

ELECTROMAGNETIC CIRCULATION PUMP

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This Application is related to Application Ser. No. 61/693,497 filed August 27, 2012 by Cox, Jr., which is hereby incorporated herein by reference in its entirety and to which priority is claimed.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to fluid pump assemblies in general, and more particularly to a fluid pump that is magnetically supported in position and in which a driving force is transmitted to a fluid motion imparting device through the medium of magnetic force by a solid state electromagnetic motor.

2. Description of the Related Art

[0003] In order to properly care for fish and other aquatic organisms contained within a reef aquarium, adequate circulation is required. The role of circulation is twofold: first, circulation acts to constantly mix the aquarium water itself, ensuring that proper chemistry is maintained

throughout the entire aquarium. Adequate circulation maintains carbon dioxide by increasing the rate at which water flows from the bottom of the tank to the top, where it can take in these compounds from the air. The second role of circulation is related to the nature of the inhabitants of a reef aquarium. Because many reef inhabitants are sessile (they do not move), circulation is the only means by which nutrients such as food and oxygen are brought to these animals and the only means by which waste is expelled. In the ocean, corals and other sessile animals have the benefit of large waves crashing into the reef in a random but consistent fashion. Within the constraints of a glass box or aquarium, a pump is used as a substitute.

[0004] Prior aquarium circulating devices and pumps feature two aspects that make them less ideal than the present invention. First, designs featuring epoxy sealed motors within the aquarium have the unfortunate side effect of being relatively large and distracting to the intrinsic beauty of an aquarium, add unwanted heat to the aquarium through direct contact with the motor stator, and require that electricity be brought into the aquarium itself via a power cord or a battery sealed into the motor assembly. Second, some prior designs utilize a mechanical bracket which hangs over the top of the aquarium in order to support the pump within the aquarium. In some prior pumps in which the motor and the centrifugal propeller are magnetically coupled through the glass, brackets are used to support and align the rotating component within the aquarium. The prior designs are unsatisfactory because they are bulky due to the motor being placed within the aquarium or due to the brackets supporting the motor outside the aquarium. Furthermore, the prior designs required that the pump be located at a location determined by the location of the bracket or be on the bottom of the aquarium due to the weight of the pump.

[0005] Moreover, current magnetic pump designs use a brushless attached to a first permanent magnet (magnetic drive member) and clamping it to a second permanent magnet (magnetic driven member) through a substrate to drive a propeller. Problems may arise over time with the moving parts wearing down and creating excessive resistance as well as noisy operation. The following design according to the present invention removes those moving components and replaces them with a solid state electromagnetic motor, which has no moving parts.

[0006] The present invention attempts to remedy the drawbacks of the prior art and provides a fluid pump assembly adapted to be mounted to an aquarium without the use of mechanical aids, such as brackets. The disclosed pump can be located anywhere on the surfaces of the aquarium, thus maximizing the aesthetic effects of the aquarium and facilitating water circulation by allowing the pump to be located at a location achieving optimized fluid flow based upon the interior characteristics of the aquarium.

SUMMARY OF THE INVENTION

[0007] The present invention provides a fluid pump assembly for use in a fluid container.

[0008] According to a first aspect of the present invention, there is provided a fluid pump kit comprising a stationary first magnetic assembly including a stationary magnetic drive member, a first casing supporting and housing said first magnetic assembly, a rotatable second magnetic assembly including a rotatable magnetic driven member drivingly coupled to a fluid motion imparting device, a second casing supporting and housing the second magnetic assembly, and a non-magnetic spacer separating the first and second magnetic assemblies.

The magnetic drive member and the magnetic driven member are each other by a magnetic attraction force therebetween through the spacer. The magnetic drive member comprises a number of electromagnets non-rotatably mounted within the first casing so as to face the magnetic driven member. The electromagnets are controlled so as to be energized in succession to create a rotating magnetic field for continuously rotating the rotatable magnetic driven member. The magnetic drive member is spaced from the spacer on one side thereof, while the magnetic driven member is spaced from the spacer on an opposite side thereof. The second casing is detachably securable to the spacer solely by the magnetic attraction force between the magnetic drive member and the magnetic driven member sufficient to support the first and second casings in a particular position without the use of mechanical aids.

