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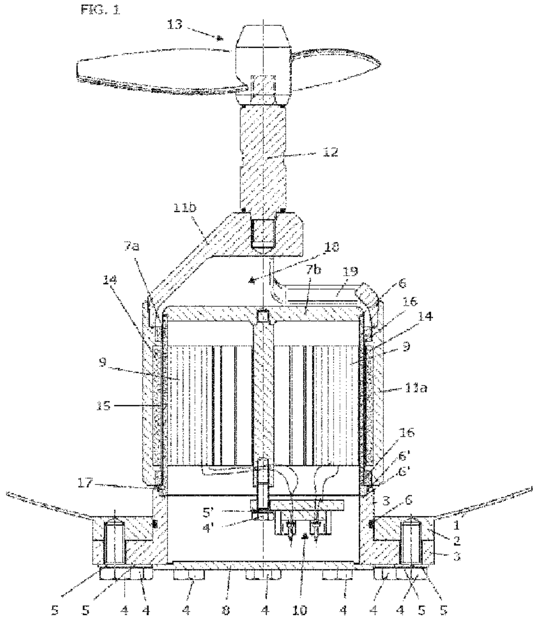
(54) DEVICE FOR STIRRING LIQUIDS AND LIQUID MIXTURES

(57) The invention relates to a device for stirring liquids and liquid mixtures, the device comprising a housing extending in an axial direction, in which the housing comprises a proximal end and a distal end, and defines an internal volume (18) that is closed along the distal end, and further comprising a rotor (11), with at least one stirring element (13) connected, in which the rotor defines a holder (11a) that receives said housing along its distal end, in such way that the rotor sits radially bearing onto the housing, in a mutually rotating way around the axial direction, the holder further comprising a plurality of permanent magnets (14) and the device further comprising a plurality of electromagnetic windings (9); in particular said electromagnetic windings are comprised by said internal volume and are configured for electromagnetically interacting with the permanent magnets, thereby exercising a force-couple onto the rotor, around the axial direction.

FIG. 1



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Description

TECHNICAL DOMAIN

[0001] The present invention relates to the stirring of liquids and liquid mixtures.

STATE OF THE ART

[0002] For stirring liquids and liquid mixtures, these are typically put into a stirring container, in which that stirring container is provided with a stirring element inside. According to the most classic arrangement, the stirring element is mounted onto a rotating shaft. This shaft is brought into the stirring container from above, and is driven by an electric motor. The motor is mostly located above the stirring container. A significant disadvantage hereby is that high stirring containers require a long rotation axis, because this shaft should extend from above to the liquid that has to be stirred, at the bottom of the stirring container. Such long shafts experience significant forces and moments of force, as a result of which the stirring shaft and bearing should be made very heavy. The cost price of such systems is thus typically very high. Another disadvantage is that the motor and the shaft take a lot of space inside and above the stirring container, and hence sit in the way. Finally, the motor is also very vulnerable, because it protrudes.

[0003] In alternative arrangements, a so-called shaft passage is provided, that is a rotating shaft that crosses the wall of the stirring container. The shaft is thereby provided with a dynamic shaft seal. In such an arrangement, the motor is still located outside the stirring container, but the location of the shaft passage can now be chosen anywhere along the wall. First of all, one looks for the most optimal position of the stirring element inside the stirring container, so that an efficient stirring process is obtained. Possibly, one also takes into account the least inconvenient/vulnerable position for the motor, outside the stirring container. An important disadvantage hereby is that dynamic shaft seals are subject to wear. Hence, such seals require a lot of maintenance. Moreover, dynamic shaft seals can leak, causing problems with the quality of the stirred product, in particular as to hygiene. In case of dangerous products, this also implies safety risks. Also, costs arise as a result of loss of product and the required cleaning. In the worst case, the complete content of the stirring container can leak outside, in case of failure of a dynamic shaft seal.

