Sept. 6, 1966 R. N. DOLPHIN 3,270,689

MATERIAL MOVING APPARATUS

Filed March 16, 1964 2 Sheets-Sheet 1

FIG. 1.

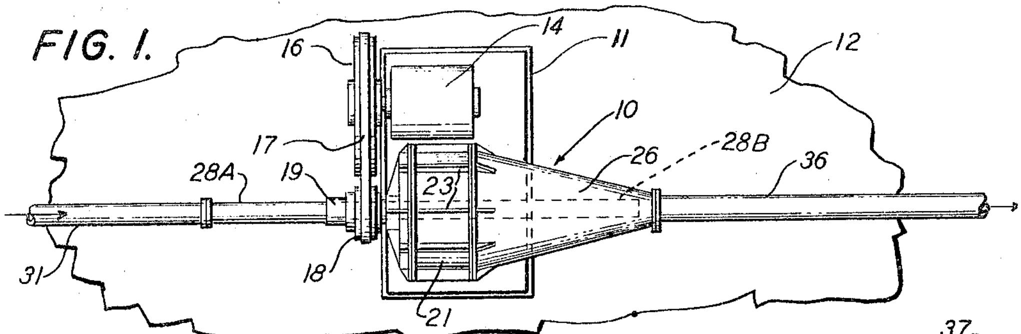


FIG. 2.

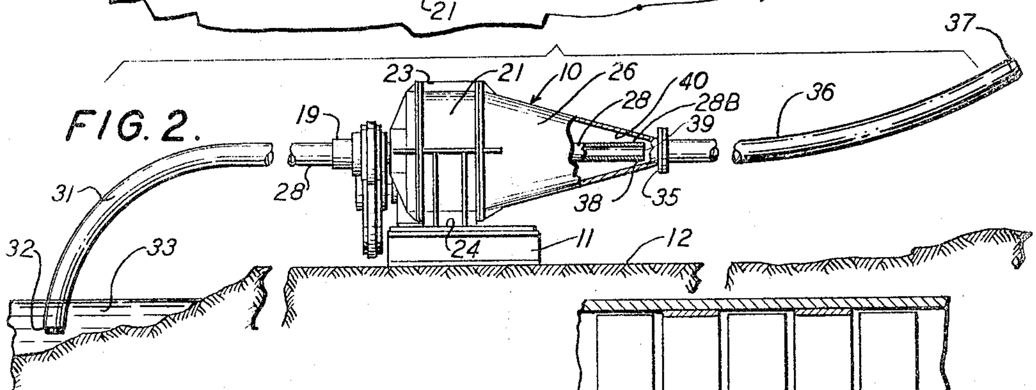


FIG. 5.

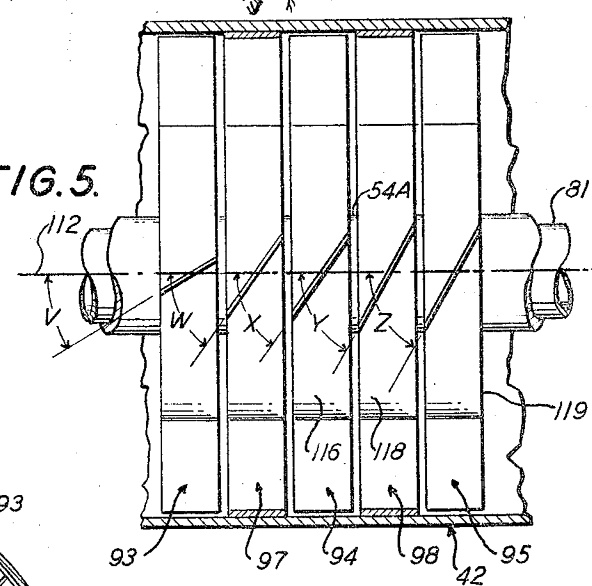
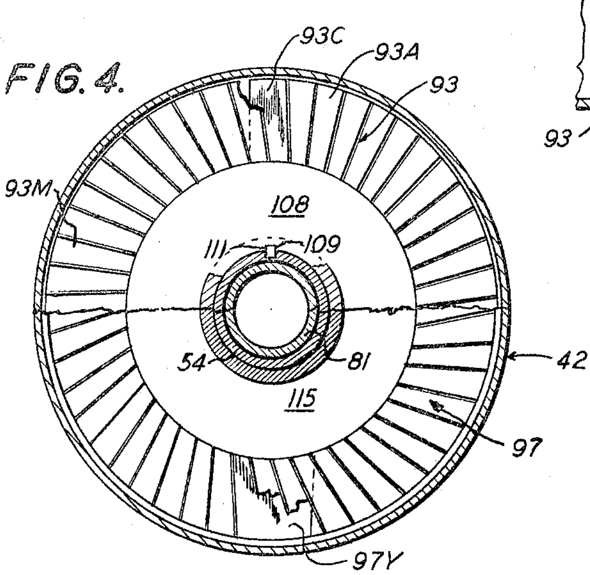