[0009] According to a second aspect of the present invention, there is provided a fluid pump assembly used in combination with a container having a wall for holding an amount of fluid. The fluid pump assembly comprises a first casing disposed exteriorly of the container on a first side of the wall, a stationary first magnetic assembly including a stationary magnetic drive member non-rotatably mounted to the first casing and spaced from the wall outside the container, a second casing disposed interiorly of the container on a second side of the wall, and a rotatable second magnetic assembly mounted to the second casing and including a rotatable magnetic driven member spaced from the wall inside said container. The rotatable magnetic driven member is drivingly coupled to a fluid motion imparting device. The magnetic drive member comprises a number of electromagnets non-rotatably mounted within the first casing so as to face the magnetic driven member. The electromagnets are controllably activated so as to be energized in succession to create a rotating magnetic field for

continuously rotating the rotatable magnetic driven member. The magnetically coupled to the magnetic driven member by a magnetic attraction force through the wall for imparting a rotary driving force to the fluid motion imparting device. The second casing is detachably securable to the wall solely by the magnetic attraction force between the magnetic drive member and the magnetic driven member sufficient to support the first and second casings in a particular position without the use of mechanical aids.

[0010] The invention furthermore includes a method of circulating fluid within a container. The method comprises the steps of providing a first casing having a stationary first magnetic assembly including a stationary magnetic drive member non-rotatably mounted to the first casing, a second casing having a rotatable second magnetic assembly mounted to the second casing and including a rotatable magnetic driven member drivingly coupled to a fluid motion imparting device, and a container having a fluid therein. The magnetic drive member comprises a number of electromagnets non-rotatably mounted within the first casing so as to face the magnetic driven member. The method of the present invention further comprises the steps of positioning the first casing on an exterior side of a wall of the container and positioning the second casing on an interior side of the wall of the container within the fluid in coaxial alignment with the first casing and allowing the first and second casings to remain in alignment solely as a result of a magnetic attraction force between the stationary magnetic drive member and the rotatable magnetic driven member sufficient to support at least the second casing against gravity without the use of mechanical aids. In order to actuate a fluid pump assembly, the electromagnets are controllably energized in succession so as to create a rotating magnetic field extending from the stationary magnetic drive member and causing

cooperating rotation of the rotatable magnetic driven member an imparting device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings are incorporated in and constitute a part of the specification. The drawings, together with the general description given above and the detailed description of the exemplary embodiments and methods given below, serve to explain the principles of the invention. In such drawings:

[0012] FIG. 1A is a perspective view of a fluid pump kit including a fluid pump assembly according to an exemplary embodiment of the present invention;

[0013] FIG. 1B is a sectional view of the fluid pump kit including the fluid pump assembly according to the exemplary embodiment of the present invention;

[0014] FIG. 2 is a sectional view of the fluid pump assembly according to the exemplary embodiment of the present invention in combination with a fluid container;

[0015] FIG. 3A is a perspective view of a magnetic drive member of a first magnetic assembly having six electromagnets and a second magnetic assembly of the fluid pump assembly of FIGS. 1A-2;

[0016] FIG. 3B is a perspective view of the magnetic drive member of the first magnetic assembly having four electromagnets and the second magnetic assembly of the fluid pump assembly of FIGS. 1A-2

[0017] FIG. 4 is a schematic view of a control circuit of a control unit of the first magnetic assembly; and

[0018] FIG. 5 is a schematic view of a control circuit of a control assembly according to the exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS AND EXEMPLARY METHODS

[0019] Reference will now be made in detail to exemplary embodiments and methods of the invention as illustrated in the accompanying drawings, in which like reference characters designate like or corresponding parts throughout the drawings. It should be noted, however, that the invention in its broader aspects is not limited to the specific details, representative devices and methods, and illustrative examples shown and described in connection with the exemplary embodiments and methods.

[0020] This description of exemplary embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. In the description, relative terms such as "horizontal," "vertical," "front," "rear," "upper", "lower", "top" and "bottom" as well as derivatives thereof (e.g., "horizontally," "downwardly," "upwardly," etc.) should be construed to refer to the orientation as then described or as shown in the drawing figure under discussion and to the orientation relative to a vehicle body. These relative terms are for convenience of description and normally are not intended to require a particular orientation. Terms concerning attachments, coupling and the like, such as "connected" and "interconnected," refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described

otherwise. The term "operatively connected" is such an attachment that allows the pertinent structures to operate as intended by virtue of that relationship.