[0004] US 2015 124 557 A1 describes a technique in which the stirring element, that is located inside the stirring container, is driven through the material of the stirring container. In this way, a shaft passage with dynamic shaft seal is avoided rigorously. The wall is thereto provided with a cylindrical invagination. On the one hand, there is a shaft that is driven by a motor, and that is provided at the end with a first configuration of permanent magnets. This configuration is brought into said indentation, from the outside the stirring container. On the other hand, there is a stirring element that is provided with a second configuration of permanent magnets and that is slit over said indentation, from the inside of the stirring container. Thereby, an electromagnetic exchange between both configurations of permanent magnets arises. As a result, the drive of the shaft is transferred to the stirring element, through the material of the indentation in the stirring container. A disadvantage is that the motor is hereby still located outside the stirring container.

[0005] Such an electric motor, for example an IEC approved motor, consists of a stator part and a rotor part. As a result of an electromagnetic exchange between both, the stator exercises a force-couple onto the rotor, as a result of which the rotor start rotating. This exchange is for example realized by means of current-transporting, electromagnetic windings. At the same time, the heat that is generated as a result thereof (through amongst other things friction and joule losses), should be diverted, which is typically done by means of cooling fins and forced convection. Typically, the rotor part comprises a motor shaft that is located in a bearing way by means of two or more ball bearings onto the housing of the motor. Such motors are typically also provided with a reduction. The final force-couple is therefore higher, while the rotation speed is lower. Such reductions comprise oil, in which their shaft passages are provided with dynamic shaft seals. The motor shaft can also be provided with a dynamic shaft seal. A disadvantage is that such motors, like their reductions, are therefore strongly subject to wear, in particular with respect to the gearings and the dynamic shaft seals. Therefore, they only have a reduced lifetime. Another disadvantage is that such motors therefore require a lot of maintenance. Another disadvantage is that such motors generate a lot of noise in use. This noise is especially the result of the bearing and of the ventilated, forced convection.

[0006] Thus, there is a need for a device for stirring liquids and liquid mixtures, in which the motor takes much less space. Also, this motor should be arranged in a much less vulnerable way. Furthermore, there is a need for such a device, in which this device requires less maintenance and has a much longer lifetime. There also is a need for such a device that is not or less subject to leakage. There also is a need for a device that, in use, produces less noise.

[0007] US 2017 007 973 A1 describes another mixing apparatus in which electric stator windings interact with a ferromagnetic, passive stirring element through a plastic "bucket". US 5 090 944 A describes a contactless drive by means of permanent magnets. CN203663773 U describes a stirring element that interacts in a contactless way by means of permanent magnets. CN 2011 79430 Y also describes a stirring element that interacts in a contactless way by means of permanent magnets.

SUMMARY OF THE INVENTION

[0008] The invention relates to a device for stirring liquids and liquid mixtures, said device comprising:

- a housing extending in an axial direction, in which the housing comprises a proximal end and a distal end, and defines an internal volume that is closed at its distal end,
- a rotor, that is adapted for being enclosed by liquids and liquid mixtures and that is connected with at least one stirring element, in which the rotor defines a holder that receives said housing along its distal end, in such a way that the rotor sits radially bearing onto the housing, mutually rotatable about the axial direction,

said holder further comprising a plurality of permanent magnets and said device further comprising a plurality of electromagnetic windings; in particular, said electromagnetic windings are comprised by said internal volume and configured for electromagnetically interacting with the permanent magnets, thereby exercising a force-couple onto the rotor, around the axial direction.

[0009] Preferably, the device is provided along the inner side of a stirring container, or it is at least possible to provide the device along the inner side of that stirring container.

[0010] Preferably, the configuration with permanent magnets and electromagnetic windings acts as a permanent-magnet motor, in which said permanent magnets at least partially provide for magnetisation of the rotor. An advantage is that the motor is fully integrated with the stirring parts. The rotor is amongst other things directly connected to the stirring element, or it can be connected directly with that stirring element. Thus, no use is made of a commercially available, standard electromagnetic motor that should be positioned outside the stirring container and drives a shaft there, in which this shaft in turn is coupled magnetically with the stirring container head. As a result, the motor is much more compact, and the device as a whole comprises less parts. Also, the motor is therefore positioned much less vulnerably.