FIG. 4.



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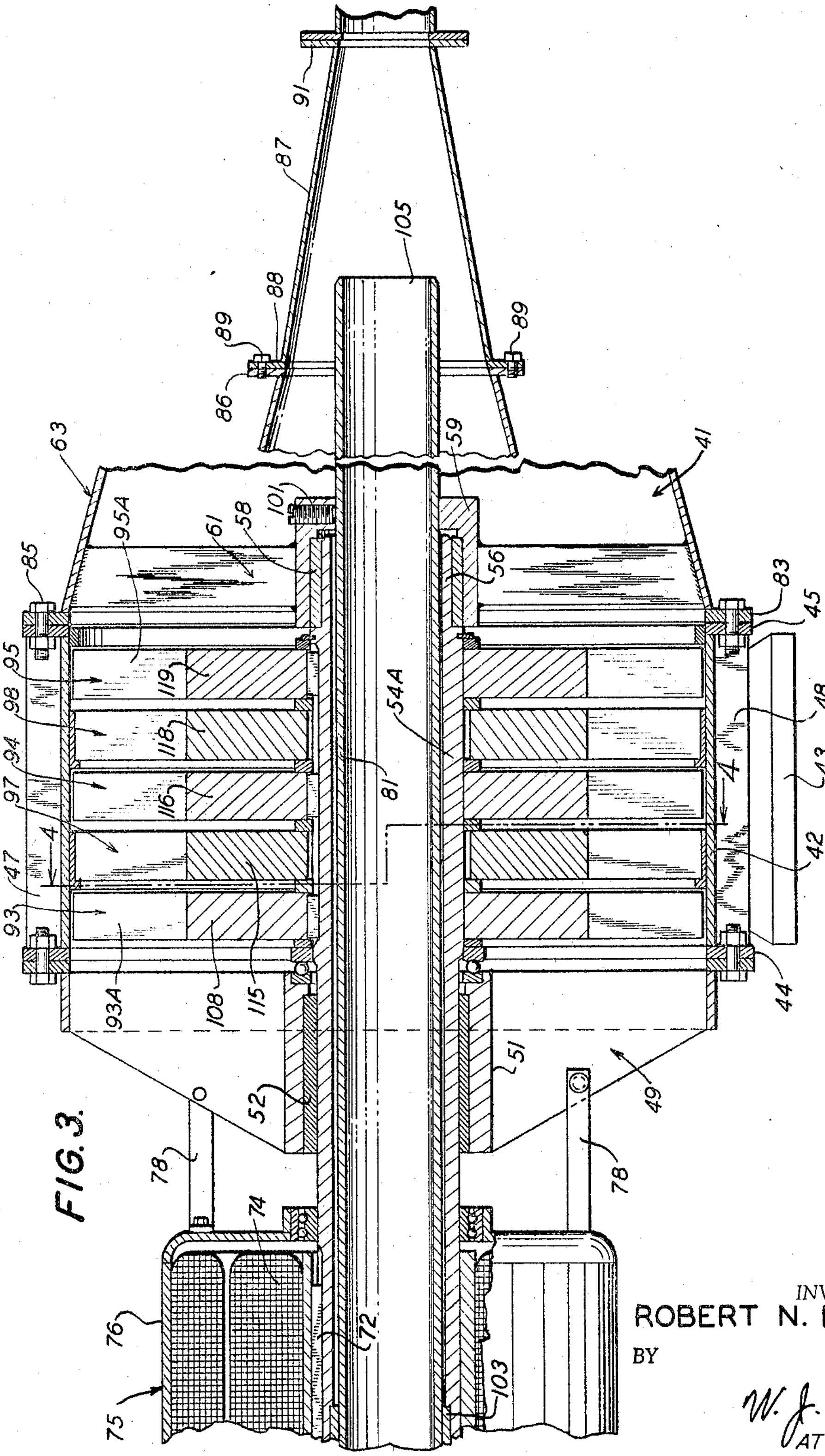