Additionally, the word "a" as used in the claims means "at least one".

[0021] FIGS. 1A and 1B depict a fluid pump kit 8 comprising a fluid pump assembly according to an exemplary embodiment of the present invention, generally depicted with the reference numeral 10, in the form of a kit. The fluid pump assembly 10 comprises a first casing 12 housing a first magnetic assembly 14, and a second casing 32 housing a second magnetic assembly 34 operatively associated with a fluid motion imparting device 38 for imparting motion to a fluid when rotated by the second magnetic assembly 34, such as a propeller, if the fluid pump assembly of the present invention is used for an aquarium, or an impeller, if the fluid pump assembly of the present invention is used for an foot spa. The fluid pump kit 8 further comprises a non-magnetic spacer 42 separating the first and second magnetic assemblies 14 and 34, respectively. The non-magnetic spacer 42 has a first side 42a and a second side 42b oriented opposite and substantially parallel to each other. The first side 42a of the spacer 42 is in contact with the first casing 12, while the second side 42b is in contact with the second casing 32. The spacer 42 may be rubber or other non-magnetic polymer and has a thickness of approximately 0.5 inches.

[0022] FIG. 2 depicts the fluid pump assembly 10 in accordance with the exemplary embodiment of the present invention, used in combination with a container 2 provided for holding an amount of fluid 7, such as liquid. It will be appreciated that the container 2 may be of any appropriate form, such as an aquarium. The container 2 comprises a bottom wall 4 and a side wall 6 extending substantially vertically upwardly from the bottom wall 4. The bottom wall 4 and the side wall 6 of the container 2 define a compartment 5 holding the liquid 7. The

side wall 6 of the container 2 has a first side 6a and a second side 6b substantially parallel to each other.

[0023] The first casing 12 of the fluid pump assembly 10 is disposed outside the container 2 and houses the first magnetic assembly 14, while the second casing 32 is disposed inside the container 2 submersed within the liquid 7 and houses the second magnetic assembly 34 operatively associated with an impeller, such as a propeller 38. A material such as ABS, Teflon or ultra high molecular weight polyethylene (UHMW) may be used for both first and second casings 12 and 32, respectively. A protective shroud 33 is attached to the second casing 32 around the propeller 38 to prevent aquarium inhabitants from contacting the spinning impeller 38 and for permitting water to circulate in response to rotation of impeller 38.

[0024] The second magnetic assembly 34 includes a magnetic driven member 35 and a driven support disc 36 non-movably attached (i.e., fixed) to the magnetic driven member 35 by any appropriate means known in the art, such as by adhesive bonding, for rotation about a second axis 37. The second magnetic assembly 34 (i.e., both the magnetic driven member 35 and the driven support disc 36) are drivingly coupled to the propeller 38 by a driven shaft 40. In other words, the driven shaft 40 is coaxial with the second axis 37.

[0025] The magnetic driven member 35 is a permanent magnet formed from a magnetic material, such as neodymium or any other high performance magnetic material offering low physical volume and high magnetic flux, mounted within the second casing 32. The magnetic driven member 35 has at least one pair of magnetic poles (N) and (S). In an exemplary embodiment of the present invention, the magnetic driven member 35 is a 2-pole magnet in the form of circular disk and has a pair of magnetic poles (N) and (S). In such an arrangement

of the magnetic driven member 35, the magnetic poles (N) and (S) are arranged in a radial dimensional array, such as radially along the disc 35. Alternatively, the magnetic driven member 35 can have a plurality of pairs of magnetic poles (N) and (S). The magnetic material of the magnetic driven member 35 in accordance with the exemplary embodiment of the present invention is grade N35SH to N45H permanent magnet, having a surface magnetic field of about 2400 G.

[0026] The driven support disc 36 is made of magnetically permeable material, such as steel, and is attached to and covers a distal side of the magnetic driven member 35 opposite the first magnetic assembly 14. The driven support disc 36 short circuits the magnetic flux of the magnetic driven member 35 and thereby increases the efficiency of the pump assembly 10.

