

[54] **AXIAL FLOW UNIT**

[75] Inventor: **Harvey E. Richter**, Farmington, Conn.

[73] Assignee: **The Tec Group Inc.**, Bloomfield, Conn.

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[51] Int. Cl. **B02c 18/18**

[58] Field of Search **241/39, 46 R, 46.17, 185 A, 241/278 R, 278 A, 282.1, 292.1, 299; 415/210, 121 B, 122 A; 417/247; 30/349**

[56] **References Cited**

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Primary Examiner—Granville Y. Custer, Jr.
Attorney, Agent, or Firm—John M. Prutzman et al.

[57] **ABSTRACT**

An axial flow unit is provided having a cylindrical rotor with impeller blades extending radially inwardly from the inside wall of the rotor and terminating in an elongated knife-like cutting edge. The radial distance of the cutting edge of each blade from the inside rotor wall progressively increases from one end of the blade toward its opposite end. The blades are arranged in helical symmetrical relation about the major longitudinal axis of the rotor, and a blade profile in a plane normal to that axis provides a projection with each blade in spaced relation to an adjacent blade.

8 Claims, 4 Drawing Figures

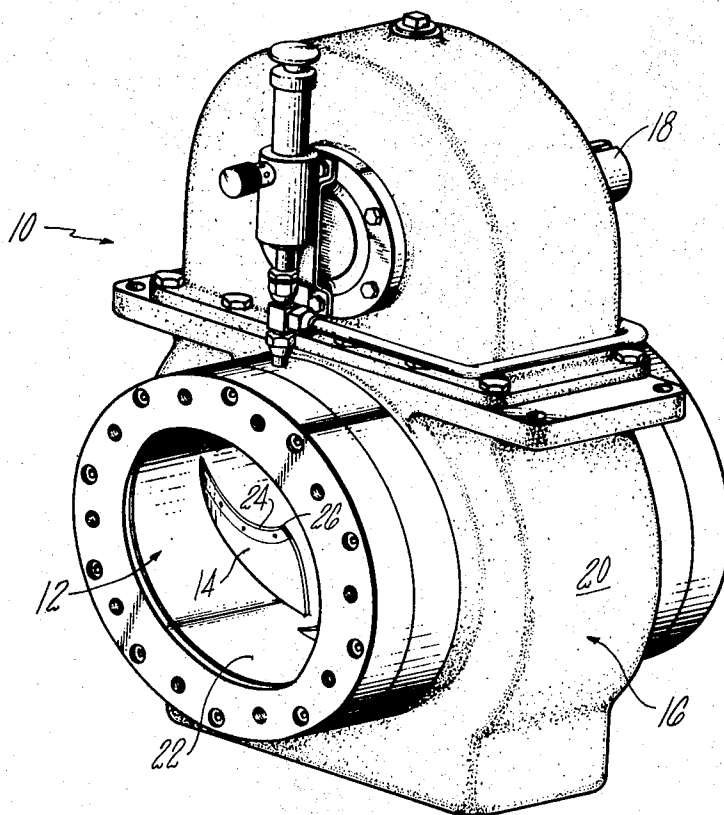


FIG. 1

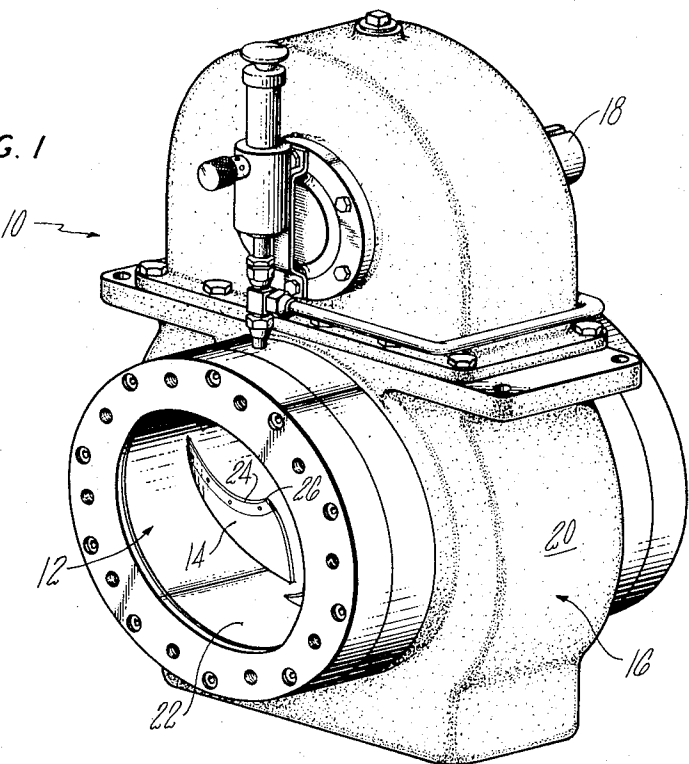


FIG. 2

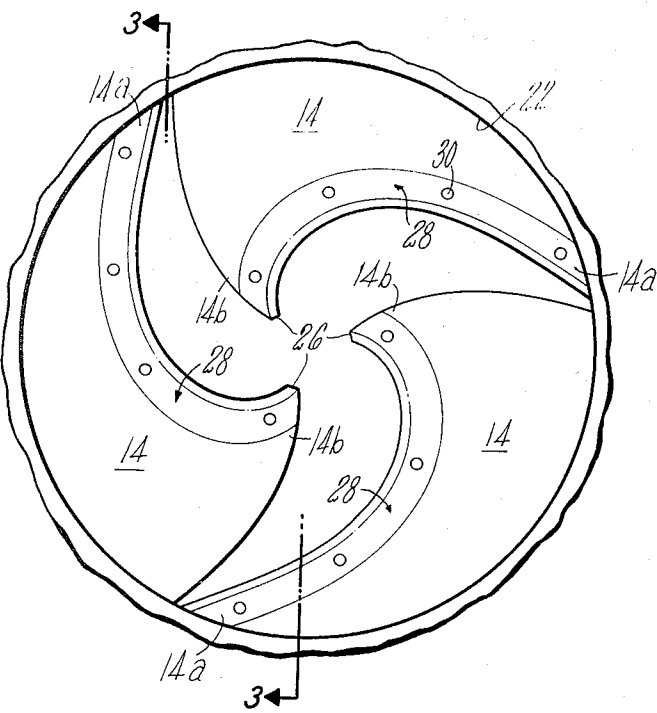
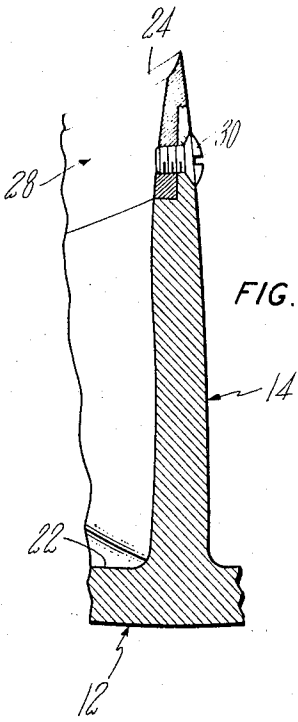


FIG. 4



AXIAL FLOW UNIT

This invention generally relates to flow propulsion units and particularly concerns such units characterized by axial flow.

A primary object of this invention is to provide a new and improved axial flow unit having a unique impeller blade construction.

Another object of this invention is to provide a new and improved axial flow unit capable of being used in a variety of different applications while reliably meeting rigorous performance requirements under demanding conditions with minimum service problems.