[0011] An important point with electromotors is the discharge of heat that arises in use, as a result of friction and joule losses. Standard electromotors are therefore mostly provided with cooling fins and a ventilator, for forced convection with the surrounding air. In the present arrangement, the windings are located in the housing, in which the housing is surrounded radially and distally with the liquid or the liquid mixture. The classic techniques for cooling the motor are thus more difficult to apply. On the other hand, dependent on the design of the device and the material choice, the motor can directly be cooled convectively by the surrounding liquid or the surrounding liquid mixture. The associated convection coefficient is typically much higher than the one for free convection at the surrounding air, with or without cooling fins. An additional advantage is that it is therefore no longer necessary to provide a ventilator for extra cooling, because the convective cooling by the liquid or the liquid mixture as such is already sufficient. In particular, the ventilator is avoided in that way, as a noise-generating and maintenance-requiring part.

[0012] Another advantage of the stirring device is that it does not comprise a shaft passage with dynamic shaft seal. There is a so-called contactless drive of the rotor, through the material of the housing, by means of electromagnetic fields that are generated by the electromagnetic windings. As a result, the device requires less maintenance and leaks are rigorously avoided.

[0013] According to a further or alternative embodiment, the housing and/or the rotor comprises a ceramic material. Suitable ceramic materials comprise, but are not limited to, silicon nitride, silicon carbide, zirconium oxide, aluminium oxide, aluminium nitride, boron nitride, boron oxide, boron carbide, polycrystalline diamond, tungsten carbide, titanium carbide and tantalum carbide.

[0014] Typically, the stirring technique especially uses synthetic materials and types of steel, in particular rust-free steel. With respect to said materials, structures comprising ceramic materials as described above, have at least one of the following advantages:

- they are more wear-resistant and harder, and offer less frictional resistance,
- they are more inert, in that sense that they are better resistant to corrosion as a result of the liquid to stir or the liquid mixture to stir, for a large variety of liquids and liquid mixtures,
- they have a higher thermal conduction coefficient and are therefore more appropriate for transporting heat,
- they hardly disturb magnetic fields and
- they are better resistant to higher temperatures.

[0015] According to a further or alternative embodiment, the ceramic material is silicon carbide. Preferably, the housing comprises a cylindrical side wall that radially encloses the internal volume, said side wall comprising silicon carbide. More preferably, said side wall mainly consists of silicon carbide.

[0016] A particular advantage is linked to the realization of the side wall of the housing in silicon carbide. Indeed, this allows the surrounding liquid to withdraw more heat from the housing, as a result of the high thermal conduction coefficient of silicon carbide. The cooling of the electromagnetic windings is thus much more efficient.

DESCRIPTION OF THE FIGURES

[0017]

Figure 1 shows, in cross-section, an embodiment of the device according to the present invention, for stirring liquids and liquid mixtures.

Figure 2 shows, again in cross-section, an embodiment of the device according to the present invention, for stirring liquids and liquid mixtures.

Figure 3 shows, in a schematic way, a stirring container provided with four stirring devices, according to an embodiment of the present invention.

Figures 4A and 4B show, in a schematic way, a plan view and a side view of a stirring container provided with two stirring devices, according to an embodiment of the present invention.

Figures 5A and 5B respectively show a cross-section and a partially cut-away, perspective view of a stirring device according to another alternative embodiment of the invention.

DETAILED DESCRIPTION

[0018] The present invention relates to the stirring of liquids and liquid mixtures.

[0019] Unless otherwise specified, all terms used in the description of the invention, including technical and scientific terms, shall have the meaning as they are generally understood by the worker in the technical field of the invention. For a better understanding of the description of the invention, the following terms are explained specifically.

[0020] "A", "an" and "the" refer in the document to both the singular and the plural form unless clearly understood differently in the context. "A segment" means for example one or more than one segment.