[0027] According to the exemplary embodiment of the present invention, both the magnetic driven member 35 and the driven support disc 36 are geometrically substantially identical, i.e., both are in the form of a circular disk and have the same outer diameter and thickness. Alternatively, the magnetic driven member 35 and the driven support disc 36 may have different thickness and/or outer diameter.

[0028] Moreover, the second casing 32 is situated against the second side 6b of the container 2, and the magnetic driven member 35 is mounted in the second casing 32 so that the axis 37 of rotation of the driven shaft 40 is substantially perpendicular to the second side 6b of the container 2.

[0029] As further illustrated in Figs. 1B and 2, the magnetic driven member 35 is disposed adjacent to the spacer 42 or the side wall 6 of the container 2, and is axially spaced from the second side 42b or the second side 6b thereof with a small gap 39. The mounting of the magnetic driven member 35 and the propeller 38 in the second casing 32 includes a bearing

41 of suitable material properties to support the driven shaft 40, 32 the clamping forces caused by the first and second magnetic assemblies 14 and 34, and minimize the friction of rotation. When used for salt water applications, the bearing 41 should be a plastic composition, Teflon or UHMW with a suitably hard and smooth mating surface, such as made from metal or ceramic material.

[0030] The first magnetic assembly 14 is in the form of a solid state electro-magnetic motor non-rotatably mounted within the first casing 12 and coaxial to a first axis 15. The first magnetic assembly 14 includes a stationary (i.e., non-rotatable) magnetic drive member 16, and a control unit 18. The magnetic drive member 16 is coaxial to the first axis 15 and stationary (i.e., non-rotatable) relative to each other and to the first casing 12. The first magnetic assembly 14, as illustrated in FIGS. 1B and 2, is attached to a power source 22 separate from the first casing 12 through electric wires 23. The first magnetic assembly 14 may also be powered by a battery attached to the electric wires 23. As illustrated in Figs. 1B and 2, the stationary magnetic drive member 16 is axially spaced from the first side 42a of the spacer 42 or the first side 6a of the side wall 6 of the container 2 with a small gap 24.

Alternatively, the stationary magnetic drive member 16 is supported upon the first side 6a of the side wall 6 of the container 2 by an adhesive material, such as a double-sided adhesive tape disposed between the stationary magnetic drive member 16 and the side wall 6 of the container 2, which adhesively bonds the stationary magnetic drive member 16 to the first side 6a of the side wall 6 of the container 2.

[0031] According to the exemplary embodiment of the present invention, as illustrated in FIGS. 1B-3B, the magnetic drive member 16 comprises a circular drive support plate 25 non-rotatably mounted within the first casing 12 and a number of substantially identical

electromagnets 26₁-26_n fixedly mounted angularly equidistantly as to face the magnetic driven member 36 of the second magnetic assembly 34. The circular drive support plate 25 is coaxial to the first axis 15 and substantially orthogonal thereto. According to the exemplary embodiment of the present invention, the drive support plate 25 is made of a ferromagnetic material, such as steel. In the exemplary embodiment of Figs. 1B-3B, the electromagnets 26₁-26_n are non-rotatably attached to the support plate 25 around the axis 15 equidistantly in a circular pattern so as to extend substantially parallel to the axis 15 by any appropriate means known in the art, such as by adhesive bonding or by threaded fasteners. In other words, each of the electromagnets 26₁-26_n, the support plate 25 and the control unit 18 is stationary (i.e., non-rotatable) relative to each other and to the first casing 12. Thus, in the case of the electro-magnetic drive member 16, there would be no moving parts on the outside of the container 2.

[0032] As illustrated in detail in Fig. 3A, the solid state electromagnetic motor 14 according to the exemplary embodiment of the present invention utilizes 6 individual electromagnets 26₁-26₆ placed equidistantly in a circular pattern coaxial to the axis 15 (two electromagnets adjacent to each other yielding opposite magnetic fields). It will be appreciated that the solid state electromagnetic motor 14 may include more or less than 6 electromagnets, such as 4, as illustrated in Fig. 3B. Each of the electromagnets 26₁-26₆ extends substantially parallel to the axis 15. Moreover, each of the electromagnets 26₁-26₆ includes a ferromagnetic (or iron) core 27₁-27₆, respectively, placed inside a corresponding electro-magnetic coil 28₁-28₆, respectively, and extending substantially orthogonally from the support plate 25 toward the magnetic driven member 36 of the second magnetic assembly 34, and substantially parallel to the axis 15. Thus, the magnetic driven member 36 of the second magnetic assembly 34 has 2