A further object of this invention is to provide an axial flow unit of the type described particularly suited for substantially clog-free operation. Included in this object is the aim of providing such a unit having a new and improved impeller blade arrangement which effects a knife-like slicing action capable of slashing and reducing foreign matter, such as aquatic weeds, sewage, etc. normally tending to clog and stop conventional devices of this type, into easily handled effluence.

Still another object of this invention is to provide a unit of the type described having a compact construction quick and easy to manufacture, assembly and to maintain.

Other objects will be in part obvious and in part pointed out in more detail hereinafter.

A better understanding of the objects, advantages, features, properties and relationships of the invention will be obtained from the following detailed description and accompanying drawings which set forth an illustrative embodiment and is indicative of the way in which the principle of this invention is employed.

In the drawings:

FIG. 1 is an isometric view of a unit incorporating this invention;

FIG. 2 is an enlarged axial end view, partly broken away, showing a blade profile projection of the unit of FIG. 1;

FIG. 3 is a further enlarged view, partly broken away and partly in section, taken generally along line 3—3 of FIG. 2; and

FIG. 4 is a still further enlarged view, partly broken away and partly in section, taken generally along line 4—4 of FIG. 3.

Referring to the drawings in detail, a preferred embodiment of this invention is shown for illustrative purposes as being incorporated in an axial flow device or unit generally designated 10. While this invention may be employed in different ways such as, e.g., a power propulsion unit of the type described in my U.S. Pat. No. 2,997,015 issued Aug. 22, 1961 and entitled "Marine Propulsion Device," this invention is shown and described for illustrative purposes in the context of a pump. Moreover, this invention may be used in a wide variety of different pumping applications such as for pumping sludge, sewage, sand etc. while being equally useful in dredging operations, oil transfer, fruit and weed harvesting and other industrial processes requiring a pumping function.

The pump 10 is an open-center axial flow type such as described in my U.S. Pat. No. 3,276,382 issued Oct. 4, 1966 and entitled "Fluid Flow Device." Pump 10 has a generally cylindrical rotor 12 with impeller blades such as at 14. The rotor 12 provides a passageway for

flow media such as liquids, gases or solids or mixtures and/or solutions or liquids, gases and solid matter. The rotor 12 is shown mounted for rotation within a housing generally designated 16.

Units of this type are normally powered and require a suitable power source such as a motor, not shown, for rotating an input shaft 18 drivingly connected to gearing, and suitable bearing means must be employed for axially positioning and rotatably supporting the rotor 12 within the housing 16. As will be appreciated, a number of problems are associated with conventional units of this type. The present inventor recently solved certain longstanding, troublesome mechanical sealing problems, associated with such units under high peripheral speed conditions, and additionally provided quick and easy adjustment of sealing pressures to correspond to varying operating conditions. A positive-acting rotary mechanical seal suitable to overcome these problems is the subject matter of patent application Ser. No. 236,433, filed Mar. 20, 1972 in the name of the present inventor and assigned to the assignee of this invention. This patent application fully describes the particular housing and rotor construction shown in FIG. 1, and the subject matter of that application is incorporated herein by reference.

Housing 16 defines and encloses a lubricant chamber having an annular portion provided within base portion 20 of the housing 16 and surrounding the rotor 12. Suitable drive and bearing components are mounted within the housing 16 and support the rotor 12 for rotation. It will be understood that rotor 12 has an external ring gear, not shown, mounted on an outside wall surface of the rotor and which is in meshing engagement with a suitable gear drivingly connected to the input shaft 18 as shown in my referenced patent application.

A longstanding problem encountered in many different uses to which axial flow units are being applied, concerns the need for such units to operate efficiently without becoming clogged by foreign matter carried by liquid or other flow media passing through the rotor and consequently resulting in undesired and costly downtime.

