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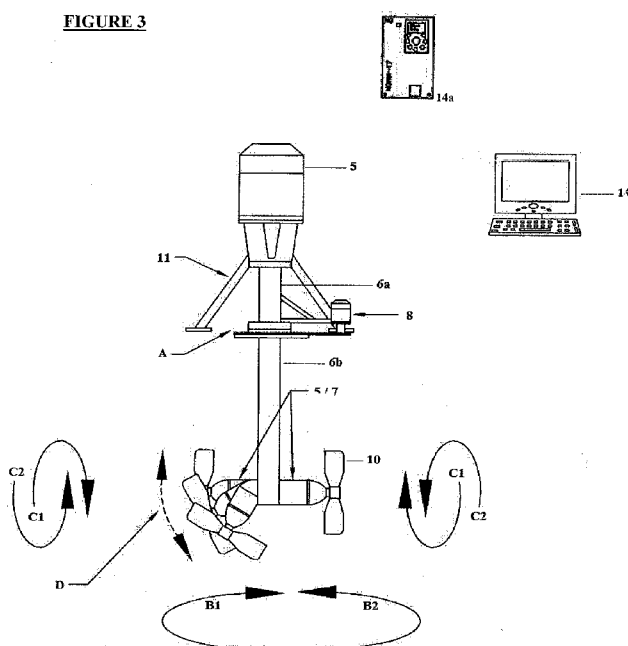
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(54) **Title:** IMPROVEMENTS IN AND RELATING TO AGITATOR SYSTEMS**FIGURE 3**

(57) **Abstract:** An agitator system for mixing slurry, said slurry being contained in a slurry pond, said agitator system including an agitator assembly and a support assembly, said support assembly supporting said agitator assembly relative to the slurry, said agitator assembly including at least one drive assembly associated with at least one impeller, the drive assembly being adapted to rotate the agitator system in whole or part through 360 degrees.

IMPROVEMENTS IN AND RELATING TO AGITATOR SYSTEMS

Technical Field

This invention relates to improvements in and relating to agitator systems.

- 5 In particular, this invention is directed to providing a substantially improved means to agitate and thereby mix slurries to provide better homogenisation of a slurry and ultimately better aeration and/or pumping and/or flowability of the slurry, depending on the required process for treatment and handling of the slurry, or the required use of the slurry.

It is envisaged the invention will be applicable to any situation, for example agricultural,
10 commercial or industrial applications where slurry storage, handling, treatment or use, is required. However, the invention may have applications outside this field.

Background Art

Slurry ponds, or reservoirs and the like, are pits or containers in which waste products or materials formed at a specific stage within a process, are stored.

- 15 In agriculture, animal manure, wash-down water from milking sheds and/or animal barns and the like, is typically stored this way until the farmers are able to spread it on fields. Municipal sewage treatment ponds are another example. Various industries, including mining, rely on storage ponds or reservoirs for storing waste material derived from the particular activity. In a range of commercial activities, slurries may be formed as part of a particular manufacturing process.
- 20 Such storage reservoirs or ponds typically offer longer term storage facilities until, if and when, the waste is able to be further treated or removed. In commercial applications, the slurry may be contained until the next stage of the process is initiated and the slurry used or, until the time is right for the slurry to be discarded.

Agricultural slurry pits may be found on many farms, where a combination of cow manure and
25 water from washing the milking shed is stored as liquid manure, until it is applied to the land as fertiliser for promoting pasture or crop growth by adding organic matter and nutrients to the soil. With opportunities to apply slurries to grassland on several occasions during the growing season, this could provide up to 20% of the N; 100% of the P; and 80% of the K fertiliser required by grasslands used for grazing and/or hay or silage production.

Slurry ponds may have a concrete bottom and walls, may be an earthen pit (which in turn may be lined, such as with a thermoplastic or foil liner), or may be metal or thermoplastic tanks. The ponds may be open to the atmosphere or may be covered.

5 For filling and emptying the slurry pond, pumps of varying specifications are employed, depending on the exact function and on the type of fluid that requires pumping - whether domestic sludge, liquid industrial waste, commercial products within a process stage, or agricultural slurry.

However, pumping systems alone may not be sufficient to empty a slurry pond. Non-settling slurries have particles of typically less than 40 micrometres that stay in suspension for long periods of time; while settling slurries have particles of typically more than 40 micrometres that
10 fall and settle at the bottom of a reservoir in which the slurry is held. If the slurry is to be transported from the reservoir for application, treatment or storage to another site, it requires the slurry particles be in suspension, otherwise the liquid is removed and the particles remain as sediment on the bottom of the reservoir.

Therefore, mixing of the slurry is required to address the problem of the slurry matter settling to
15 the bottom of the pit, or floating and forming a crust. To facilitate homogenisation for pumping, movement or separation of the slurry, a submersible mixer is used to achieve the best possible flowing ability and/or pumping of the slurry from the slurry pond to the location where it is required.

Existing slurry mixers are obtainable with various PTO drives, hydraulic, electric motor or oil
20 motor drives. It is preferable that any mixer employed be powerful, robust, long-lived, low on maintenance and adjusted for the daily operations it is required to complete.

Various mixers are available in the prior art. Screw and auger mixers, submersible agitators and so forth, are available.

With an auger mixer, the auger rotates in a casing, producing thrust to minimise the likelihood of
25 the auger mixer getting blocked by residues. Movement is single directional. Trying to agitate the entire slurry pond to ensure homogenisation and flowability of the slurry, may not be so readily achieved via use of such mixers.

Submersible agitators are designed for mixing many kinds of slurries, including manure in manure pits, along with other uses. The mixing power is derived from a specially constructed

propeller, and the aim is that in a short time, an enormous amount of manure can be agitated and mixed. However, there are limitations with existing systems.

Those driven by PTO drives typically require long support arms with the propeller fixed at the submersible end. The propeller is lowered into the slurry pond in a manner similar to an outboard
5 motor. The position of the agitating unit may need to be adjusted throughout the period by moving the vehicle driving the unit, or directing the propeller in different directions. Whilst mixing does occur, the degree of homogenisation throughout the whole slurry pond may not be uniform and sediment may still be present on the bottom.

Those submersible agitators having their own drive means may be more versatile. Some available
10 agitator systems may be fixedly located at the corners or along the sides of the slurry pond in fixed positions. Others may move in a single direction across a pond. This latter option operates by dipping a propeller into the slurry and the entire device is moved within the slurry pond. However, again, if fixed, or even if moving in a single direction at a time, the degree of homogenisation throughout the whole slurry pond may not be uniform and sediment may still be
15 present on the bottom.

While the present invention has a number of potentially realisable applications, it is in relation to problems associated with existing slurry storage, pumping and/or treatment systems that the present invention was developed.

More specifically, it was with regard to the issues of providing a system more appropriately
20 tailored to mix the major proportion, if not all, of the contents of a slurry pond, quickly and throughout the pond.

It was also with ease of use issues typically associated with such systems, that the present invention was developed.

Finally, it was having regard to the need to provide a treatment system that would easily disperse
25 the solids within the liquids in slurry ponds of varying sizes, shapes and depths, for keeping solids in suspension and assisting with the homogeneity of slurry for improved, transportation and handling of the waste or slurry product when applied, that the present invention was developed.

It would be useful therefore, to have an agitator system that:

1. Could be tailor-made to specifically suit one or multiple particular slurry requirements; and

2. Considered and improved the available options provided by existing systems; and
3. Was effective at mobilising the settled solids in slurry reservoirs; and
4. Effected greater homogenisation of the slurry within the entire slurry reservoir; and
5. Minimised the time taken to achieve preferred homogenisation of the slurry; and
- 5 6. Provided a more cost effective alternative to present systems employed; including costs of handling; and
7. Provided a system which could be used in varyingly shaped and dimensioned slurry ponds; and
8. Would be easy to use.

10 It would therefore be advantageous to have an invention that offered at least some, if not all, of the potential advantages of the above proposed agitator system. It is therefore an object of the present invention to consider the above problems and provide at least one solution which addresses a plurality of these problems.

15 It is another object of the present invention to at least provide the public with a useful choice or alternative system.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only. It should be appreciated that variations to the described embodiments are possible and would fall within the scope of the present invention.

Disclosure of Invention

20 This invention relates to substantially improved means to agitate and thereby mix slurries to provide better homogenisation of a slurry and ultimately better aeration and/or pumping and/or flowability of the slurry, depending on the required process for treatment and handling of the slurry, or for enabling use of the slurry.

25 For the purpose of the present invention, the agitator system shall be described as including an agitator assembly. The agitator assembly is adapted for homogenisation of thick slurries, including thick slurries found with liquid manures in agricultural slurry reservoirs, and so forth. It is further adapted to improve the homogenisation of the entire contents of the slurry reservoir,

including not only the liquid component which already includes suspended solid material, but also the solid material that typically settles on the floor of the reservoir, along with preferably also any floating scum.

5 For the purpose of the present invention, the agitator system also preferably includes a support assembly. The support assembly supports the agitator assembly in and relative to the slurry.

For the purpose of the present invention the term slurry describes, in general, a thick suspension of solids in a liquid. Whilst the solids typically referred to will be animal manure and the liquid will be generally water and/or milk, it should be appreciated that the present invention may be used, or be adapted for use, with other slurries with varying suspended solids in varying liquids.

10 For the purposes of the present invention the term slurry pond will be used. This term is used to cover not only ponds, but reservoirs, vessels, containers, pits and so forth – whether lined or unlined, covered or uncovered, large or small, dug into the earth or made of concrete, metal, or thermoplastics materials.