FIG. 3.

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MATERIAL MOVING APPARATUS

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1 Claim. (Cl. 103—263)

The invention relates to apparatus for moving materials, and more particularly to apparatus for educing a flow of liquids, semi-solids and solids.

Conventional pumps have been used for many years for transferring materials in land reclamation projects, mining operations, dredging and like fields of endeavor requiring large volume or continuous transfer of materials from one point to another. However, conventional pumps have both economic and mechanical limitations in handling large volume over a long distance. Recently experiments have been made with eduction pumps, which conventionally utilize the venturi principle by water flow through a venturi throat.

I have invented apparatus based upon the eduction principle utilizing air flow to educe other materials, such as granules, mud or solids. Since large volumes of educing fluid are essential to any eduction pump, the unlimited availability of the fluid air as compared to the fluid water weighs heavily on the side of air eduction devices.

The invention contemplates apparatus for educing materials that comprises a base, a housing on the base, an eductive tube extending through the cylindrical housing and projecting from one side of the housing. Connecting means extend between the material to be educed and the input end of the eductive tube. A drive shaft rotatable with respect to the eductive tube is coaxial therewith. Power means rotate the drive shaft which has turbine means fixed thereto adapted to effect a flow of air. Confining means downstream enclose the air flow, and a venturi throat is adjacent the output end of the eductive tube. Conducting means connect to the volume adjacent the venturi throat and are adapted to receive and transmit both the educed material and the air volume from the turbine means. Preferably, the power means, which may be a motor or other engine, has a hollow drive shaft through which the eductive tube extends.

In the preferred embodiment of the invention the drive shaft mounts a turbine means which includes a plurality of turbine fans or rotors between which turbine stators are disposed. The blades on the successive turbine rotors and stators vary in pitch, the pitch of the blades on the first turbine fan with respect to the rotational axis of the drive shaft being less than the pitch of the last or downstream turbine fan blades.

It is believed that the articular arrangement of the rotors and stators imparts to the air stream impelled by the rotation of the rotors a swirling or helical pattern within the air-confining funnel which leads to the venturi throat. The spiral air flow pattern is believed to encourage smooth air flow through the throat into the lesser volume of the receiving conduit. The smoothness of air flow tends to increase the amount of material that may be educed through an eductive tube of a given diameter. Also, the power requirements to move a given load of material are substantially reduced because of the smooth air flow pattern.

These and other advantages of the invention are apparent in the following detailed description and drawing in which:

FIG. 1 is a plan view of an embodiment of the invention having a detached electrical motor drive;

FIG. 2 is a side elevation partly in section of the embodiment of FIG. 1;

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FIG. 3 is a longitudinal sectional elevation of the preferred embodiment of the invention;

FIG. 4 is a schematic section, taken along line 4—4 of FIG. 3, and illustrates the configuration of the rotor and stator blades; and

FIG. 5 is a schematic side elevation of the embodiment of FIG. 3.

In FIGS. 1 and 2 an eduction turbine 10 is supported by a rectangular platform 11 that may rest upon a ground surface 12. An electric drive motor 14 is also fixed to the base. A large pulley sheave 16 is fixed to the drive shaft of the motor. A drive belt 17 connects between sheave 16 and a small pulley sheave 18 fixed to a hollow drive shaft 19 extending from the turbine eductor 10.