To overcome the above mentioned problem in a bidirectional axial flow unit wherein flow through the passageway may be in either axial direction depending upon the direction of rotation of the rotor, the rotor 12 of the specifically illustrated embodiment of this invention is shown with its blades such as at 14 extending radially inwardly from an inside circumferentially extending rotor wall surface 22 with the radial dimensioning of each blade 14 being tapered to progressively diminish from one end 14b toward its opposite end 14a. That is, should the left hand end of rotor 12 as viewed in FIG. 3 be considered the normal inlet end, blades 14 are each tapered along the length of the blade toward the normal inlet end of the rotor 12 in the illustrated embodiment, with the innermost radially projecting side of each blade 14 being formed with a knife-like cutting edge 24 (FIG. 4).

Each blade 14 is helical in shape, preferably of a true helix shape, which when rotated acts as a screw propeller to propel flow media through the rotor 12. The blades 14 directly apply a driving force to the perimeter of any column of flowable material being propelled through rotor 12. In the specifically illustrated embodiment, a smooth, powerful thrusting flow is achieved in

a substantially clog-free design wherein multiple blades 14 of generally parallel pitch with the same lead are shown equidistantly spaced apart on the inner surface of the rotor 12 about its major longitudinal axis. In viewing the blades 14 from an axial end of the rotor 12 along its major longitudinal axis as shown in FIG. 2, it will be seen that the blades 14 do not overlap one another. Rather, the blade profile which, when projected in a plane normal to the major rotor axis, shows each blade 14 in spaced relation to an adjacent blade 14 with the apex 26 of each blade 14 at its maximum radial depth being symmetrically spaced apart from the other blades 14 about the major rotor axis. FIG. 2 additionally shows that the lead and pitch of each blade 14 is selectively dimensioned and contoured such that the orthographic projection of each blade 14 in a plane normal to the major rotor axis extends a circumferential distance of less than 120° in the three blade arrangement illustrated, or $1/n$ of the circumferential distance around the rotor 12 where n is the number of blades such as 14 mounted on the rotor 12.

A significantly improved knife-like cutting action is obtained by virtue of the above described axially tapering helical blade construction which is further enhanced by tapering the cross-sectional thickness of each blade toward its innermost cutting edge 24 (FIG. 4). Quick and easy maintenance of the knife-like blade cutting edges 24 is ensured by the provision of elongated, replaceable knife attachments 28 individually mounted on each blade 14 and providing the cutting edges 24 which are preferably sharpened with hollow ground edges and extend coextensively with the blade 14 along its full length. The knife attachments 28 are secured to their respective blades 14 by suitable fasteners such as the illustrated machine screw 30, preferably with a lapping fit relative to its blade 14 as shown in FIG. 4. The disclosed impeller blade mounting and the axially unobstructed open-center design of this invention further simplifies removal and replacement of the knife attachments 28.

In operation, the effect of the rotating rotor 12 is to impart a centrifugal force on the media being propelled through the passageway, and the blades 14 act on a substantial depth of the perimeter of a flow column. Accordingly, any foreign matter carried by the flow media tends to be driven outwardly toward the outer perimeter of the column at a point at which the maximum peripheral speed of the blades 14 is encountered and the maximum slicing action is effected by the blades 14. That is, tapered end portions 14a of the blades 14 in particular tend to move through any foreign matter impinging against the blades 14 with a vigorous high speed knife-like slicing action, and the screw-like propulsive thrust of the blades 14, together with their helical configuration and disclosed blade taper toward the tapered end portion 14a of each blade 14 causes foreign matter carried by the flow media to slip along the blade cutting edge 28, whereby continued cutting action is effected by each succeeding blade 14 of the constantly rotating rotor 12 and the foreign matter is sequentially attacked and cut apart into readily handled effluence for discharge. This slicing action has been found to be very effective in reducing long fibrous material such as seaweed into a multiplicity of short length portions, particularly since such elongated foreign matter normally tends to become axially aligned in the direction of flow upon entering the unit

10. The tapered cross-sectional configuration of each blade 14 as best seen in FIG. 4 further serves to physically break solid matter into a particulate form.