poles of magnet, while the magnetic drive member 16 has 6 (six: A-, B-, C-). The ferromagnetic cores 27₁-27₆ of the electromagnets 26₁-26₆ are preferably made of stacks of thin steel sheets, or laminations, oriented parallel to the magnetic field, with an insulating coating on the surface. The insulation layers prevent eddy current from flowing between the sheets. Any remaining eddy currents must flow within the cross section of each individual lamination, which reduces losses greatly. An alternative is to use a ferrite core, which is a nonconductor. The electro-magnetic coils 28₁-28₆ use AWG 32 with an input current 1.1 A, which has 646 AT (Amper·Turn), or AWG 29 with an input current 2.0 A having the maximum of 734 AT (Amper·Turn). AWG (American Wire Gauge) is a standardized wire gauge system used since 1857 predominantly in the United States and Canada for the diameters of round, solid, nonferrous, electrically conducting wire. The number of turns in each of the electro-magnetic coils 28₁-28₆ is about 1200.

[0033] Each of the individual electromagnets 26₁-26₆ (or electromagnets 26₁-26₄) is energized in succession and thus creates a magnetic pulse (or field) that continuously rotates in a clockwise or counterclockwise direction about the axis 15. The control unit 18 includes a microprocessor 29 (shown in Figs. 4 and 5) used to energize each of the electromagnets 26₁-26₆ (or electromagnets 26₁-26₄) in succession. In turn, the continuously rotating magnetic pulse causes the second magnetic assembly 34 (which is in the form of the permanent magnet 35) to follow the magnetic pulses of the magnetic drive member 16 and, subsequently, spinning the propeller 38. Moreover, the microprocessor 29 of the control unit 18 may be used to alternate the current applied to the electromagnetic coils 28₁-28₆ of the electromagnets 26₁-26₆ in such a way that speed of the propeller 38 is controllable.

[0034] In a properly assembled condition, the axis 15 of the magnetic drive member 16 and

the axis 37 of magnetic driven member 35 are substantially coax

magnetic assembly 14 and the propeller 38 are magnetically coupled to each other by the magnetic drive member 16 and the magnetic driven member 35 through the side wall 6 of the container 2 so as to magnetically couple the first magnetic assembly 14 to the impeller 38.

[0035] The first casing 12 housing the first magnetic assembly 14, and the second casing 32 housing the second magnetic assembly 34 are detachably held together by magnetic attraction between the magnetic driven member 35 of the second magnetic assembly 34 and the ferromagnetic cores 27₁-27₆ of the electromagnets 26₁-26₆ and the drive support plate 25 of the first magnetic assembly 14. The magnetic attraction is very high. The spacer 42, which may be made from rubber or some non-magnetic polymer, has sufficient thickness to reduce the attractive force between the magnetic assemblies 14, 34 sufficient to allow the casings 12, 32 to be separated prior to installation. More specifically, the drive support plate 25 and the ferromagnetic cores 27₁-27₆ of the magnetic drive member 16 and the magnetic driven member 35 generate sufficient magnetic attraction therebetween to clamp the first casing 12 and the second casing 32 against the spacer 42 with sufficient force to support both casings against gravity in a particular position without the use of mechanical aids. Also, as illustrated in Fig. 2, the first casing 12 and the second casing 32 are detachably connected to the side wall 6 of the container 2 solely by the magnetic attraction force between the drive support plate 25 and the ferromagnetic cores 27₁-27₆ of the magnetic drive member 16 and the magnetic driven member 35 against gravity in a particular position without the use of mechanical aids. Optionally, a rubber gasket or other compressible member may be placed between

[0036] When installed and the electromagnets 26₁-26₆ of the first magnetic assembly 14 are

activated, the first magnetic assembly 14 creates the rotating magnetic field 15, the second magnetic assembly 34 to rotate due to the attractive magnetic forces between opposing poles on the magnetic driven member 35 and the electromagnets 26₁-26₆ of the magnetic drive member 16. As the second magnetic assembly 34 is drivingly connected to the propeller 38, the rotation of the magnetic field of the magnetic drive member 16 causes corresponding rotation of the propeller 38 due to the magnetic coupling between the magnetic drive member 16 and the magnetic driven member 35. Thus, the magnetic drive member 16 is magnetically coupled to the magnetic driven member 35 by a magnetic attraction force through the side wall 6 of the container 2 for imparting a rotary driving force to the fluid motion imparting device 38.

