June 27, 1972 J. N. WHITE ET AL 3,672,790

AIR LIFT PUMP

Filed April 15, 1971 3 Sheets-Sheet 1

FIG. 1

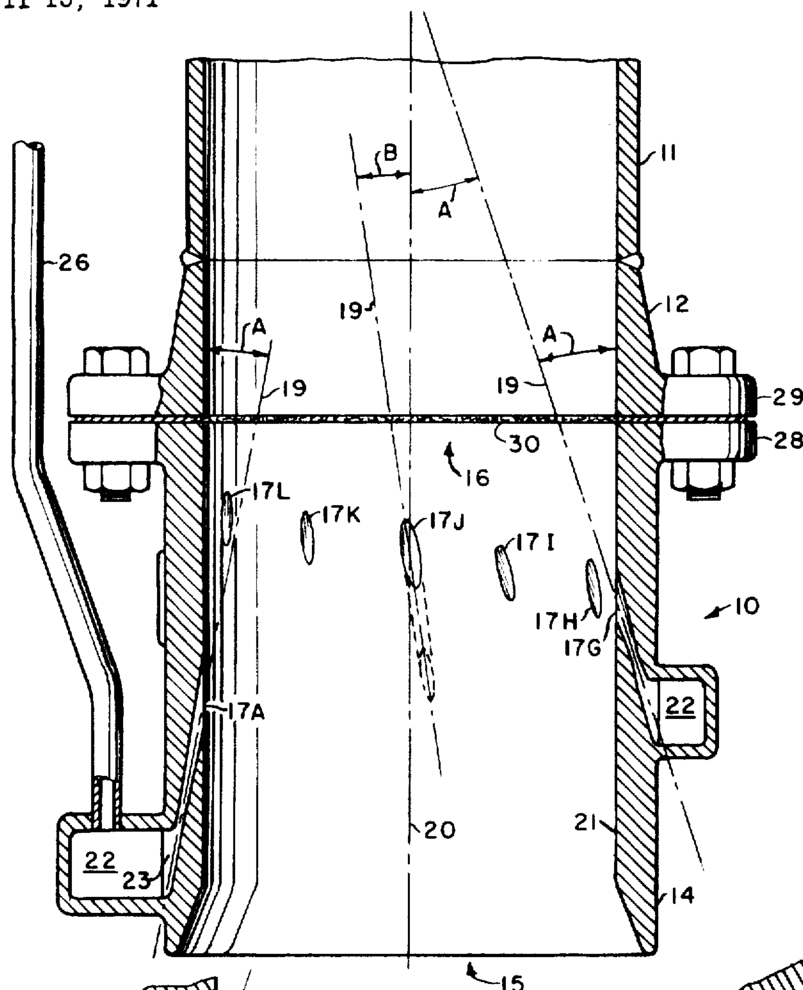


FIG. 2

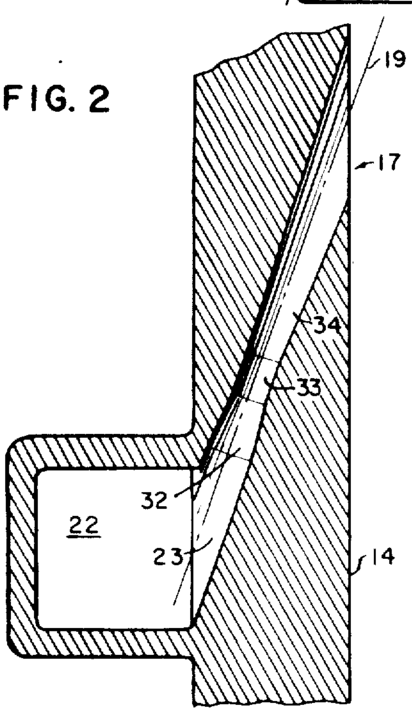
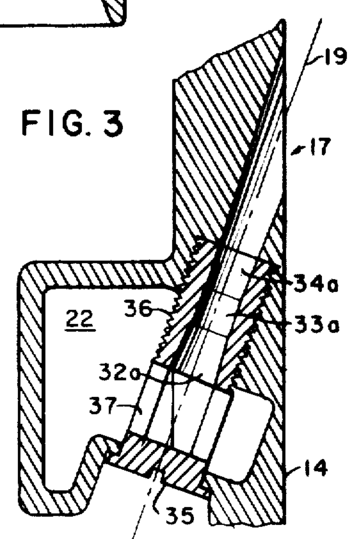