The axially unobstructed open-center rotor design permits many different materials to pass through the rotor 12 in a clog-free operation. These materials may be solids, liquids or gases or mixtures or solutions thereof in varying combinations of forms. The efficiency and effectiveness of rotor 12 increases continually with increased rpm and power, and the thrust of a blade 14 of this design, as disclosed, increases with increased blade speed without fall off in thrust output. The tapered radial dimensioning of the blade 14 relative to the rotor 12 additionally simplifies reverse action cleaning, should such be desired. Material passed downstream by the blades 14 discharges in a whirling vortical motion. This motion, together with the velocity imparted to the flow media, may be of additional benefit in certain applications. For example, the disclosed unit could be employed without any need for nozzles, filters, etc. in pumping hot sea water with sea weeds, clam shells, etc. into the air in a homogenized mixture to meet certain industrial processing demands. A maximum temperature drop in the material pumped for the horse power used could be efficiently effected in a clog-free manner. The axial flow unit of this invention would effect a high absolute velocity of the pumped material, relative to its absolute line velocity, due to the vortical media flow pattern which additionally serves to discharge the pumped material over a significantly increased area upon leaving the constraint of the rotor 12 or connected pipeline, and would further cause certain materials such as liquid media to break into yet smaller particles. This action maximizes the surface area to the volume of the material pumped for amplified heat transfer. Temperature drop and the quantity of the material delivered per unit time may also be controlled by regulating pump output. Variations in the operating characteristics of the unit and the dimensions of the core of the flow media column actually acted upon by the blades 14 may also be varied to meet demands of different power propulsion and pumping applications.

As will be apparent to persons skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the teachings of the present invention.

I claim:

1. An axial flow device comprising a housing, a hollow rotor supported on the housing and having inlet and outlet ends with a flow passageway therebetween, and

a blade mounted on and projecting radially inwardly from an inside wall surface of the rotor,

the blade having an upstream end and a downstream end with a longitudinally extending cutting edge extending at least in part therebetween, at least a portion of the blade cutting edge being disposed at an increasing radial distance from the inside wall surface of the rotor progressively along said cutting edge portion in a direction from the inlet toward the outlet ends of the rotor,

the projection of the blade in a plane normal to a major longitudinal axis of the rotor defining a concave blade profile wherein the edge of the blade from its down-stream end toward its upstream end

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is curved inwardly toward the inside wall surface of the rotor adjacent the blade.

2. The device of claim 1 wherein the blade terminates in a radially inwardly projecting cutting edge extending along the entire length of the blade between its upstream and downstream ends, and wherein the projecting cutting edge of the blade is formed on a detachable elongated knife member removably secured to the blade.

3. The device of claim 1 further including at least one other blade mounted on the inside wall surface of the rotor in addition to said one blade, the blades being of substantially identical construction with each blade having corresponding variations in the radial positioning of the blade cutting edge relative to the inside wall surface of the rotor, the blades being generally helical and spaced apart on the rotor in a symmetrical arrangement about its major longitudinal axis.

4. The device of claim 3 wherein each blade is dimensioned such that its maximum radial distance from the

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inside wall surface of the rotor is less than its radius.

5. The device of claim 3 wherein the projection of the blades in a plane normal to the major axis of the rotor defines a blade profile with each blade spaced apart from the adjacent blade.

6. The device of claim 3 wherein the blades each have generally equal pitch and substantially the same lead.

7. The device of claim 3 wherein n is the number of blades, wherein each of the blades have a selected pitch and lead such that a projection of each blade in a plane normal to the major axis of the rotor extends a distance less than $1/n$ of the circumferential distance about the inside wall surface of the rotor.

8. The device of claim 1 wherein the blade is formed with a cross section of progressively reduced thickness in a direction extending from the inside wall surface of the rotor toward the cutting edge of the blade.

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