15 For the purpose of the present invention, the main purposes of an agitator assembly for mixing a slurry are: for keeping the solids in suspension (off-bottom suspension), where the solid particles keep moving just above the bottom of the slurry pond preventing the settling of solids; and/or for homogeneity of the slurry or full suspension, where the agitator always moves the bottom solids to the top or closer to the top, to keep the solids fully in suspension.

The agitator assembly of the present invention is preferably a submersible mixer.

20 The agitator assembly dimensions and specifications would preferably be tailored to complement the slurry pond dimensions and volume, and the required processing of the slurry materials. For example, larger slurry ponds may require larger agitator assemblies and/or bigger component parts and more powerful drive means.

25 For the purpose of describing the features of the agitator assembly of the present agitator system, the agitator components shall be referred to and include the following terms: impeller; and drive assembly (including motor drive means having the power suitably designed for meeting the process requirements; drive shaft; gear box). These terms will be discussed and defined further in relation to various embodiments. However, these broader terms are not to be seen as limiting.

The agitator assembly preferably includes at least one drive shaft. However, in other embodiments, the agitator assembly may include two or more drive shafts arranged relative to each other and driven by one or more drive means.

Preferably, the drive shaft is located within the slurry in a substantially vertical orientation.

- 5 The drive shaft preferably includes a fixed upper section and a rotating lower section.

The rotating lower section of the drive shaft is adapted to rotate 360 degrees inducing rotational motion of the slurry within the reservoir about the generally vertical axis of the agitator shaft. The rotation may be set for either clockwise or anti-clockwise. Alternatively, the direction of rotation may be varied between clockwise and anti-clockwise for preferred periods of time.

- 10 The rotating lower section of the drive shaft (adapted to rotate 360 degrees) may rotate either or both the entire lower portion of the agitator assembly (being the lower section of the drive shaft to which other agitator assembly components are attached); or, the whole agitator assembly; or the entire agitator system (including both the support assembly and the agitator assembly).

- 15 In embodiments where the lower portion of the agitator assembly rotates, there is preferably a rotating type flange or slew ring provided in relation to the drive shaft, allowing the entire lower section (including components attached thereto), to rotate 360 degrees (around the vertical axis of the shaft).

- 20 In the above referenced embodiment, the top portion of the agitator system, being the support assembly and/or the top section of the agitator assembly (comprising motor and gearbox), will not rotate and shall remain fixed.

Preferably, the lower portion of the agitator assembly will rotate by means of a motor and gearbox drive unit via a variable frequency drive at slow speed ranges. The rotational speed may be controlled by adjusting the frequency on the variable frequency drive. Preferably, there will be a large range of speed options available.

- 25 The speed options in one preferred embodiment will preferably be a large range of slow speed options.

The impellers of the present invention are the means by which to mix fluids, solids or the fluid/solid slurry in the slurry pond. Depending on flow regimes required to be created axial, or radial flow impellers may be employed.

Radial flow impellers are typically employed in the mixing of very viscous fluids by virtue of the shear stresses imposed; while axial flow impellers are preferably used for homogenisation processes, in which is important to increase fluid volumetric flow rate in slurry reservoirs.

5 In preferred embodiments of the present invention, the impellers are propellers, since the axial thrust generated by propellers effects a very high degree of swirling, preferred in the slurry reservoir. However, this does not limit the invention to only the use of propellers.

Preferably, the agitator assembly includes at least two rotating propellers that are used for agitating slurries/liquids.

10 The propellers are preferably attached towards the lower distal end of the lower portion of the drive shaft.

Preferably, the propellers will be rotating in different directions. One will rotate clockwise and one will rotate anti-clockwise. However, same directional rotation may be required in some embodiments. In addition, the direction of rotation of each of the propellers may be reversed. The direction of rotation will be determined for periods of time as required to achieve the overall process.

Preferably, the rotation of the propellers is adapted to be controlled to either draw in or push out the slurry.

20 Preferably, the propellers will be angled downwards at an angle of 30-45 degrees from horizontal, as opposed to operating through either a horizontal plane (such as when attached to the outer distal end of the lower section of the drive shaft) or at 90 degrees (such as when the propellers rotate through a vertical plane when the propellers sit at right angles to the vertical axis of the drive shaft). In such instances, a 45 degree gearbox is also preferably used to control the speed of rotation of the propellers.

25 However, in some embodiments, the angular displacement of the propellers may be varied to between 30 and 60 degrees, or between 20-80 degrees, and so forth, as required in mixing different slurries of varying viscosities.

A potentially realisable advantage of this arrangement is that angular positioning of the propellers at preferred angles will create a swirling motion of the slurry which is determined to be much

more effective than achieved with a "conventional" vertical type propeller. The propellers will be submerged.

Increased homogeneity of the slurry will also be achieved by rotational movement of the agitator assembly (in whole or part).

- 5 In one embodiment, the plane of rotation of the propellers may be set at a more acute angle from horizontal (such that the propellers rotate through a more vertical plane when the propeller adjustment approximates close to right angles to the vertical axis of the drive shaft and with the axes of rotation of the propellers oriented substantially horizontally).

10 In other embodiments, the plane of rotation may be set closer to an almost perpendicular orientation relative to the distal end of the lower section of the drive shaft and with the axis of rotation oriented substantially vertically). As such the range of angles may be between 0-90 degrees relative to the vertical axis of the drive shaft.

15 In yet another embodiment, one propeller may be angled downwards and the other angled upwards. In such an embodiment the propellers may be arranged so that their rotational axes are aligned. The propellers may then move the slurry upwards or downwards respectively, or depending on whether an individual propeller, or both, is/are set to draw in or push out the slurry.

The design of the propellers may preferably be determined relative to the slurry in which they will be used. For example, the preferred speed of the propellers may be set by testing and measurement to establish preferred tip speeds for different slurries. The term tip speed refers to
20 the speed of a point on the outermost arm (blade) of the propeller and may be used for expressing and comparing the speed of various diameter agitating propellers.

In addition, the propeller power number is an important parameter used for calculating the propeller power requirements for mixing liquids or suspensions in the turbulent region.

25 Further, the propeller discharge flow number can provide the pumping capacity of the propeller in a given geometry. The propeller power number to propeller discharge flow number ratio provides information about pumping efficiency of the propeller for specific uses.

Three other factors are important in the propeller design. These factors relate to the geometry of the propeller and are the number, width, and angle of the propeller blades; the speed of the propeller; and the diameter of the propeller relative to the pond diameter.

The agitator assembly of at least one embodiment of the present invention will therefore preferably have at least two propellers, with each propeller having at least two (opposed) blades. The blade number will be determined by the slurry being mixed.

5 As mentioned previously, the propeller design and rotation speed will be determined by the viscosity and/or type of slurry that is required to be stirred. The preferred speed of the propellers in a typical liquid manure slurry pond may be in the range of 50rpm to 750rpm.

Given, the propellers of the present invention will be available for use in varyingly sized ponds and may be used in a fixed, or rotating, or roving manner, appropriate consideration of propeller design is important. Such design will also be impacted on by the use of at least two propellers per
10 agitator assembly.

These considerations are important to achieve desired homogenisation and/or pond turnover. Low viscosity slurries will turnover and be mixed more quickly than high viscosity slurries, due to the lower resistance effected by the slurry composition. With high viscosity slurries, flow rates will be slowed and greater driving force will be needed to achieve mixing and homogenisation in
15 preferred time frames.

Homogenised slurry is preferable in situations where the slurry is liquid manure required for application to fields.

Another aspect of a preferred embodiment of the agitator assembly is that the location of the propellers within the slurry may be adjusted vertically upwards or downwards via the depth at
20 which the lower section of the drive shaft is located within the slurry. This enables the homogenisation process and mixing of the slurry in the slurry pond to occur at different levels, which contributes to a further improvement of homogenisation.

This adjustment may be via use of telescoping sections in the drive shaft, or by physical movement of the upper and/or lower portion(s) of the shaft upwards and downwards.

25 In preferred embodiments of the present invention, the agitator system and/or assembly is preferably powered by a drive assembly. The agitator system and/or agitator assembly will preferably be powered hydraulically or electrically. However, hydraulic motors and gearboxes are generally preferred for some embodiments of the present invention.

The whole agitator system preferably includes a separate motor and drive adapted to rotate the whole system and/or the lower portion of the agitator assembly at a very slow speed. This rotational speed is preferably controllable.

5 In addition, the propellers preferably operate at a range of speeds; and the propeller speeds will be dependent on the viscosity of slurry that is to be stirred.

The power of the agitator motor must be of the order to mix the slurry composition – comprised of a liquid component mixed with solids, from light materials to thick materials.

The motor size for preferred embodiments will preferably be at least between 5kW to 22kW.

10 Preferably, power is transmitted via bevel type planetary drive gearboxes to drive the propellers. The drive planetary gearboxes offer advantages over traditional gearbox arrangements, such as compactness, power transmission efficiencies, improved load distribution and greater stability. However, gearboxes other than bevel type planetary drive gearboxes may be used or adapted for use with the invention.

In preferred embodiments, the agitating assembly is located on a support assembly.

15 The support assembly includes either or both a frame and a pontoon.

It is important to note that the frame and/or pontoon can be formed by a variety of means and from a variety of materials available in the prior art.

20 The support assembly (frame and/or pontoon) allows the agitator system to float, rotate, move directionally or be located in a fixed position anywhere in the slurry pond. Preferably, the agitator system is located in the middle of a slurry pond during the mixing process.