The turbine eductor comprises a cylindrical housing 21 having a plurality of external braces 23 and a base plate 24 that is fixed to platform 11.

A conical air-confining shroud 26 is fixed to the downstream end of cylindrical housing 21. The shroud surrounds an eductive tube 28 which extends through drive shaft 19 of the turbine eductor. The eductive tube has an intake portion 28A and a discharge portion 28B. An intake conduit 31 is fastened to the intake portion of the eductive tube. The intake end 32 of the conduit may, as shown in FIG. 2, be submerged in water 33 of a pond 34 and educe material from beneath the water. A flanged end 35 of shroud 26 connects with a discharge conduit 36 whose discharge end 37 emits the material educed from pond 34.

A restricted venturi throat 41 is defined by a circular end 42 of the eductive tube and a reduced inner diameter 43 of shroud 26 adjacent the tube. The rotors (not shown) of the turbine eductor direct a large volume of air into the shroud and past the end of the eductive tube. Fluid flow in large volume past the end of the tube educes material through conduit 31 and tube 28 at high velocity. The air and the educed material commingle at the venturi and are impelled through discharge conduit 36 to its discharge end 37 by the air flow from the turbine eductor.

FIGS. 3 and 4 illustrate a preferred embodiment of the invention. An eductor turbine 41 has a turbine housing 42 at its input end and a second flange 45 at its output end. The housing is preferably cylindrical and externally braced by longitudinal ribs, such as top and bottom ribs 47, 48 of FIG. 3.

A journal spider assembly 49 is bolted to input flange 44. The spider assembly supports a journal hub 51 having a bearing sleeve 52. The bearing sleeve journals a propulsion shaft 54 that extends on either side of sleeve 52 and journal hub 51. The downstream extent of the shaft 54 terminates just beyond housing 42 in a reduced diameter portion 56 upon which is mounted a second bearing sleeve 58. The bearing sleeve is housed in a second bearing journal 59 supported by a second journal spider assembly 61. The spider assembly is fastened within a conical compression section 63 which is fixed to output flange 45 of the turbine housing.

The upstream end of the propulsion shaft protrudes leftwardly in FIG. 3 from journal bearing hub 51. A hollow motor drive shaft 71 is fixed to the propulsion shaft by a key 72. Armature windings 74 of an electric motor 75 surround the hollow drive shaft of the motor. The outer housing 76 is held against rotation by torque ties 78 secured to the housing end of the turbine pump.

When power is supplied to the electric motor the armature and the hollow power shaft turn the propulsion shaft of the turbine through key 72. The propulsion shaft turns freely within bearing sleeves 52 and 58.

An eductive tube 81 extends through the propulsion shaft from a point upstream of the electric motor to a point beyond compression shroud 63. The upstream end of the eductive tube is adapted to receive intake conduit (not shown) in the manner shown and described with respect to FIGS. 1 and 2.

Compression shroud 63, as stated before, is conical in configuration. A shroud flange 83 is fixed to the larger end of the shroud. Securing means, such as bolts 85, fix the shroud flange in position against output flange 45 of the turbine housing 42. The reduced diameter, or smaller end, of the shroud has an annular flange 86 to which a venturi cone 87 is affixed by means of a flange 88 and bolts 89. The venturi cone has an output flange 91 to which output conduit may be fastened.

The intermediate portion 54A of the propulsion shaft supports a plurality of turbine rotors 93, 94, 95. Each rotor is keyed to shaft 54 to turn therewith within housing 42.

Bladed stators 97, 98 are fixed within the housing intermediate the turbine wheels. The stators and rotors have a configuration shown in more detail in FIGS. 4 and 5.

In operation the turbine pump 41 of FIG. 3 is similar to pump 10 of FIGS. 1 and 2. When motor 75 is actuated, the propulsion shaft turns about the eductive tube which is fixed by a plurality of set screws 101 which are threadably engaged with bearing journal housing 59. Anti-friction bearings, such as the bearing 105, may be placed between the eductive tube and propulsion shaft to reduce turning friction between those two members.

