pump of claim 1 wherein at least one of the first passageway and the second passageway has a non-circular cross section.

8. The rotating radial tube pump of claim 1 wherein at least one of the first passageway and the second passageway has a variable cross sectional area.

9. The rotating radial tube pump of claim 1 wherein the rotary portion is a rotating flat disk which is disposed perpendicular to the extended inlet and centered on the extended inlet so as to rotate about the longitudinal axis through the extended inlet.

10. The rotating radial tube pump of claim 9 wherein:
the rotary portion has a third passageway diametrically disposed within the rotating flat disk and intersecting the first passageway and the second passageway; and
the third passageway having a third inlet opening coincident with the first inlet opening of the first passageway.

11. The rotating radial tube pump of claim 1 wherein the rotary portion is a first elongated cylindrical portion with a first passageway there through which is disposed perpendicular to the second passageway through the extended inlet and centered on the extended inlet so as to rotate about the longitudinal axis through the extended inlet.
12. The rotating radial tube pump of claim 11 wherein: the rotary portion has a second elongated cylindrical portion having a third passageway there through which is disposed perpendicular to the second passageway through the extended inlet and centered on the extended inlet so as to rotate about the longitudinal axis through the extended inlet.

13. A method of pumping fluid with a rotating radial tube pump, comprising:
   providing a rotary portion having a extended inlet integral therewith;
   rotating the extended inlet and the rotary portion about a longitudinal axis through the extended inlet;
   moving the fluid into an inlet opening of a second passageway traversing the extended inlet and into a first passageway traversing the rotary portion; and
   expelling the fluid radially outward from outlet openings at each end of the first passageway.

14. The method of claim 13 including moving the fluid into the first passageway at a location where the second passageway bisects the first passageway in the rotary portion.

15. The method of claim 13 including moving the fluid through the second passageway having a circular cross section and into the first passageway having a circular cross section.

16. The method of claim 13 including moving the fluid through the second passageway and into the first passageway wherein at least one of the first and second passageways has a noncircular cross section.

17. The method of claim 13 including moving the fluid through the second passageway and into the first passageway wherein at least one of the first and second passageways has a variable cross sectional area.

18. The method of claim 13 including:
   moving the fluid through the rotary portion formed as a rotating flat disk; and
   rotating the flat disk about the longitudinal axis through the extended inlet.

19. The method of claim 18 including:
   providing the rotary portion with a third passageway diametrically disposed within the rotating flat disk and intersecting the first passageway and the second passageway; and
   providing the third passageway with a third inlet opening coincident with the first inlet opening of the first passageway.

20. The method of claim 13 including:
   moving the fluid through the rotary portion formed as a rotating elongated cylindrical portion; and
   rotating the elongated cylindrical portion about the longitudinal axis through the extended inlet.

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