FIG. 3



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AIR LIFT PUMP

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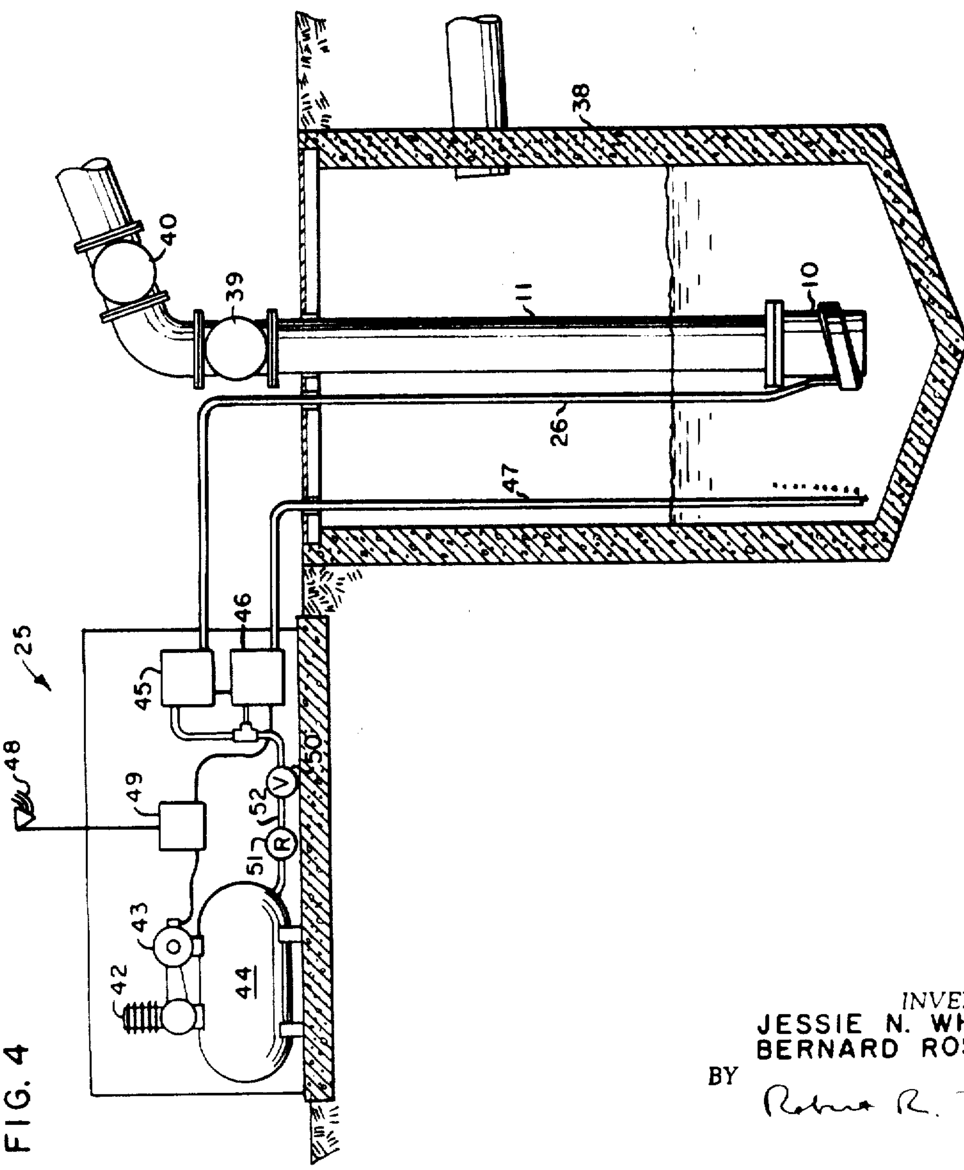