In some embodiments multiple agitator systems may be positioned in the slurry pond to effect optimal homogenisation – depending on the size and depth of the slurry pond. These multiple agitator systems may be interlinked by linkage arms.

25 Preferably, the agitator system operates completely independently via automated systems driven by appropriate software and hardware systems. The remote controlling option is via programmable systems (in conjunction with/including control via the use of variable speed/frequency drive systems).

The programmable systems preferably enable any part of the agitator system to be activated. For example, the support assembly may be selectively moved in any predetermined direction or remain in a fixed position. This makes it possible to move the support assembly to a selected location in the pond, or on a predetermined path through the slurry pond.

- 5 Further, any of the components of the agitator assembly, may be operated via the programmable systems to select the best operating parameters for the slurry to be mixed.

For example, the propellers may be pivoted and thereby enable setting of the angle of the propellers relative to the vertical axis of the shaft. The speed of the propellers may be set and/or adjusted. The propeller height in the slurry may be adjusted. The speed of rotation of the agitator
10 system generally and/or the agitator assembly portions specifically may be predetermined and set, for initiation at predetermined times and for predetermined lengths of time. Such as, the speed of rotation of the lower portion of the drive shaft through the variable drive means, which may be initiated, stopped and adjusted remotely via programmable means. Preferably, the gearboxes can also be programmable, set by a timer to mix the slurry at certain speeds and times; and so forth.

- 15 Improved mixing of the slurry is achieved preferably by the agitator assembly being held or locked in preferred positions for pre-determined and programmed time periods, as opposed to it rotating continually at a slow speed.

In one preferred embodiment of the present invention, up to eight or more different positions are able to be programmed into the variable speed drive. During operation, a preferred embodiment
20 is adapted such that the agitator assembly is programmed to stay in each one of the preferred positions for between 5-8 minutes. However, it should be appreciated that the time spent in any and all positions can be set, along with the propeller speed and/or propeller direction.

For example, when a first position is selected, the lower portion of the agitator assembly may stay in this position for 12 minutes, with the propeller speed set at 250 rpm and rotation of the
25 propeller set to a clockwise direction. For a subsequent second selected and programmed position, the lower portion of the agitator assembly may stay in this position for 8 minutes, with the propeller speed set at 150 rpm and rotation of the propeller set to an anti- clockwise direction. For a subsequent third selected and programmed position, the lower portion of the agitator assembly may stay in this position for 10 minutes, with the propeller speed set at 300 rpm and
30 rotation of the propeller set to a clockwise direction; and so forth throughout the pre-determined, selected and programmed multiple positions.

In addition, any selected periods where the agitator assembly may remain stationary, between changes in the speed, direction and duration of operation, may also be pre-determined and programmed into the operation of the agitator system.

5 Locking the agitator assembly of the submersible mixer in a preferred position for different periods of time effects better agitation of ponds of unequal shapes/sizes ensuring there are no “dead areas”.

Preferably, the agitator system is able to be easily operated by one person.

10 Embodiments of the present invention have been described whereby, the agitator assembly includes a single drive shaft or multiple drive shafts, with at least two propellers mounted opposite to each other, each propeller rotating in an opposite direction; and, the whole unit is adapted to float, be fixed, be moved or rotate as a whole agitator system, or with only the lower portion of the agitator assembly rotating.

15 In yet other embodiments, there may be two or more independent agitator systems, arranged in relative proximity to each other and operating independently. However, each system would work together – in unison, or in sequence - with the other systems.

In addition, in yet another embodiment, two submersible agitator systems, may be mounted opposite to each other, each with one propeller, but the systems each operating as would a single agitator assembly with a combined total of two propellers and, the combined system would similarly be adapted to float, be fixed or rotate, depending on the mode of operation required.

20 It should be appreciated that this invention is described as including a full a range of possible options in terms of motors, gearboxes, shaft designs, propeller designs, floating and fixed pontoons or frames, as may be appreciated would be required to enable the invention to be adapted for use in a range of slurry ponds of different sizes, shapes and depths; as well as for a range of types of slurries with which the invention may be used.

25 According to one aspect of the present invention there is therefore provided an agitator system for mixing slurry, said agitator system including an agitator assembly and a support assembly, said agitator assembly including at least two impellers located opposite to each other, said impellers adapted to be driven by at least one drive means; said drive means adapted to rotate either or both the agitator system and parts thereof, 360 degrees.

According to another aspect of the present invention, there is provided an agitator system substantially as described above, wherein the agitator assembly is submersible in whole or part.

According to another aspect of the present invention, there is provided an agitator system substantially as described above, wherein the impellers are mounted on at least one drive shaft.

- 5 According to another aspect of the present invention, there is provided an agitator system substantially as described above, wherein the drive shaft, part thereof, or impellers are height adjustable within the slurry.

According to another aspect of the present invention, there is provided an agitator system substantially as described above, wherein the drive shaft is adapted to rotate any one of the
10 agitator system and parts of the agitator assembly by 360 degrees.

According to another aspect of the present invention, there is provided an agitator system substantially as described above, wherein the at least two impellers are positioned at an angle of between at least 20 to 80 degrees from the vertical axis of the agitator drive shaft assembly.

According to another aspect of the present invention, there is provided an agitator system
15 substantially as described above, wherein the agitator system is adapted to be fixed or moveable around the slurry reservoir.

According to another aspect of the present invention, there is provided an agitator system substantially as described above, wherein the agitator system is operated manually.

According to another aspect of the present invention, there is provided an agitator system
20 substantially as described above, wherein the agitator system is operated via electronic programmable means.

According to another aspect of the present invention there is provided a method for mixing slurry using an agitator system, said agitator system including an agitator assembly, said agitator assembly including at least two impellers located opposite to each other, said impellers adapted to
25 be driven by at least one drive means; and said method including the steps of:

- a) Selecting the drive means required to mix the slurry of known composition; and
- b) Selecting the impellers and adjusting the angles of the impellers as determined to mix the slurry; and

said method characterised by the drive means being adapted to rotate any one of the agitator system and parts thereof, 360 degrees to mix the slurry in a predetermined time.

It will be appreciated that the invention broadly consists in the parts, elements and features described in this specification, and is deemed to include any equivalents known in the art which, if substituted for the prescribed integers, would not materially alter the substance of the invention.

Variations to the invention may be desirable depending on the applications with which it is to be used.

Regard would of course be had to effecting the desired orientation of the propellers, the speed of rotation of either or both the propellers, the lower portion of the drive shaft and the agitator system (as may be required), the various designs of the propellers, the power of the drive means, the fixed or moving agitator system within a slurry pond and so forth as required to effect the desired outcome – dependent on the type of slurry, the size, shape and depth of the slurry pond and the intended end use or treatment of the slurry.

Whilst some varying embodiments of the present invention have been described above and are to be yet exemplified, it should further be appreciated different embodiments, uses, and applications of the present invention also exist.

Further embodiments of the present invention will now be given by way of example only, to help better describe and define the present invention. However, describing the specified embodiments should not be seen as limiting the scope of this invention.

Brief Description of Drawings

Further aspects of the present invention will become apparent from the following description, given by way of example only and with reference to the accompanying drawings in which:

Figure 1 is an agitator system in accordance with one embodiment of the present invention; and

Figure 2 is an agitator system in accordance with another embodiment of the present invention; and

Figure 3 is an agitator system in accordance with another embodiment of the present invention; and

Figure 4 is an agitator system in accordance with another embodiment of the present invention; and

Figure 5 is an agitator system in accordance with another embodiment of the present invention; and

5 Figure 6 is an agitator system in accordance with another embodiment of the present invention; and

Figure 7 is an agitator system in accordance with another embodiment of the present invention; and

10 Figure 8 is an agitator system in accordance with another embodiment of the present invention; and

Figure 9 is an agitator system in accordance with another embodiment of the present invention.

Best Modes for Carrying Out the Invention

15 With reference to the Figures 1 to 9 by way of example only, there is provided an agitator system (generally indicated in Figures 5 to 8, by arrow 1).

The agitator system is adapted to agitate and thereby mix slurries, such as thick liquid manures in agricultural slurry reservoirs/ponds, to provide better homogenisation of a slurry and ultimately better aeration and/or pumping and/or flowability of the slurry, depending on the required process for treatment and handling of the slurry, or for use of the slurry.

20 The agitator system includes an agitator assembly (generally indicated by arrow 2). While Figures 1 through 9 provide illustrations of some envisaged embodiments of the agitator assembly, it should be appreciated that other arrangements are possible.

In addition, the agitator system includes a support assembly (generally indicated by arrow 3). Figures 5 through 9 illustrate some configurations of the range of potential configurations of the support assembly (fixed and floating); while Figure 2 through 9 show modification to the agitator assembly to enable the agitator assembly to engage with the support assembly in fixed or removable configuration.

25

The support assembly supports the agitator assembly in and relative to the slurry.

The agitator assembly of the present invention is a submersible mixer.

The agitator system, includes impellers (propellers 4) and drive assembly means (including motor 5 and/or small drive motor 8 having the power suitably designed for meeting the process requirements, drive shaft 6; gear box 7 and variable frequency/speed drive 14a (as shown in Figure 3, but relevant to other varying embodiments also)).

The agitator system and/or agitator assembly will preferably be powered hydraulically or electrically.

The motor size for preferred embodiments will be at least between 5kW to 22kW. However, larger motors providing greater power may be required depending on the size and depth of a slurry pond and the viscosity of the slurry.