[0037] In accordance with the exemplary embodiment of the present invention, the first casing 12 and the second casing 32 are detachably held together solely by clamping the side wall 6 of the container 2 from opposite sides thereof by a magnetic attraction force between the drive support plate 25 and the ferromagnetic cores 27₁-27₆ of the magnetic drive member 16 and the magnetic driven member 35. The second casing 32 is detachably connected to the first side 6b of the side wall 6 of the container 2 solely by the magnetic attraction between the magnetic drive member 16 and the magnetic driven member 35, as described hereinabove. The rotation of the magnetic field of the magnetic drive member 16 causes corresponding rotation of the propeller 38 due to the magnetic coupling between the magnetic drive member 16 and the magnetic driven member 35.

[0038] Moreover, the first casing 12 and the second casing 32 automatically come into coaxial alignment (so that the first axis 15 is coaxial with the second axis 37) by virtue of the magnetic attraction provided by the magnetic assemblies 14 and 34 communicating

magnetically with each other. The first casing 12 and the second rotating and held against gravity by means of at least one first friction member 44 attached to an inner face 12a of the first casing 12 facing the first side 6a of the side wall 6 of the container 2, and at least one second friction member 46 attached to an outer face 12b of the second casing 32 facing the second side 6b of the side wall 6 of the container 2. The friction members 44 and 46 are made from material with a relatively high friction coefficient and preferably are formed from a resilient material.

[0039] As best shown in FIG. 1A, a series of slots 100 extend longitudinally along the second casing 32 parallel to the second axis 37 of the propeller 38. A series of contoured openings 102 are formed in an end 104 of the protective shroud 33 of the second casing 32. Also illustrated in FIG. 3 is a nut 106 that secures the propeller 38 to the shaft 40.

[0040] In the exemplary embodiment of the present invention, a magnetic air gap between the permanent magnet of the magnetic driven member 35 and the electromagnets 26₁-26₆ (or electromagnets 26₁-26₄) of the magnetic drive member 16 is about 1.08". The pump 10 spins at about 2200 - 2300 rpm. The magnetic material of the magnetic driven member 35 in accordance with the exemplary embodiment of the present invention is grade N35SH permanent magnet, having a surface magnetic field of about 2400 G. The current input voltage for the electromagnets 26₁-26₆ (or electromagnets 26₁-26₄) is 12 V (upper limit of 40 V) and input current is 1.1~1.2 A, but has an upper limit of around 2A. The design parameters, such as magnet grade, number of poles, winding turns, wire gauge number are flexible and are determined through the design.

[0041] Fig. 4 illustrates a control circuit of the control unit of a magnetic assembly, which utilizes 6 individual electromagnets 26₁-26₆ placed equidistantly in a circular pattern coaxial

to the axis 15. The control circuit of Fig. 4 shows the 6 individual MOSFETs 30 and 32, which energize one of the electromagnets 26₁-26₆ at any given time. The control circuit of Fig. 4 allows the magnetic driven member 35 to follow the magnetic pulses essentially spinning the propeller 38. The control circuit of Fig. 4 attains a maximum RPM of 1800 of the speed of the propeller 38, which fell short of the 2200 RPM that needs to be achieved. Higher RPM proved to be a problem due to the short on time of the magnetic field as the speed increased which made the magnetic driven member 35 drift, no longer tracking the electromagnetic pulses. In order to achieve higher RPMs multiple sets of two coils need to be energized to attain longer on times at higher RPMs.