FIG. 4

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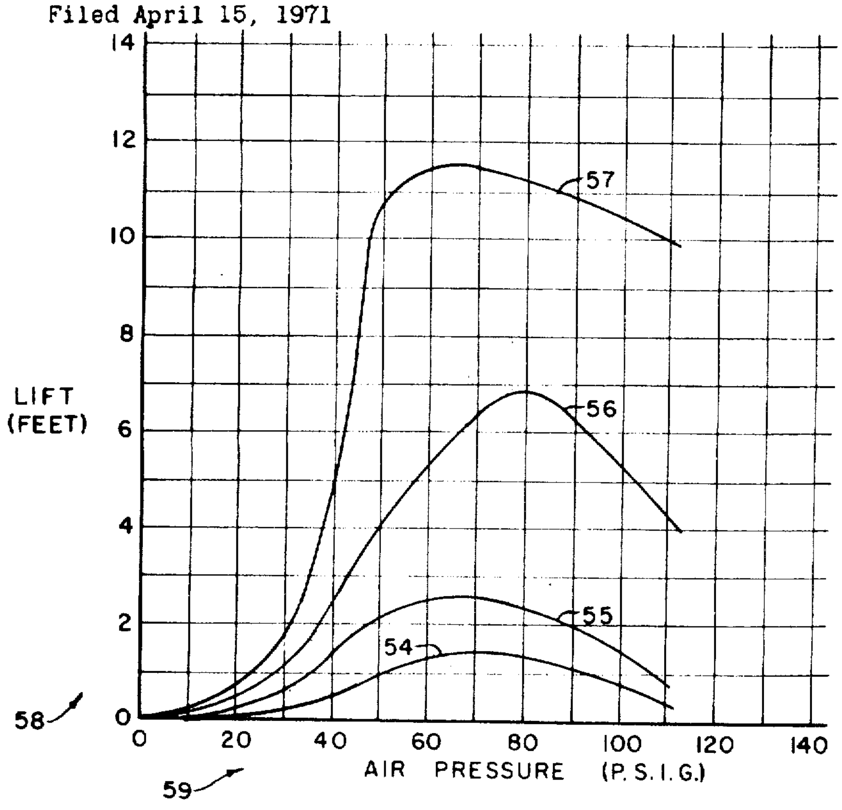
FIG. 5



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United States Patent Office 3,672,790
Patented June 27, 1972

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3,672,790

AIR LIFT PUMP

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Filed Apr. 15, 1971, Ser. No. 134,218
Int. Cl. F04f *1/18, 5/00*
U.S. Cl. 417—108 6 Claims

ABSTRACT OF THE DISCLOSURE

An air lift pump for use as a sewage lift pump is provided with an air injection section in which jet nozzles are disposed peripherally and helically around the pump section and arranged at angles to the planes radial and tangential to the longitudinal axis of the pump which vary when progressing peripherally around the pump section.

BACKGROUND OF THE INVENTION

This invention relates generally to pumps and in particular to air lift pumps.

Air lift pumps are useful as sewage or biological waste lift pumps in that they have no moving parts in the pump itself to wear out or become damaged due to solid particles in the sewage material. They are additionally beneficial in that oxygen is entrained in the waste liquid which is utilized by the bacteria to assist in treating the biological waste prior to reaching the treatment plant.

Air lift pumps in the past operated by virtue of the vertical updraft of the air bubbles in a column of liquid which caused the liquid to be swept up with the bubbles. These pumps required the air injection device to be submerged relatively deeply compared to the lift or head requirements in order for the air bubbles to gain enough upward momentum to lift the liquid, and to receive assistance from the static head provided by the said submergence.

Even when deeply submerged, the prior art pumps attempted to improve the efficiency by employing various methods of injecting greater amounts of air into the liquid. Such methods included the placing of the injection orifices at a fixed angle to the direction of fluid flow and helically about the air injection section.