[0021] When "approximately" is used in the document together with a measurable quantity, a parameter, a period or moment, etc., variations of +/-20% or less, preferably +/-10% or less, more preferably +/-5% or less, still more preferably +/-1% or less, and even still more preferably +/-0.1% or less than and of the cited value are meant, as far as such variations apply to the invention that is described. It will however be clearly understood that the value of the quantity at which the term "approximately" is used, is itself specified.

[0022] The terms "include", "including", "consist", "consisting", "provide with", "contain", "containing", "comprise", "comprising" are synonyms and are inclusive of open terms that indicate the presence of what follows, and that do not exclude or prevent the presence of other components, characteristics, elements, members, steps, known from or described in the state of the art.

[0023] For the heat transfer between two "in a thermally conductive way" linked/associated/connected bodies to take place optimally, a heat-conductive paste has optionally been provided along a border area in between. Of course, such bodies can also be realized as one integral body.

[0024] The citation of numeric intervals by means of end points includes all integers, fractions and/or real numbers between the end points, including these end points.

[0025] In a first aspect, the invention relates to a device for stirring liquids and liquid mixtures, said device comprising:

- a housing extending in an axial direction, in which the housing comprises a proximal end and a distal end, and defines an internal volume that is closed at its distal end,
- a rotor, that is adapted for being enclosed by liquids and liquid mixtures and that is connected with at least one stirring element, in which the rotor defines a holder that receives said housing along its distal end, in such a way that the rotor sits radially bearing onto the housing, mutually rotatable about the axial direction,

said holder further comprising a plurality of permanent magnets and said device further comprising a plurality of electromagnetic windings; in particular, said electromagnetic windings are comprised by said internal volume and configured for interacting in an electromagnetic way with the permanent magnets, thereby exercising a force-couple onto the rotor, around the axial direction.

[0026] The term "liquid mixture" should in this respect be interpreted as comprising any arbitrary mixture comprising one or several liquid phases. This can be both homogeneous and heterogeneous mixtures, optionally comprising one or several solid and/or gas phases. According to a number of non-limiting embodiments, but in no way limited thereto, the "stirring element" comprises one or more blades that are connected directly to the holder of the rotor. Also, it is possible that a stirring shaft is extending onto the rotor, in axial direction, onto which a stirring element is mounted or to which a stirring element, for example a toothed disc or a rudder propeller is connected.

[0027] Preferably, the device is provided along the inner side of a stirring container, or it is at least possible to provide the device along the inner side of an stirring container. More preferably, the connection between the device and the stirring container is realized by means of an attachment between the proximal end of the housing on the one hand and the inner side of the stirring container on the other hand.

[0028] In this respect, the terms "proximal" and "distal" should also be interpreted. "Proximal" refers to the parts that are provided or can be provided at or along the inner side of an stirring container and/or that are positioned close or closest to such inner side, contrary to "distal". "Distal" refers to everything that is located farthest from the inner side, or to everything is directed away from this inner side, thus for example to the centre of the stirring container. Here, we always talk about the configuration in which the proximal end of the housing would be provided along the inner side of the stirring container.

[0029] With respect to the "axial direction", a proximal and a distal sense can thus be defined. This "radial" can be interpreted as perpendicular to the axial direction.

[0030] According to a number of non-limiting embodiments, the proximal end of the housing is welded directly to said inner side or glued to said inner sides, or the housing comprises along its proximal end a flange that can be screwed/welded onto or glued together with said inner side. If the flange would be appropriate for screwing it against the inner side of the stirring container, preferably, both this flange and the wall of the stirring container are provided with a corresponding set of bores. More preferably, the wall of the stirring container is at the inner side provided with a corresponding flange. It is also possible that the housing is integral part of the stirring container, and thus forms an indentation in the wall of the stirring container, towards the inner side. The expert in the domain is largely competent to realize himself one of the above, or any other appropriate connection between the proximal end of the housing and the inner side of the stirring container.