[0042] Fig. 5 illustrates a control circuit of the control unit 18 of the first magnetic assembly 14 which utilizes 6 individual electromagnets 26₁-26₆ placed equidistantly in a circular pattern coaxial to the axis 15, according to the exemplary embodiment of the present invention, designed to energize more than one of the electromagnets 26₁-26₆ at any given time, as opposed to the control circuit of Fig. 4. Multiple reference signals are sent to each MOSFET 30, 32 using microcontroller control system firmware that allow the electromagnets to energize longer, allowing the strength of the electromagnet to achieve full power keeping the permanent magnet (i.e., the magnetic driven member 35) on track with the electromagnetic pulses and rotate the magnetic driven member 35 with the electromagnets 26₁-26₆ at higher RPM, thus solving the problem of the permanent magnet drifting.

[0043] Another concern is how to track the magnetic driven member 35 at any given time to ensure that the electromagnets 26₁-26₆ are energizing at the proper time. This proved to be challenging due to the interference of the flux generated by the electromagnets. Utilizing the

back EMF through the existing circuitry allows the driver to recalculate the position of the driven member 35 is at any given time and to automatically make appropriate adjustments as needed. Accordingly, the control unit 18 measures the back EMF that is created by the driven magnet 35 rotating past the un-driven electromagnets 26₁-26₆. This signal would be interpreted by the microprocessor 29. Moreover, the control unit 18 monitors rotation of the driven magnetic assembly 34 and adjusts drive current and magnetic field of the electromagnets 26₁-26₆ to rotate the second magnetic assembly 34 properly within specifications to achieve correct speed and performance of the driven magnetic assembly 34 through custom control loop software.

[0044] The foregoing description of the exemplary embodiments of the present invention has been presented for the purpose of illustration in accordance with the provisions of the Patent Statutes. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments disclosed hereinabove were chosen in order to best illustrate the principles of the present invention and its practical application to thereby enable those of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated, as long as the principles described herein are followed. Thus, changes can be made in the above-described invention without departing from the intent and scope thereof. It is also intended that the scope of the present invention be defined by the claims appended thereto.

PCT Claims

1. A fluid pump kit, comprising:
 - a stationary first magnetic assembly including a stationary magnetic drive member;
 - a first casing supporting and housing said first magnetic assembly;
 - a rotatable second magnetic assembly including a rotatable magnetic driven member drivingly coupled to a fluid motion imparting device;
 - a second casing supporting and housing said second magnetic assembly; and
 - a non-magnetic spacer separating said first and second magnetic assemblies;said magnetic drive member and said magnetic driven member being magnetically coupled to each other by a magnetic attraction force therebetween through said spacer;
 - said magnetic drive member comprising a plurality of electromagnets non-rotatably mounted within said first casing and facing said magnetic driven member, said electromagnets controlled so as to be energized in succession to create a rotating magnetic field for continuously rotating said rotatable magnetic driven member;
 - said magnetic drive member being spaced from said spacer on one side thereof and said magnetic driven member being spaced from said spacer on an opposite side thereof;
 - said second casing being detachably securable to said spacer solely by the magnetic attraction force between said magnetic drive member and said magnetic driven member sufficient to support said first and second casings in a particular position without the use of mechanical aids.
2. The fluid pump kit as defined in claim 1, wherein said magnetic driven member is a permanent magnet.

3. The fluid pump kit as defined in any of the preceding claims, wherein said magnetic driven member further including a driven support disc non-movably attached to said magnetic driven member.

4. The fluid pump kit as defined in claim 3, wherein said driven support disc is made of magnetically permeable material.

5. The fluid pump kit as defined in any of the preceding claims, wherein said stationary magnetic drive member further comprises a drive support plate, said electromagnets are non-rotatably and angularly equidistantly mounted on said support plate.

6. The fluid pump kit as defined in claim 5, wherein said drive support plate is made of a ferromagnetic material.

7. The fluid pump kit as defined in any one of claims 5 and 6, wherein said electromagnets are non-rotatably attached to said drive support plate around a first axis equidistantly in a circular pattern so as to extend substantially parallel to said first axis.

8. The fluid pump kit as defined in any of the preceding claims, wherein each of said electromagnets includes a ferromagnetic core surrounded by an operably associated electro-magnetic coil so that current passing through one of the coils generates a magnetic field emanating from the associated electro-magnetic coil.

9. The fluid pump kit as defined in claim 8, wherein each of said ferromagnetic cores extends toward said magnetic driven member of said second magnetic assembly substantially parallel to a first axis of said stationary magnetic drive member.