SUMMARY OF THE INVENTION

The air lift pump of the present invention reduces the need for submerging the air injection section below the surface of the water and achieves a low submergence to lift ratio and high efficiency through the use of air injection nozzles which are disposed peripherally around the air injection section at various angles which change from the one nozzle or group of nozzles to the next, according to a schedule, when progressing peripherally around the section.

It is, therefore, an object of the present invention to provide an air lift pump of high efficiency.

It is another object of the present invention to provide an air lift pump in which a minimum of submergence of the air injection section is required.

It is a further object of the present invention to provide an air lift pump having a low submergence to lift ratio.

It is still another object of the present invention to provide an air lift pump for biological waste material to beneficially modify the biological oxygen demand.

Other and more particular objects of this invention will be manifest upon study of the following detailed description when taken together with the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational sectional view of the air injection section of the present invention;

FIG. 2 is an elevational partial sectional view of a single air injection nozzle of the air injection section;

FIG. 3 is an elevational partial sectional view of a removable air injection nozzle for use in the air injection section;

FIG. 4 is an elevational sectional view of a complete pumping system using the air lift pump of the present invention; and

FIG. 5 is a graph showing the lift as a function of air pressure for various nozzle arrangements including that of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, there is illustrated an elevational sectional view of the air lift pump of the present invention comprising an air injection section **10**, a pump riser section **11** and a transition section **12** for connecting air injection section **10** to pump riser section **11**.

Air injection section **10** comprises cylindrical nozzle assembly **14** having an inlet end **15** and an outlet end **16** and including a plurality of air injection nozzles **17** individually identified as nozzles **17A** through **17L**, inclusive. Each nozzle **17** is arranged to point inwardly and upwardly in the direction of fluid flow. The longitudinal axis **19** of each jet nozzle is aligned to define an angle A and an angle B with the longitudinal axis **20** of air injection section **10** (the inside surface **21** of nozzle assembly **14** is parallel to the axis **20**). That is, as seen from FIG. 1, angle A defines the "inward" tilt of axis **19** toward axis **20**. Angle B defines the "forward" tilt of axis **19** with respect to axis **20**.

Taking, for example, nozzle **17G**, the angles are defined as follows:

Angle A is measured by establishing an imaginary first plane surface which contains and is coincident with longitudinal axis **20** and radial thereto, which plane is also coincident with the point of intersection of nozzle axis **19** with the extended inside surface **21** of nozzle assembly **14**. For nozzle **17G**, this plane would be parallel to the surface of drawing of FIG. **1**.

A second imaginary plane surface is established normal or perpendicular to the first plane surface but also containing and coincident with nozzle axis **19**. The angle that the line of intersection of the two planes makes with axis **20** defines angle A. Angle A shown for nozzle **17G** is such an angle.

Although in FIG. 1, angle A is also measured from surface **21**, through well known principles of plane geometry, the angles are the same.

Angle B is measured (for nozzle **17G**) by establishing an imaginary third plane surface containing and coincident with axis **20**, which plane is also perpendicular to the first imaginary plane described above, and, for nozzle **17G**, is also perpendicular to the surface of the drawing of FIG. 1. A fourth imaginary plane is established normal or perpendicular to the third imaginary plane but also containing and coincident with nozzle axis **19**. The angle that the line of intersection of planes three and four makes with axis **20** defines angle B. Angle B shown for nozzle **17J** is such an angle.

Air injection section **10** further comprises an air supply plenum **22** at the inlet end **23** of nozzles **17A–17L** which is connected to a compressed air supply and control means **25** (FIG. 4) by conduit **26**.

A flange **28** is provided at the outlet end **16** of section **10** which is adapted to mate with a like flange **29** connected to transition section **12** between which is a gasket **30** so that section **10** can be conveniently removed and replaced.

FIG. 2 is an enlarged view of a typical air injection nozzle **17** and comprises an inlet section **32**, a venturi section **33** and an expiration section **34**.

It has been found that good results are achieved when the conical angle of expiration section **34** is approximately 5 degrees with venturi section **33** having an inside diameter of about ¼ inch and a length of about ½ inch.