[0031] Preferably, the configuration with permanent magnets and electromagnetic windings acts as a permanent-magnet motor, in which said permanent magnets at least partially provide for magnetisation of the rotor. According to a non-limiting embodiment, the configuration acts as an alternating-current permanent-magnet motor. An advantage of alternating-current permanent-magnet motors is that they have a lower consumption than induction motors. Another advantage is that there are less frictional losses and joule losses, so that the motor is heated less in use. Another advantage is that the rotor itself does not have to be provided with electrical current, because the rotor, more in particular the holder of the rotor, comprises permanent magnets. They provide for the magnetic fields and the electromagnetic exchange with the stator, comprising the housing and the electromagnetic windings. In the present type of alternating-current permanent-magnet motor, the stator is located centrally and the rotor (with permanent magnets) rotates around this stator. As an alternative, it is however possible that the stator constitutes a ring comprising the electromagnetic windings, in which ring the rotor rotates.

[0032] An advantage is that the motor is fully integrated with the stirring parts. The rotor is amongst other things directly connected to the stirring element, or it can be connected directly to that stirring element. Thus, no use is made of a commercially available, standard electromagnetic motor, which should be positioned outside the stirring container and drives a shaft there, in which this shaft in turn is coupled magnetically with the stirring container head. As a result, the motor is much more compact, and the device as a whole comprises much less parts. Also, the motor is therefore positioned much less vulnerably.

[0033] Preferably, the housing is a substantially tubular element extending in the axial direction, and of which the distal end is sealed fluid-tightly. Its proximal end is connected in a fluid-tight way to the inner side of the stirring container. According to a non-limiting embodiment, the housing thus constitutes a liquid-tight indentation in the wall of the tank. More preferably, the electromagnetic windings in the internal volume are separated in a fluid-tight way from the internal volume of the stirring container, by means of this housing. When using the stirring device, the stirring container is filled with a liquid or liquid mixture, which radially and distally surrounds the housing. The term "fluid-tight" preferably expresses that something is impenetrable for the stirred liquids and liquid mixtures.

[0034] An important point with electromotors is the discharge of heat that arises in use, as a result of friction and joule losses. Standard electromotors are therefore mostly provided with cooling fins and a ventilator, for forced convection with the surrounding air. In the present arrangement, the windings are located in the housing, in which the housing is surrounded radially and distally with the liquid or the liquid mixture. The classic techniques for cooling the motor are thus more difficult to apply. On the other hand, dependent on the design of the device and the material choice, the motor can directly be cooled convectively by the surrounding liquid or the surrounding liquid mixture. The associated convection coefficient is typically much higher than the one for free convection at the surrounding air, with or without cooling fins. An additional advantage is that it is therefore no longer necessary to provide a ventilator for extra cooling, because the convective cooling by the liquid or the liquid mixture as such is already sufficient. In particular, the ventilator is avoided in that way, as a noise-generating and maintenance-requiring part.

[0035] Another advantage of the stirring device is that it does not comprise a shaft passage with dynamic shaft seal. There is a so-called contactless drive of the rotor, through the material of the housing, by means of electromagnetic fields that are generated by the electromagnetic windings. As a result, the device requires less maintenance and leaks are rigorously avoided.

[0036] According to a non-limiting embodiment, the housing forms one integral part comprising a tubular side wall with a flat closure at its distal end. The proximal edge of the tube is thereby connected to the inner side of an stirring container as described above. In this way, the housing forms a fluid-tight indentation within the stirring container. This indentation defines an internal volume that comprises the electromagnetic windings. According to an alternative, non-limiting embodiment, the housing consists of two or more parts that are linked to each other. For example, the housing comprises a tubular side wall with a flat closure at the distal end, in which the side wall and the flat closure are respectively made of a different material, and are coupled to each other. Both are for example coupled to each other by means of a static seal, but are not limited thereto. Static seals are much less subject to wear and leakage than dynamic shaft seals.