10. The fluid pump kit as defined in any one of claims 8 and 9, wherein said ferromagnetic core is made of pole laminations formed from sheet metal.

11. The fluid pump kit as defined in any of the preceding claims, wherein said first magnetic assembly further comprises a control unit operably associated with each of said electromagnets for sequentially energizing each of said electromagnets.

12. A combination of a fluid pump assembly and a container having a wall, said pump assembly comprising:

- a first casing disposed exteriorly of said container on a first side of said wall;
 - a stationary first magnetic assembly including a stationary magnetic drive member non-rotatably mounted to said first casing and spaced from said wall outside said container;
 - a second casing disposed interiorly of said container on a second side of said wall; and
 - a rotatable second magnetic assembly mounted to said second casing and including a rotatable magnetic driven member spaced from said wall inside said container, said rotatable magnetic driven member drivingly coupled to a fluid motion imparting device;
- said magnetic drive member comprising a plurality of electromagnets non-rotatably mounted within said first casing and facing said magnetic driven member, said electromagnets

controlled so as to be energized in succession to create a rotating m
rotating said rotatable magnetic driven member;

said magnetic drive member being magnetically coupled to said magnetic driven member
by a magnetic attraction force through said wall for imparting a rotary driving force to said fluid
motion imparting device;

said second casing being detachably securable to said wall solely by the magnetic
attraction force between said magnetic drive member and said magnetic driven member
sufficient to support said first and second casings in a particular position without the use of
mechanical aids.

13. The combination as defined in claim 12, wherein said magnetic driven member is a
permanent magnet.

14. The combination as defined in any one of claims 12 and 13, wherein said magnetic
driven member further including a driven support disc non-movably attached to said magnetic
driven member.

15. The combination as defined in claim 16, wherein said driven support disc is made of
magnetically permeable material.

16. The combination as defined in any one of claims 12 to 15, wherein said stationary
magnetic drive member further comprises a drive support plate, said electromagnets are non-
rotatably and angularly equidistantly mounted on said support plate.

17. The combination as defined in claim 16, wherein said drive support plate is made of a ferromagnetic material.

18. The combination as defined in any one of claims 16 and 17, wherein said electromagnets are non-rotatably attached to said drive support plate around a first axis equidistantly in a circular pattern so as to extend substantially parallel to said first axis.

19. The combination as defined in any one of claims 12 to 18, wherein each of said electromagnets includes a ferromagnetic core surrounded by an operably associated electro-magnetic coil so that current passing through one of the coils generates a magnetic field emanating from the associated electro-magnetic coil.

20. The fluid pump kit as defined in claim 19, wherein each of said ferromagnetic cores extends toward said magnetic driven member of said second magnetic assembly substantially parallel to a first axis of said stationary magnetic drive member.

21. The combination as defined in any one of claims 19 and 20, wherein said ferromagnetic core is made of pole laminations formed from sheet metal.

22. The combination as defined in any one of claims 12 to 21, wherein said first magnetic assembly further comprises a control unit operably associated with each of said electromagnets for sequentially energizing each of said electromagnets.

23. The combination as defined in any one of claims 12 to 22, wherein said stationary magnetic drive member is adhesively bonded to said first side of said wall of said container.

24. A method of circulating fluid within a container, comprising the steps of:

providing a first casing having a stationary first magnetic assembly including a stationary magnetic drive member non-rotatably mounted to said first casing, said magnetic drive member comprising a number of electromagnets non-rotatably mounted within said first casing so as to face said magnetic driven member;

providing a second casing having a rotatable second magnetic assembly mounted to said second casing and including a rotatable magnetic driven member drivingly coupled to a fluid motion imparting device;

providing a container having a fluid therein;

positioning said first casing on an exterior side of a wall of said container and positioning said second casing on an interior side of said wall of said container within the fluid in coaxial alignment with said first casing and allowing said first and second casings to remain in alignment solely as a result of a magnetic attraction force between said stationary magnetic drive member and said rotatable magnetic driven member sufficient to support at least the second casing against gravity without the use of mechanical aids;

energizing said electromagnets in succession so as to create a rotating magnetic field of said stationary magnetic drive member and thereby causing cooperating rotation of said rotatable magnetic driven member and of said fluid motion imparting device.