In a similar arrangement, FIG. 3 illustrates a replaceable nozzle **35** also having an inlet section **32a**, a venturi section **33a** and an expiration section **34a** corresponding, respectively, to inlet section **33**, venturi section **34** and expiration section **35** of FIG. 2. Replaceable nozzle **35** is provided with threads **36** along its upper end so that it can be properly aligned and attached to nozzle assembly **14**. Ribs **37** connect the upper part of nozzle **35** with its lower part and permit air to flow from plenum **22** into nozzle **35**.

FIG. 4 illustrates a complete pumping system using the air lift pump of the present invention. The pump is installed in a typical catch basin or manhole **38** with air injection section **10** submerged to a point just above the bottom. A check valve **39** and a gate valve **40** are provided at the upper end of pump riser section **11** to prevent backflow of pumped fluid during inoperation of the pump.

Compressed air is supplied to section **10** by air supply and control means **25** which comprises a compresser **42** powered by electric motor **43** which are mounted on top of compressed air tank **44**.

Compressed air tank **44** supplies air to air injection section **10** through air supply regulator **45** which is controlled by pump control **46**. Pump control **46** is an "on" and "off" control device which measures the liquid level in manhole **38** through air pressure measured in bubbler tube **47**. Since the air pressure in tube **47** is proportional to the depth the end of tube **47** is below the surface of the liquid in manhole **38**, the liquid level at which air is turned "on" or "off" to section **10** can be established by appropriate pressure sensitive relays in pump control **46**.

Power to energize motor **43** and pump control **46** is provided from power line **48** through electrical distribution panel **49**.

A shut-off valve **50** and pressure regulator **51** are provided in compressed air conduit **52** between compressed air tank **44** and air supply regulator **45** and pump control **46** for manual control of the air supply.

With particular reference to FIG. 1, nozzles **17A** through **17B** and their angles A and B have been arranged in a particular manner to act on the fluid and propel it up through pipe riser **11**.

In the specific embodiment illustrated, there are 12 nozzles, individually identified as nozzles **17A** through **17L**, equally spaced around the periphery of cylindrical nozzle assembly **14** and helically about assembly **14** at about an 11 degree pitch, beginning at the lower end of the helix with nozzle **17A** and ending at the upper end of the helix with nozzle **17L**. Nozzle **17B** through **17F** are not shown since they are in the front half of the sectional elevation illustrated.

Table I is a tabulation of typical values for angle A and B for a pump having a 4 to 5.25 inch inside diameter:

TABLE I

	Angle A	Angle B
Nozzle:		
17A	10	26
17B	10	24
17C	12	22
17D	12	20
17E	14	18
17F	14	16
17G	16	14
17H	16	12
17I	18	10
17J	18	8
17K	20	6
17L	20	4

In the embodiment illustrated, the 12 nozzles are spaced at 30 degree intervals encompassing 360 degrees. This is not intended to limit the configuration of the present invention. The nozzles may also be spaced over a total angle greater than 360 degrees, for example, 450 degrees, 540 degrees, 540 degrees, 630 degrees, etc. Of course, the pitch of the helix defined by the nozzles may also be varied depending upon nozzle spacing and size.

To operate the pump of the present invention, the invert opening of air injection section **10** is submerged in the fluid to be pumped and compressed air is supplied from equipment as previously described.

The air flow from the nozzles, being accelerated and directed into a vortex by the venturi cross section **33** and the angular orientation of the nozzles, respectively, causes a pressure drop to be induced in the air injection section **10** below the nozzle openings further causing fluid to enter the air injection section **10** and submerge the nozzle openings, thus initiating the primary pumping action.

It can be seen that air from nozzle **17A** will force the liquid at the outlet of that nozzle both upwardly, inwardly and tangentially relative to axis **20**. Since angle B is large (for nozzle **17A**, the angle from Table I is 26 degrees), tangential forces will be exerted on the fluid causing it to move sideways. As it moves sideways, it comes within the range of nozzle **17B** which gives it a further boost of energy sideways to successively receive energy from nozzles **17C** through **17L**. Also, as the liquid receives this energy the vector forces on the fluid are changing by virtue of the changes in angles A and B.