[0037] According to a non-limiting embodiment, the holder of the rotor is provided with an even number of dipole permanent magnets. Said holder is for example provided with 2, 4, 6, 8, 10, 12, 14, or 16 dipole permanent magnets. Preferably, the holder also comprises a side wall, like the housing, in which the holder radially receives the side wall of the housing. Said dipole magnets are then enclosed by said (cylindric) side wall of the holder, and are equally spread over its circumference. The magnetisation is thereby always directed radially, and points for adjacent permanent magnets alternately towards the shaft and away from the shaft. Appropriate permanent magnets are flat magnets and arcuate magnets with a curvature that is approximately equal to the radius of the side wall of the holder. Preferably according to the same embodiment, the plurality of electromagnetic windings constitute a number of electromagnets within the housing. For example, but not limited thereto, their number is equal. Their shafts are also directed radially to the (cylindric) side wall of the housing, from the inside. More preferably, these electromagnets are also equally spread along the inner circumference of said side wall. Still more preferably, each pair of adjacent magnets is coupled in such way that, when transporting a current, the magnetic field that is generated for the one magnet is directed away from the shaft while it points towards the shaft for the other magnet. It is advantageous that the electromagnets are located at the same height as the permanent magnets, for an optimal electromagnetic exchange between both. For the same purpose, it is also advantageous that the permanent magnets are located as close as possible to the electromagnets. For that reason, the bearing and the side wall of the housing are preferably chosen as thin as possible.

[0038] According to alternative, non-limiting embodiments, the device is designed according to a variation of the classic alternating-current permanent-magnet motor that has been described above. For example, but not limited thereto, one or more annular multipole magnets are used instead of dipole magnets, with a radial or axial multipole magnetisation or any other magnetisation that is known in the field. Moreover or additionally, it is possible to realize the permanent-magnet motor as a multiphase multipole permanent-magnet motor. Other appropriate, alternative embodiments that are further based on this can be designed by the worker.

[0039] Preferably, the electromagnetic windings, if they are realized as a limited number of separate electromagnets, are wound around respective cores of a soft ferromagnetic material. An advantage is that this allows to strengthen and canalize the electromagnetic fields that are generated by it, without introducing too much hysteresis losses.

[0040] When transporting current of the electromagnetic windings, they interact in an electromagnetic way with the permanent magnets. The result of all of these interactions is a force-couple that is exercised onto the stator (with windings) on the rotor and vice versa, around the axial direction. The result is that the rotor with stirring element start turning, and thereby stirs the liquid of the liquid mixture.

[0041] The precise effect of the device can vary according to the finality of the stirring and the kind of the stirring processes. These stirring processes comprise, but are in no way limited to, homogenisation, suspension, dispersion, emulsion and/or any combination thereof. Dependent on the desired stirring action, the expert in the field will apply the present invention by using amongst other things one or more, appropriate stirring elements, by realizing the invention in such way that an appropriate power and an appropriate rotation speed is obtained in use, and by mounting the device within the stirring container, at a well-chosen position and with an appropriate orientation. For example, one or more, similar stirring devices can be provided at the bottom, along the side wall and/or at the upper side of the stirring container, along the inner side. Preferably, the stirring device is not provided centrally along the shaft of a cylindric stirring container, because it then starts an own-mode of liquid flowing in the stirring container. However, in an alternative arrangement, the stirring device is provided centrally along the shaft of a stirring container, in which that stirring container is moreover provided between partitions for damping that own-mode.

[0042] According to a further or alternative embodiment, the housing comprises a pillar extending in axial direction between the proximal end and the distal end, and that is enclosed by the internal volume. Preferably, said pillar is in in thermal contact with the distal cover, at the distal end. Possibly, said pillar is connected mechanically with the distal cover, in which it constitutes a rigid support for the distal cover and elements linked thereto. Possibly, the pillar is formed integrally with the distal cover, or it is at least integrally coupled thereto. Preferably, said pillar is radially in thermal conductive contact with one or more cores of said electromagnetic windings. Possibly, said pillar is in in thermal conductive contact with the stirring container wall, at the proximal end.