Power is transmitted from the motor via bevel type planetary drive gearboxes 7 to drive the propellers. The agitator assembly, including the gearboxes can also be programmable via programmable electronic means 14, and controlled via the variable speed drive (VSD) 14a – all being set by a timer to mix the slurry at certain speeds and times.

The agitator assembly includes at least one drive shaft located within the slurry in a substantially vertically orientation. Although, two or more drive shafts arranged relative to each other and driven by one or more drive means may be employed.

The drive shaft preferably includes a fixed upper section 6a and a rotating lower section 6b. The rotation occurs as illustrated at point A as exemplified in Figures 2 to 5.

The rotating lower section of the drive shaft is adapted to rotate 360 degrees (as shown at B in Figure 1 to 4) by means of the motor 5 and gearbox drive unit 7, via a variable frequency/speed drive 14a for a large range of available slow speed options.

The rotational speed may be controlled by adjusting the frequency on the variable frequency drive including a rotating type flange or slew ring 9. This rotation induces rotational motion of the slurry within the reservoir about the generally vertical axis of the agitator drive shaft.

The rotating lower section of the drive shaft (adapted to rotate 360 degrees) may rotate either or both the lower portion of the agitator assembly (being the lower portion of the drive shaft to

which other assembly components including the propellers are attached); or, the whole agitator assembly; or the entire agitator system (including the support assembly and the agitator assembly). The direction of rotation may be either clockwise or counter-clockwise as shown at B1 and B2 in Figures 3 and 4. The direction is able to be changed as required, either manually or via
5 programmable control means.

The agitator assembly includes at least two rotating propellers that are used for agitating the slurries/liquids.

The propellers will be rotating in different directions. One will rotate clockwise and one will rotate anti-clockwise (shown at C1 and C2 in Figures 1 through 4), adapted to be controlled to
10 either draw in or push out the slurry. However, same directional rotation may be required in some embodiments. The direction is able to be changed as required, either manually or via programmable control means (with the option to change direction of rotation of the propellers being illustrated in Figures 3 and 4).

Preferably, the propellers will be angled downwards at an angle of between at least 20-80 degrees
15 from horizontal. The angular displacement of the propellers may be varied to between 30 and 60 degrees; or between 30 to 45 degrees; and so forth as required in mixing different slurries of varying viscosity (as shown at D).

Alternatively the ability to change the angle of the propellers - as illustrated in Figure 3-5, 8 and 9 - enables the propellers to be configured so one is angled upwards and one downwards, or both
20 upwards, or both downwards, or both in horizontal or angular alignment.

A 45 degree gearbox is preferably used. However, a range of gearbox options may be used with or adapted for use with this invention.

The design of the propellers, including the number of propeller blades is determined relative to the slurry in which they will be used. The propellers include two or three blades 10. A two blade
25 version is illustrated in the figures.

The preferred speed of the propellers in a typical liquid manure slurry pond may be in a range of 50 to 750 rpm. However, the speed of the propellers may be varied to less than 50rpm, or greater than 750rpm, as may be required depending on the size and depth of a slurry pond and the viscosity of the slurry.

The location of the propellers within the slurry may be adjusted upwards or downwards via use of telescoping sections in the drive shaft, or by physical movement of the upper and/or lower portion of the shaft upwards and downwards.

5 The agitating assembly is permanently or removably attached to a support assembly via one or more mounting brackets 11.

The support assembly includes either or both a frame 12 and/or a pontoon 13.

Figure 9 illustrates a fixed frame option having multiple legs, and where one or more mounting brackets 11 connect to the frame 12. The frame 12 may be positioned and/or fixed relative to the bottom of the slurry pond, and/or to a side of the slurry pond. For example, as in Figure 9, the
10 base of all legs of the frame may sit on the bottom of the pond. Alternatively, the base of some of the legs of the frame may sit on the bottom and some may be positioned and/or fixed to the sides of the pond. In yet another example, the frame may be fixed to the side of the pond only and one or more extension arms may be employed in some such variations, to locate the associated agitator assembly in a specified location within the slurry pond. The arm may pivot through a
15 horizontal and/or vertical plane to position the agitator in any location around or in the pond.

Figures 5 to 8 illustrate options that include a pontoon and the mounting bracket(s) 11 fix the agitator assembly to the frame 12 of the pontoon. One or more pontoons may be included and an option exists for these to be interlinked as may be required to achieve the pattern of coverage and mixing to be achieved.

20 It is to be appreciated that the dimensions of the support assembly may be varied as required.

For example, the pontoons may be configured to be substantially elongate to traverse a substantial section of the slurry pond. Any number of agitator assemblies having varyingly numbered propellers, propeller blades and angled blades, may be employed. The pontoon may be fixed across an end, the centre of the pond, or any other location. The pontoon may rotate to cover all of
25 the slurry pond area, or may move horizontally across the slurry pond – depending on the mixing pattern required.

In other embodiments, the pontoons may be of a smaller discrete size. The smaller versions may similarly be fixed, rotate or move in any direction around the pond. One or more agitator assemblies may be associated with smaller versions of the support assembly. Smaller pontoon
30 versions may be interlinked in any configuration (side-by-side, or end-to-end, or combinations of

these) to achieve the desired overall configuration and hence mixing pattern throughout the slurry pond.

Similarly, the length of the support legs of the frame may also be varied, as may any extension arms associated with frame only options.

- 5 The support assembly (frame and/or pontoon) allows the agitator system to float, rotate, move directionally or be located in a fixed position anywhere in the slurry pond. However, the preferred location for the agitator system is in the middle of a slurry pond.

10 The agitator system is adapted to be operated manually, or operate independently via automated systems driven by appropriate programmable software and hardware systems (as shown diagrammatically at 14 in Figures 3-5, 7 and 8).

The programmable systems enable any part of the agitator system to be activated. For example, any of the components of the agitator assembly may be operated via the programmable systems to select the best operating parameters for the slurry to be mixed.

15 Accordingly, the propellers may be pivoted and thereby enable setting of the angle of the propellers relative to the vertical axis of the drive shaft. The speed of the propellers may be set and/or adjusted. The propeller height in the slurry may be adjusted by movement up and down of the lower section of the drive shaft. The speed of rotation of the agitator system generally and/or the agitator assembly portions specifically may be predetermined and set, for initiation at predetermined times and for predetermined lengths of time; and so forth.

20 The remote controlling option via programmable systems includes a pre-programmed guidance system to enable the frame/pontoon to move to different locations within the slurry pond. Therefore, the support assembly may be selectively moved in any predetermined direction or remain in a fixed position. This makes it possible to move the support assembly to a selected location in the pond, or on a predetermined path through the slurry pond.

25 The agitator system is able to be easily operated by one person.

The agitator system of varying embodiments may include single or multiple drive shafts, with at least two propellers mounted opposite to each other; and, the whole unit is adapted to float, be fixed or rotate. Figure 5 illustrates one such option.

In yet other embodiments, there may be two or more independent agitator systems, arranged in relative proximity to each other, as illustrated in Figure 6 where there is one drive shaft per pontoon, each with one propeller mounted which is mounted to the pontoon to face in a direction opposite to the other propeller. Such systems could operate independently. However, each system
5 would work typically together – in unison, or in sequence - with the other system.

In addition, it yet another embodiment (as illustrated in Figure 7), two submersible agitator systems, may be mounted opposite to each other, each with one propeller, but operating as would a single agitator assembly with two propellers and, the combined system would similarly be adapted to float, be fixed or rotate, depending on the mode of operation required.

10 In addition, in yet another embodiment (as illustrated in Figure 8), two submersible agitator systems, may be mounted opposite to each other, each with two propellers and, again the combined system would similarly be adapted to float, be fixed or rotate, depending on the mode of operation required.

It is to be appreciated that the position of attachment of the agitator assembly to the support
15 assembly may be varied.

Multiple agitator systems may be interlinked by linkage arms which may be extensions of the frame 12, or unique interlinking portions as shown in Figure 6.

When referring to the description of the present invention, it should also be understood that the term “comprise” where used herein is not to be considered to be used in a limiting sense.
20 Accordingly, ‘comprise’ does not represent nor define an exclusive set of items, but includes the possibility of other components and items being added to the list.

This specification is also based on the understanding of the inventor regarding the prior art. The prior art description should not be regarded as being an authoritative disclosure of the true state of the prior art but rather as referring to considerations in and brought to the mind and attention of
25 the inventor when developing this invention.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof, as defined in the appended claims.

THE CLAIMS DEFINING THE INVENTION ARE:

1. An agitator system for mixing slurry, said slurry being contained in a slurry pond, said agitator system including an agitator assembly and a support assembly, said support
5 assembly supporting said agitator assembly relative to the slurry, said agitator assembly including at least one drive assembly associated with at least one impeller, the drive assembly being adapted to rotate the agitator system in whole or part through 360 degrees.
2. An agitator system for mixing slurry as claimed in Claim 1, wherein the agitator assembly is a height adjustable mixer, submersible in whole or part.
- 10 3. An agitator system as claimed in Claim 2 wherein the drive assembly includes at least one drive shaft located within the slurry in a substantially vertical orientation and arranged relative to and driven by drive means and gear means.
4. An agitator system as claimed in Claim 3 wherein the drive means is at least one of hydraulic motor means, electrical motor means.
- 15 5. An agitator system as claimed in Claim 4 wherein the drive shaft includes an upper section and a lower section.
6. An agitator system as claimed in Claim 5 wherein the lower section of the drive shaft rotates through 360 degrees effecting rotation of one or more of:
 - a) the lower section of the drive shaft to which at least one impeller is attached;
 - 20 b) the agitator assembly as a whole;
 - c) the agitator system as a whole;thereby inducing rotational motion of the slurry within the slurry pond about the substantially vertical axis of the drive shaft.
7. An agitator system as claimed in Claim 6 wherein rotation of the drive shaft is facilitated
25 by rotating means.
8. An agitator system as claimed in Claim 7 wherein the rotating means includes any one of a rotating flange, a slew ring.