With angle A, the force changes from forcing the fluid generally upward with nozzles **17A** to generally forcing the fluid generally inwardly with nozzle **17L**.

With angle B, the force changes from a greater tangential force with nozzle **17A** to a lesser tangential force with nozzle **17L**.

It will also be noted that the tangential angle B is in the direction of the rising helix of nozzles **17A** through **17L** in order to follow the fluid as it rises.

With reference to FIG. 5, there is illustrated a graph of lift, in feet, along ordinate **58** and air pressure, in pounds per square inch gauge (p.s.i.g.), along abscissa **59**. The lift is a measure of the maximum height that water is raised above the surface of the water being pumped.

Curve **54** shows the lift achieved with an air injection section **10** in which the nozzles are cylindrical holes arranged with their axes pointing radially inwardly on a horizontal plane.

Curve **55** shows the lift achieved with an air injection section in which the nozzles are cylindrical holes arranged with their axes pointing inwardly and upwardly with all nozzles tilted toward axis **20** at the same angle and arranged in a helix about nozzle assembly **14**.

Both configurations for curves **54** and **55** required the air injection section **10** to be submerged at least 18 inches below the surface of the water to be pumped before they would operate.

Curve **56** shows the lift achieved with an air injection section in which the nozzles use a venturi orifice as described previously in which the axis of the orifice for each nozzle points inwardly and upwardly with all nozzles tilted toward axis **20** at the same angle and arranged in a helix about nozzle assembly **14**.

The configuration of curve **56** required the air injection section **10** to be submerged at least 9 inches below the surface of the water to be pumped in order to operate.

Curve **57** shows the lift achieved with an air injection section in which the nozzle configuration is that of the present invention, i.e., the angle the nozzle makes with a radial plane to the pump axis increases from the bottom to the top of the helix while the angle the nozzle makes with a tangential plane decreases from the bottom to the top of the helix.

It has also been found that the configuration for curve **57** does not require air injection section **10** to be submerged below the surface of the water in order to operate.

It can also be seen that air injection section **10** could also be placed in the middle of a pipe section to act as a booster pump or several placed in series to provide a greater lifting force to the fluid being pumped.

We claim:

1. An air lift pump comprising means defining a generally cylindrical injection section open at both ends, a plurality of inwardly pointing nozzles disposed peripherally around said injection section, the longitudinal axis of each of said nozzles defining an angle A and an angle B with the longitudinal axis of said injection section said angle A defined by the angle that the line of intersection of a first plane, which is coincident with said injection section axis and also coincident with the point of intersection of said nozzle axis and the extended inside surface of said injection section, and a second plane which is perpendicular to said first plane and coincident with said nozzle axis, makes with said injection section axis, and said angle B defined by the angle that the line of intersection of a third plane, which is coincident with said injection section axis and perpendicular to said first plane, and a fourth plane which is perpendicular to said third plane and coincident with said injection section axis, said angles A and B varying in size when progressing peripherally around said pump section, and means for providing fluid to said nozzles.

2. The air lift pump as claimed in claim **1** wherein said nozzles are disposed helically about the periphery of said injection section.

3. The air lift pump as claimed in claim **1** wherein said angle B decreases and said angle A increases when progressing peripherally around said injection section.

4. The air lift pump as claimed in claim **1** wherein said angle A ranges from 10 to 20 degrees and said angle B ranges from 4 to 26 degrees.

5. The air lift pump as claimed in claim **1** wherein said means for providing fluid to said nozzles comprises a plenum disposed peripherally around said injection section at the inlet end of said nozzles, and means for providing compressed air to said plenum.

6. The air lift pump as claimed in claim **1** wherein said nozzles comprise an inlet section, a venturi section and an expiration section, said expiration section communicating with the interior of said injection section and said inlet section in communication with said means for providing fluid to said nozzles.

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U.S. Cl. X.R.

417—197