As the propulsion shaft turns, turbine rotors 93, 94, 95 are rotated within housing 42, and air flow is induced through housing 42 into compression shroud 63. The air impelled into compression shroud 63 is believed to have a whirling motion about the eductive tube 81. The tremendous volume of air passing through the annular throat (defined by the inner periphery of cone 87 and the outer periphery of tube 81) induces material flow through the eductive tube. Material adjacent the input end of the conductor tube is educed from its situs and mixed with the spiraling air from the turbine eductor and propelled from the venturi cone into the discharge conduit.

As stated heretofore, the use of an eductive tube that is coaxial with the axis of rotation of the turbine blades, combined with the relationship between the respective blade pitches of turbine rotors and bladed stators is believed to result in a basically helical air flow pattern within venturi cone 87. In the embodiment of FIGS. 3, 4 and 5, housing 42 is seen to surround and confine the flow from turbine rotors 93, 94, 95. Upstream turbine rotor 93 has a plurality of blades 93A–93TT, fixed to a hub 108. Hub 108 has a keyway 109 through which a key 111 imbedded in the propulsion shaft extends.

Turbine rotor 93 is the first rotor on the shaft and has the plurality of turbine blades fixed to its hub at an angle V to axis 112 of the shaft. Obviously the rotors rotate about axis 112. Stator 97 has a plurality of turbine blades 97A–97TT. The blades of stator 97 are attached to a hub 115 at an angle W to axis 112. Rotor 94 has a plurality of turbine blades 94A–94TT evenly spaced about the periphery of a hub 116 and set at an angle X to axis 112. Stator 98 has a plurality of blades 98A–98TT evenly spaced about a stator hub 118 and fixed to the hub at an angle Y to axis 112. Rotor 95 has a plurality of turbine blades 95A–95TT fixed to a rotor hub 119 and evenly spaced about the periphery thereof. Each turbine blade is set in the hub at an angle Z to axis 112.

In a preferred embodiment the angles V through Z are, respectively, 30, 50, 50, 60 and 60 degrees. The pitch of the turbine blades to the axis varies with the load of the apparatus and with the operating speed of the propulsion shaft.

As may be noted from FIG. 5, stators 97 and 98 are interposed between rotors 93, 94 and 94, 95, respectively. Each stator has a hub 118 and a blow-by ring 122. The blades of each stator are fixed as by welding to the respective hub and the ring at the angles previously described. Thus the hub, blades and ring form a stator assembly that is fixed within housing 42.

Each of the turbine rotors 93, 94, 95 is keyed to shaft 54, as described with respect to rotor 93. The rotors turn in unison and air acceleration is induced by the difference in the turbine blade pitch from rotor to rotor.

The rotor diameter of a present embodiment is 14 inches. In a three-stage turbine, such as that illustrated, an input horsepower of 2½ H.P. is practicable. Tests of pumps in this size and power range indicate that most materials-moving jobs can be accomplished with greater efficiency than heretofore possible.

Many variations within the scope of the invention will occur to those skilled in the art. Therefore, I wish the invention to be defined by the appended claim rather than by the illustrative description and drawing hereinabove.

I claim:

Apparatus for educing flow of solid, semi-solid and fluid materials comprising a base, a cylindrical housing on the base, bearing means supported by the housing, a tubular drive shaft extending through the housing and supported by the bearing means, an eductive tube extending through the tubular drive shaft and beyond each end of the housing, means adapted to provide relative rotation between the eductive tube and the drive shaft, a plurality of turbine rotors fixed to the drive shaft at spaced intervals thereon, a plurality of turbine stators fixed to the housing and interposed between the spaced turbine rotors, a conical shroud affixed at its large end to the cylindrical housing, said eductive tube extending through the housing and the shroud and beyond the diminished end of the shroud, a tapering venturi throat surrounding the extending end of the eductive tube, the relative diameters of the eductive tube and the venturi throat being such that air flow directed through the shroud and the throat by the turbine rotors and stators educes a flow of materials through the eductive tube to be discharged from the venturi throat.

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