9. An agitator system as claimed in Claim 8 wherein rotation of the drive shaft and components included relative thereto is controlled by a variable frequency drive to effect at least one of a range of predetermined rotational speed options, predetermined rotational directions, predetermined rotational durations.
- 5 10. An agitator system as claimed in Claim 9 wherein rotation of the drive shaft is effected over a range of slow speed options.
11. An agitator system as claimed in Claim 10 wherein rotation of the drive shaft is effected clockwise, anti-clockwise and alternating between clockwise and anticlockwise directions for predetermined and variable periods of time.
- 10 12. An agitator system as claimed in Claim 11 wherein the drive shaft includes any one of axial or radial flow impellers determined by the slurry mixing and flow regimes required.
13. An agitator system as claimed in Claim 12 wherein the impellers are propellers.
14. An agitator system as claimed in Claim 13 wherein the location of the propellers is adjustable vertically to locate the drive shaft and propellers within the slurry at a
15 predetermined depth to effect homogenisation and mixing of the slurry at different levels in the slurry pond.
15. An agitator system as claimed in Claim 14 wherein each propeller includes at least two opposed blades and is determined by the slurry being mixed.
16. An agitator system as claimed in Claim 15 wherein the propellers are moveable to pre-
20 determined configured angles relative to the vertical axis of the drive shaft as determined to effect mixing of slurries of varying viscosities.
17. An agitator system as claimed in Claim 16 wherein the propellers are configured at an angle of between 0-90 degrees relative to the vertical axis of the drive shaft.
18. An agitator system for mixing slurry as claimed in Claim 17, wherein the propellers are
25 configured at an angle of between 20 to 80 degrees relative to the vertical axis of the drive shaft.
19. An agitator system as claimed in Claim 18 wherein the propellers are at an angle of 30-45 degrees from true horizontal.

20. An agitator system as claimed in Claim 18 wherein one propeller is angled downwards and a second propeller is angled upwards.
21. An agitator system as claimed in Claim 20 wherein each of the propellers is adapted to rotate in predetermined directions at predetermined speeds for predetermined periods of time, in unison, separately or reversibly.
22. An agitator system as claimed in Claim 21 wherein the speed of the propellers in a liquid manure slurry pond is in the range of 50rpm to 750rpm.
23. An agitator system as claimed in Claim 22 wherein the support assembly of the agitator system enables at least one agitator assembly to float, rotate, move directionally or be fixed in position within the slurry pond at differing locations to increase homogeneity of the slurry via rotational movement of the agitator assembly in whole or part.
24. An agitator system as claimed in Claim 23 wherein the support assembly includes either or both a frame and a pontoon.
25. An agitator system as claimed in Claim 24 wherein the support assembly positions via the agitator assembly in the middle of a slurry pond to effect optimal mixing during the mixing process.
26. An agitator system as claimed in Claim 25 wherein multiple agitator systems are adapted to operate in relative proximity to each other, either separately or interlinked and independently or in unison.
27. An agitator system for mixing slurry as claimed in Claim 26, wherein the agitator system is operated manually.
28. An agitator system for mixing slurry as claimed in Claim 27, wherein the agitator system is operated via electronic programmable means in conjunction with associated software and hardware.
29. A method for mixing slurry using an agitator system, said slurry being contained in a slurry pond, said agitator system including an agitator assembly and a support assembly, said support assembly supporting said agitator assembly relative to the slurry, said agitator assembly including at least one drive assembly associated with at least one

impeller, the drive assembly being adapted to rotate the agitator system in whole or part through 360 degrees; and said method including the steps of:

- a) Positioning the agitator system within the slurry pond at a predetermined location; and
 - 5 b) Adjusting the height of the agitator assembly within the slurry to a predetermined depth; and wherein the agitator assembly includes
 - c) The at least one drive shaft adapted to drive the at least one impeller associated therewith; and wherein
 - 10 d) Rotation of the agitator system and parts thereof through 360 degrees is effected in predetermined directions, at predetermined speeds and for predetermined durations.
30. An agitator system for mixing slurry, as herein described with reference to the included examples and attached figures.
- 15 31. A method of manufacturing an agitator system for mixing slurry, as herein described with reference to the included examples and attached figures.

5

FIGURE 1

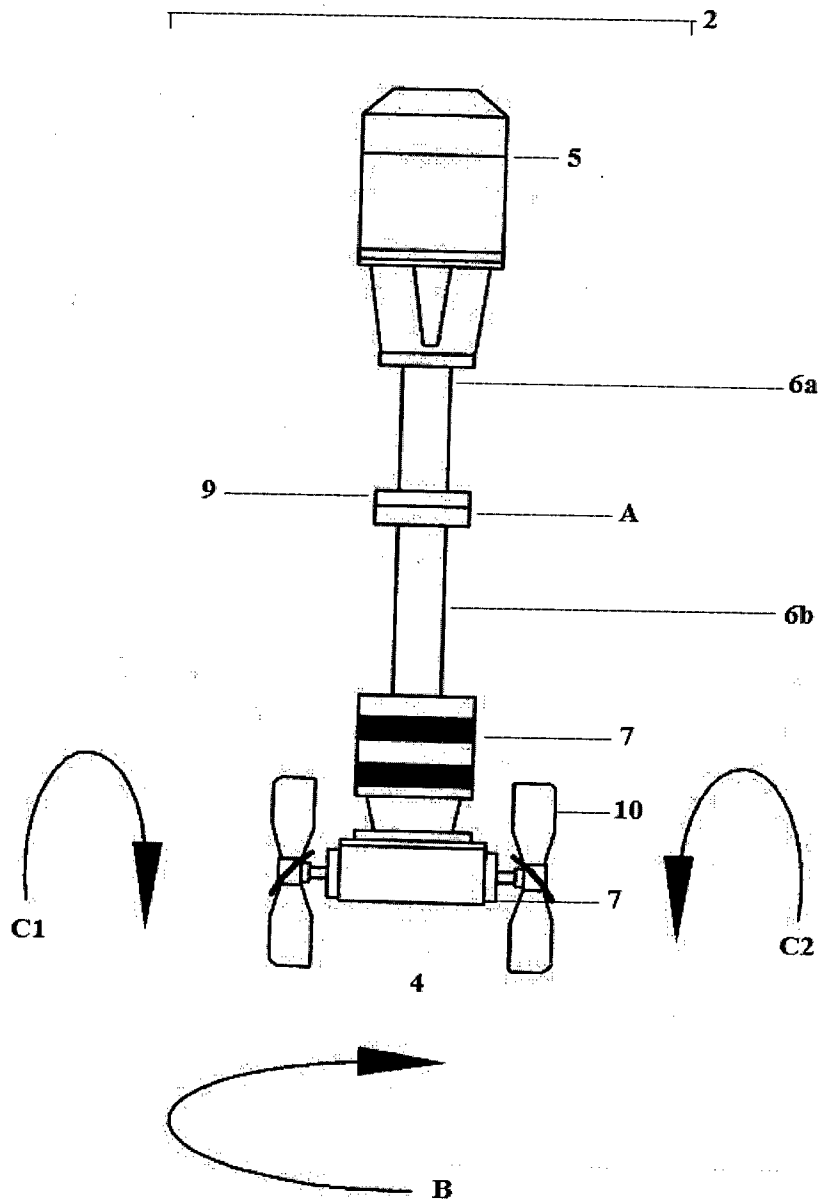


FIGURE 2

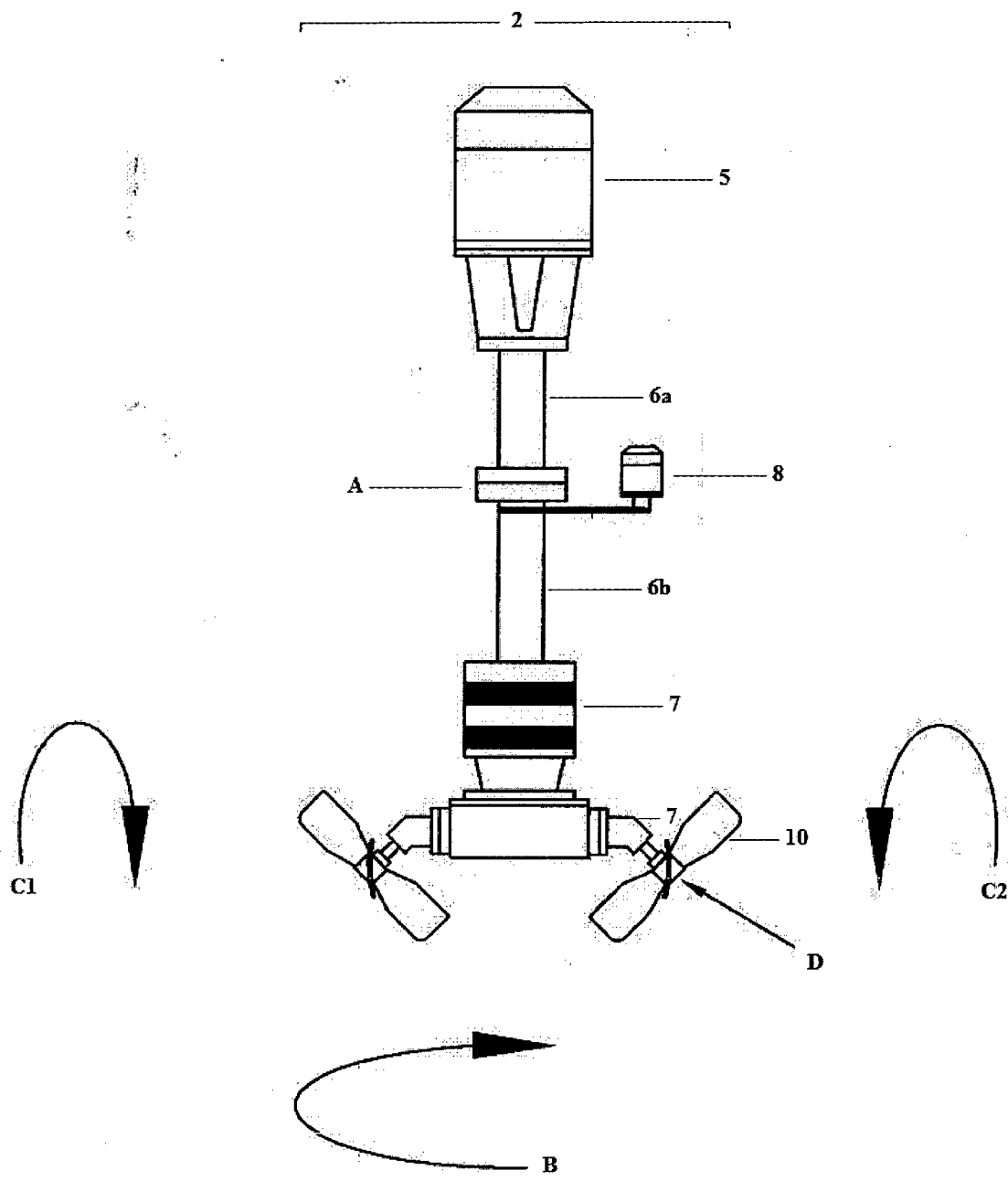


FIGURE 3

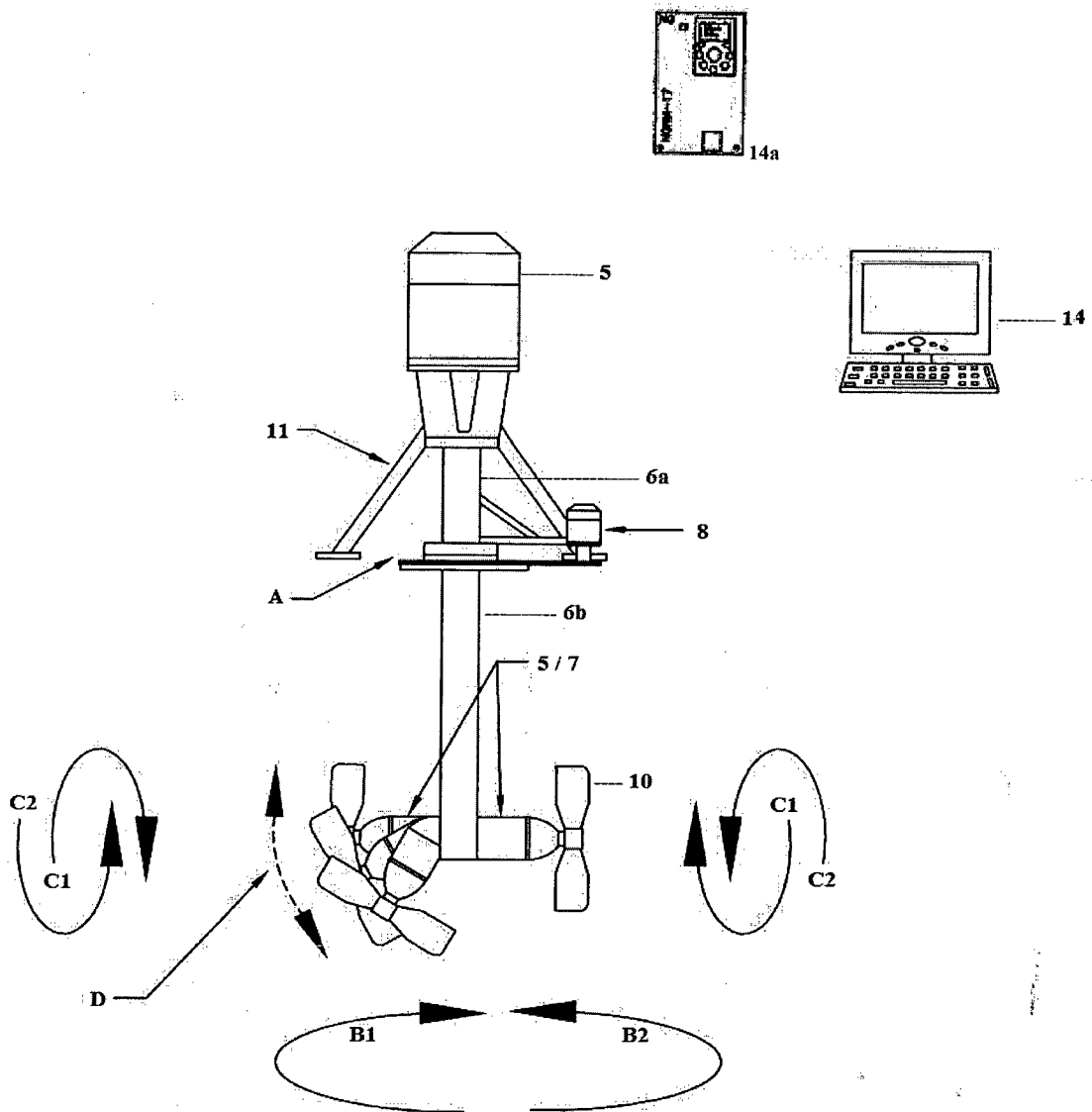


FIGURE 4

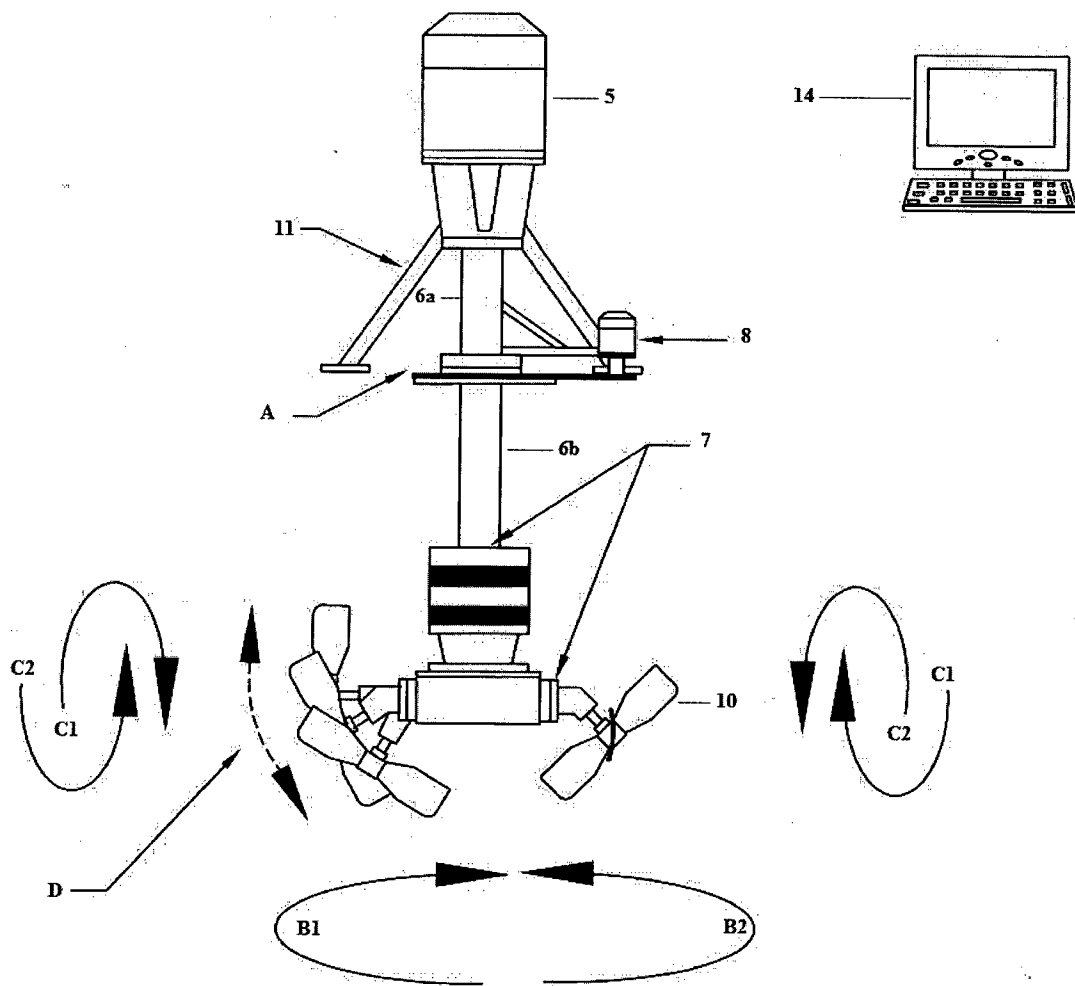


FIGURE 5

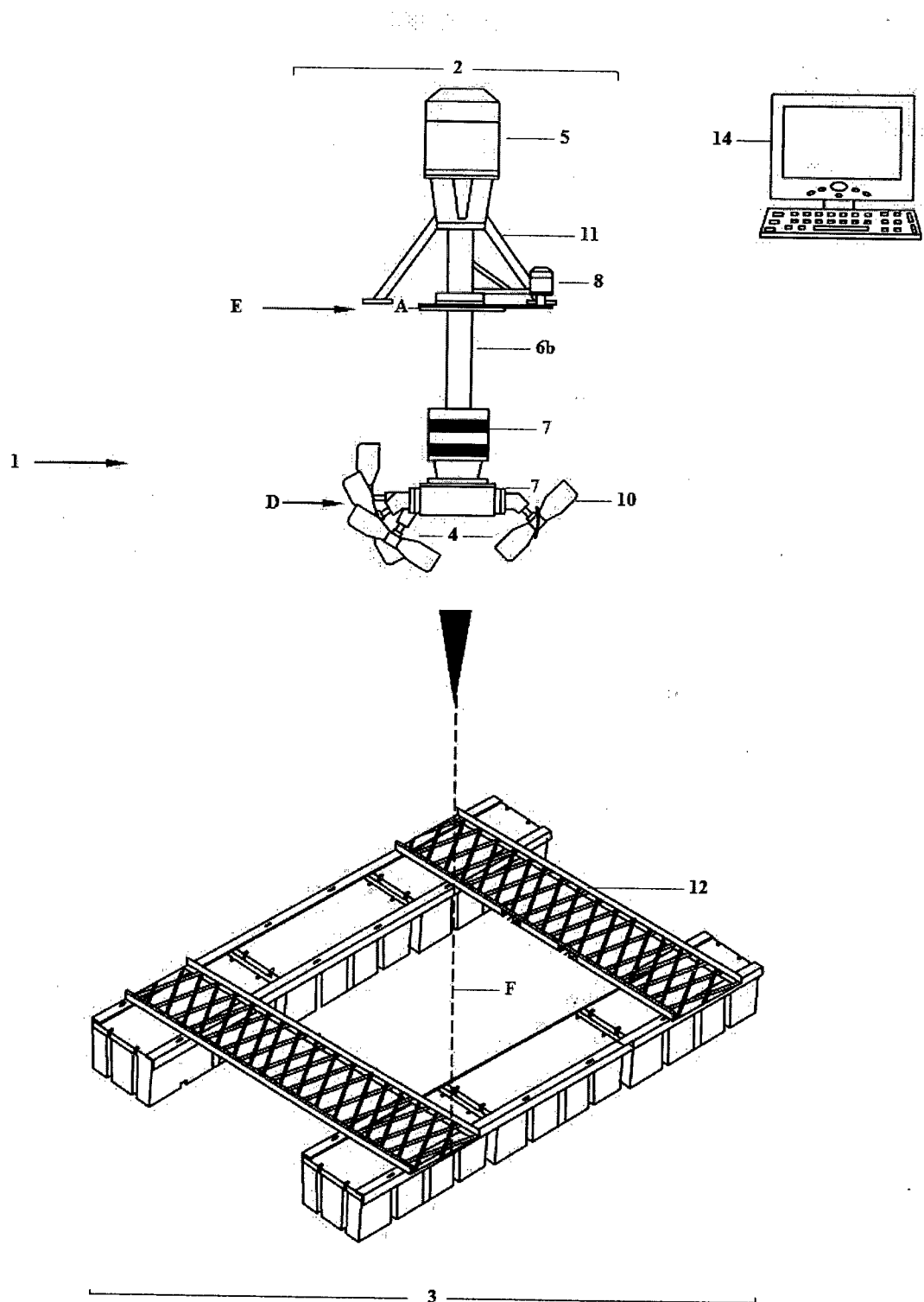


FIGURE 6

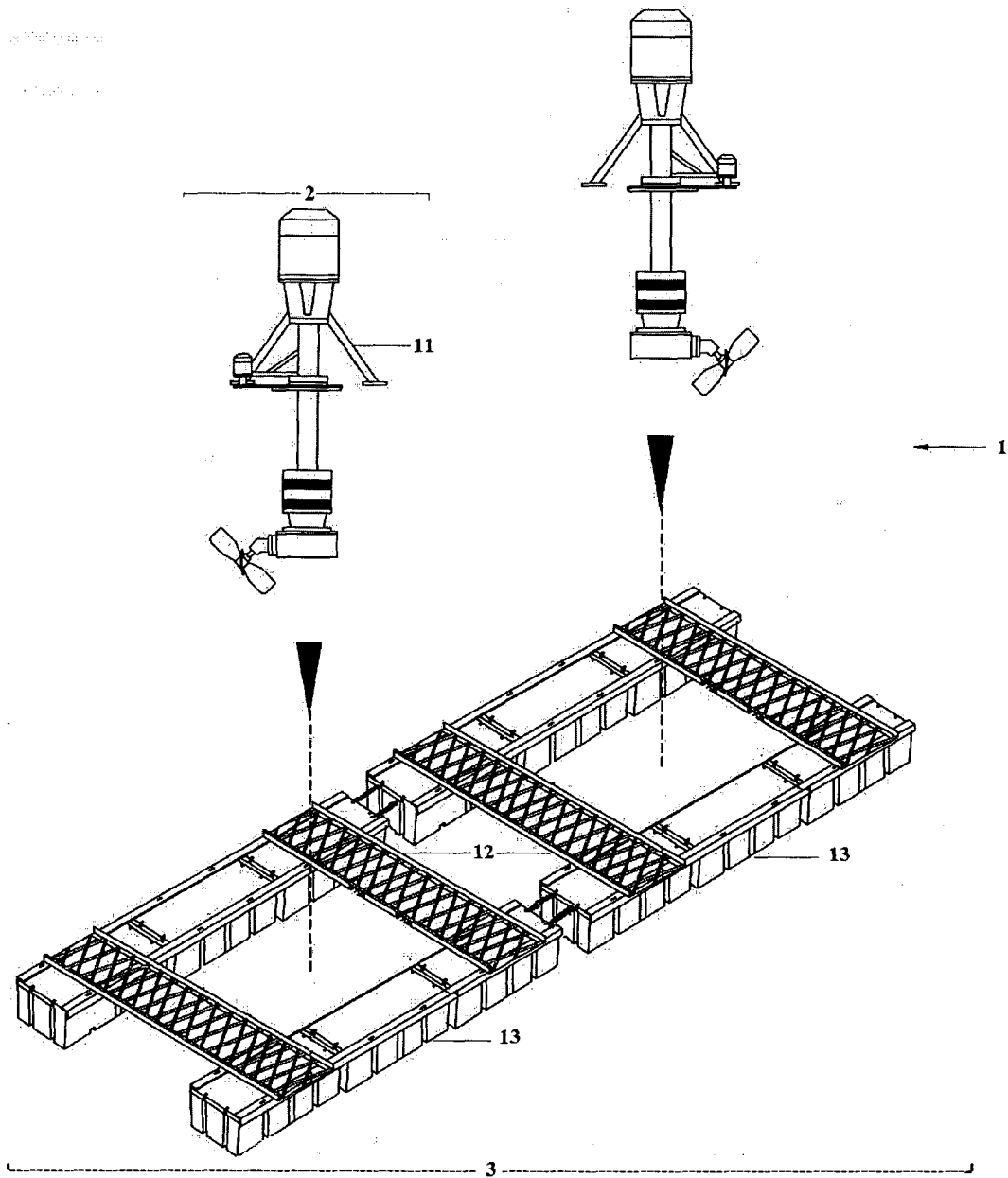


FIGURE 7

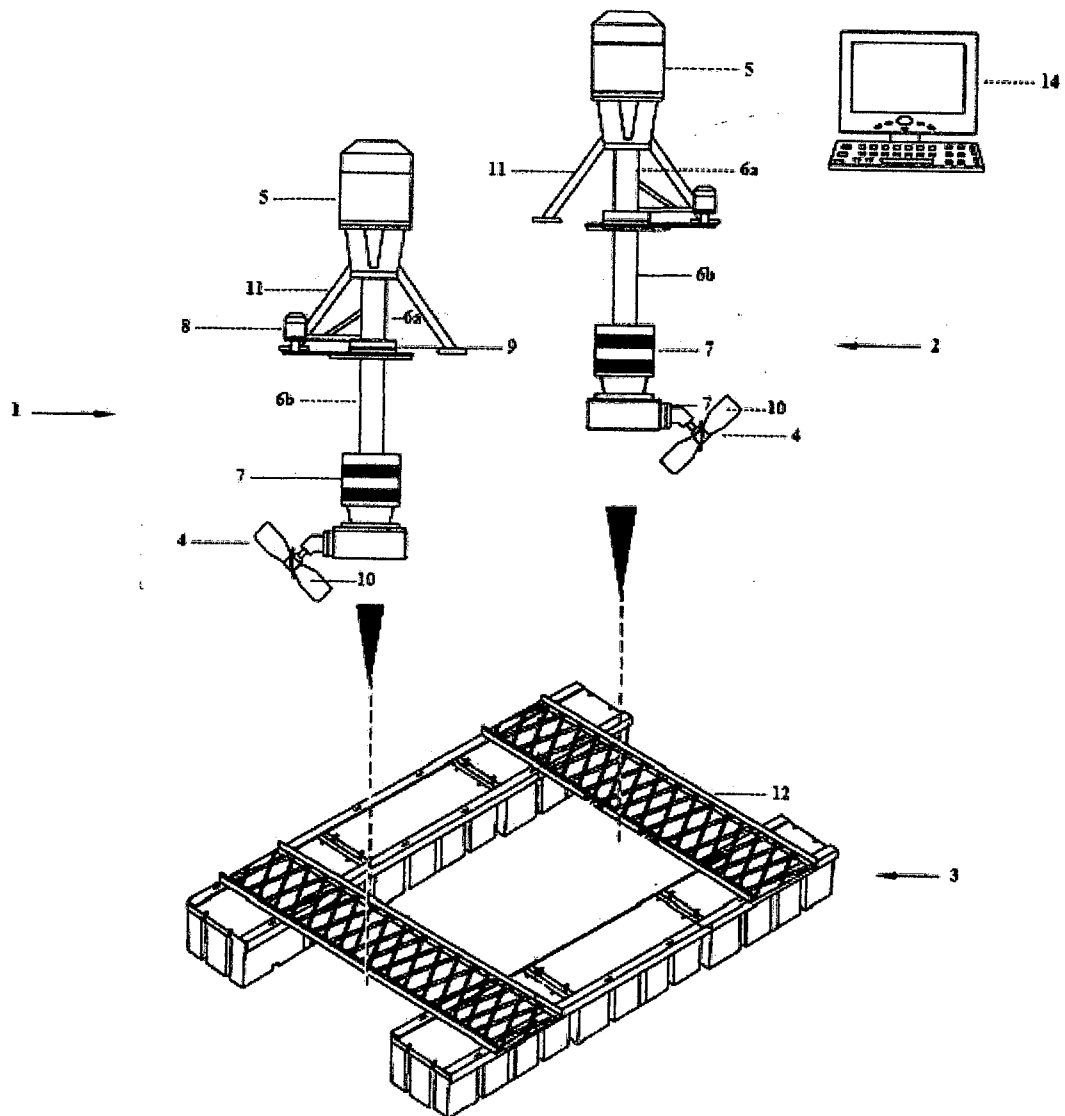


FIGURE 8

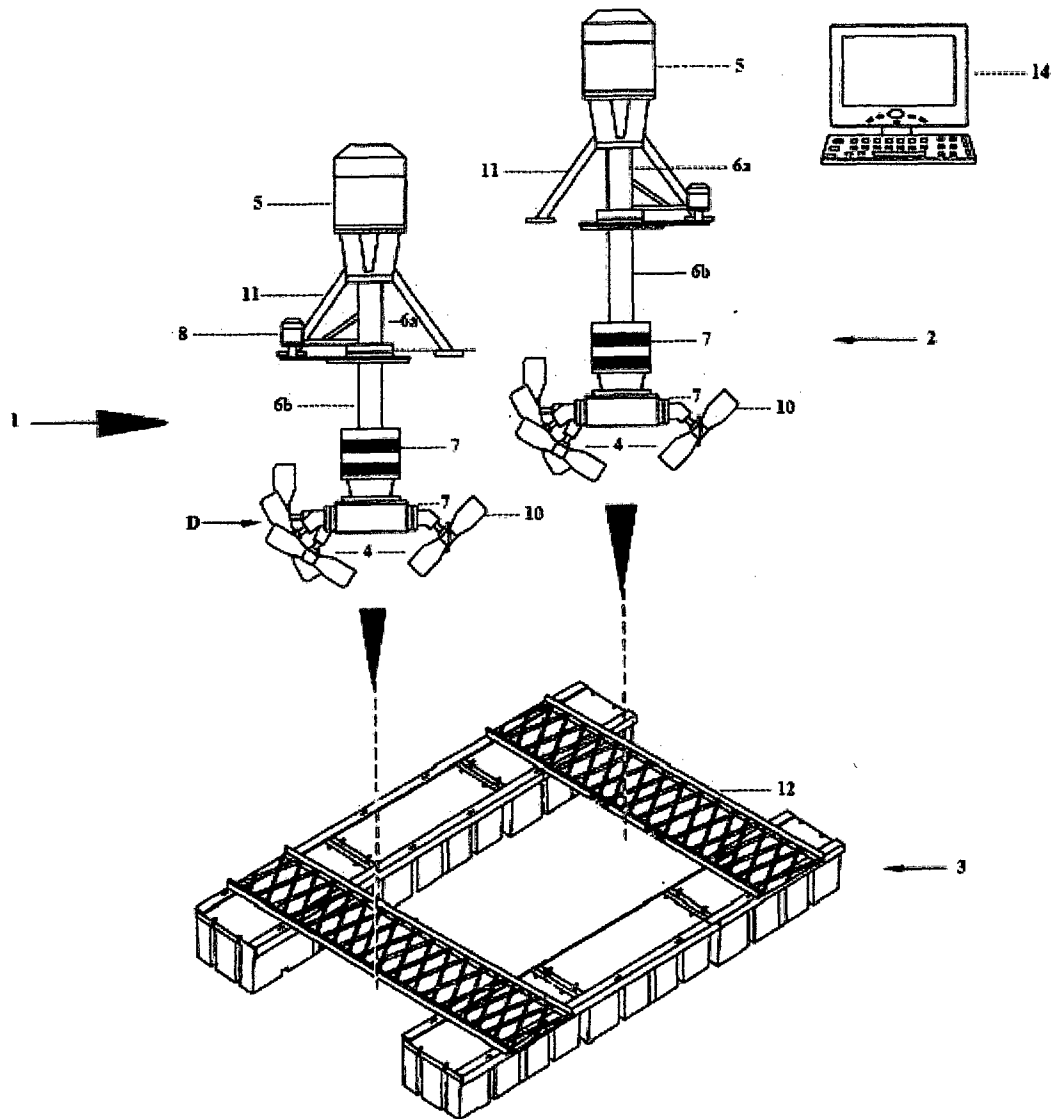
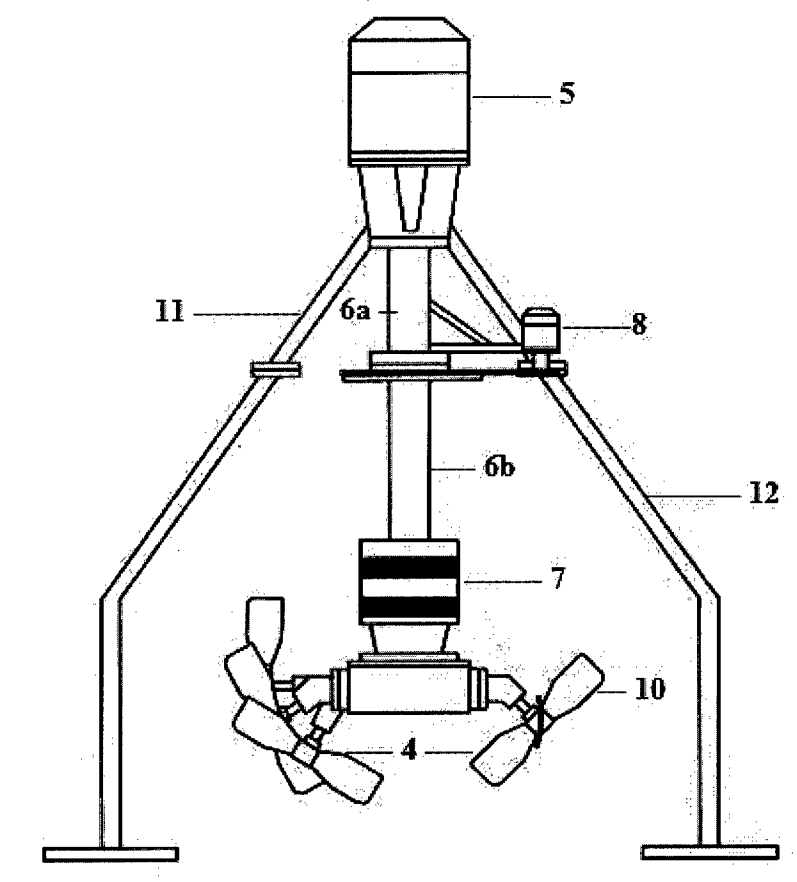


FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2013/000051

A. CLASSIFICATION OF SUBJECT MATTER

B01F 7/22 (2006.01) B01F 3/12 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC: IPC's /IC/CC B01F7/LOW, B01F3/12/LOW, B01F2003/12/LOW & KEYWORDS (SLEW, SWING, PIVOT, ADJUST, HEIGHT, VARIABLE AND SIMILAR TERMS).

GOOGLE PATENTS, ESPACENET, PATENT LENS: KEYWORDS (IMPELLER, AGITATOR, SLURRY, MIX, ROTATE AND SIMILAR TERMS).

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

☒ Further documents are listed in the continuation of Box C☒ See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
23 July 2013Date of mailing of the international search report
23 July 2013

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **30 & 31**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
See Supplemental Box

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/NZ2013/000051
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0937377 B1 (RECK ANTON) 28 August 2002 English Translation of full document obtained from Espacenet; Figures 6, 7	1-29
Form PCT/ISA/210 (fifth sheet) (July 2009)		

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2013/000051**Supplemental Box**Continuation of **Box II**

Claims 30 & 31 do not comply with Rule 6.2(a) because they rely on references to the description and/or drawings.

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/NZ2013/000051	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
EP 0937377 B1	28 Aug 2002	EP 0937377 A1	25 Aug 1999
		EP 0937377 B1	28 Aug 2002
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			