[0043] According to a further or alternative embodiment, the housing and/or the rotor comprises a ceramic material. Suitable ceramic materials comprise, but are not limited to silicon nitride, silicon carbide, zirconium oxide, aluminium oxide, aluminium nitride, boron nitride, boron oxide, boron carbide, polycrystalline diamond, tungsten carbide, titanium carbide and tantalum carbide. For example, one or more parts of the housing and/or the rotor are made of one or more such ceramic materials, or of a composite material comprising a powder of such ceramic materials, within a matrix of another material such as graphite or a metal. Additionally and moreover, it is possible that one or more surfaces are covered with a thin coating comprising such a ceramic material. More preferably, next to the use of the ceramic material, one or more parts of the device also comprise one or more types of steels, preferably rust-free steel and/or ore or more synthetic materials.

[0044] Typically, the stirring technique especially uses synthetic materials and types of steel, in particular rust-free steel. With respect to said materials, structures comprising ceramic materials as described above, have at least one of the following advantages:

- they are more wear-resistant and harder, and offer less frictional resistance,
- they are more inert, in that that they are better resistant to corrosion as a result of the liquid to stir or the liquid mixture to stir, for a large variety of liquids and liquid mixtures,
- they have a higher thermal conduction coefficient and are therefore more appropriate for transporting heat,
- they hardly disturb magnetic fields and
- they are better resistant to higher temperatures.

[0045] According to a further or alternative embodiment, the housing comprises a cylindric side wall that radially encloses the internal volume, said side wall comprising the ceramic material. Preferably, the shape of said side wall is essentially cylindric, in that sense that the wall is optionally provided with edges such as flanges, extending radially for static sealing, for bearing and similar.

[0046] An advantage of a cylindric side wall of the housing that is harder, more wear-resistant and less resistant to friction is that it can directly be part of the bearing of the holder of the rotor, around that housing. This bearing introduces less frictional resistance and is also appropriate for stirring liquid mixtures comprising small, hard parts such as grains of sand. An advantage of such a more inert side wall is that the side wall can make contact with the content of the stirring container, without being eaten away and requiring regular replacement. Preferably, the side wall of the housing then constitutes a direct separation between the windings, within the housing, and the liquid or the liquid mixture. This configuration improves the heat transport between both. It is thereby additionally advantageous that the material of the side wall would have a high thermal conduction coefficient, for an optimal heat transfer there through. An advantage of such a wall that disturbs the magnetic fields much less, is that the electromagnetic exchange between the windings and the permanent magnets, at both sides of the wall, is optimal. Also, it is advantageous that the separation wall is resistant to high temperatures.

[0047] According to a further or alternative embodiment, the ceramic materials has a thermal conductivity of at least 50 $W.m^{-1}.K^{-1}$. More preferably, the thermal conductivity of the ceramic material is at least 60 $W.m^{-1}.K^{-1}$, still more preferably at least 70 $W.m^{-1}.K^{-1}$, still more preferably at least 80 $W.m^{-1}.K^{-1}$, still more preferably at least 90 $W.m^{-1}.K^{-1}$, still more preferably at least 100 $W.m^{-1}.K^{-1}$, still more preferably at least 110 $W.m^{-1}.K^{-1}$, still more preferably at least 120 $W.m^{-1}.K^{-1}$. More preferably, in this respect, one opts for one of the following ceramic materials: tungsten carbide, silicon carbide and/or aluminium nitride. However, other ceramic materials as described above can also be applied.

[0048] An advantage is that the heat that is generated as a result of joule losses in the current-transporting electromagnetic windings are drained efficiently to the stirred liquid or the stirred liquid mixture. Therefore, it is no longer needed to additionally cool the windings by the surrounding air, by means of a ventilator. Preferably, the electromagnetic windings are coupled to said side wall of the housing in a thermally conductive way. That is, there is a path, preferably as short as possible, for conductive heat discharge from the (current-transporting) electromagnetic windings along that side wall. According to a non-limiting example, the windings are provided around a soft ferromagnetic core that is in direct contact with and/or is attached to the inside of that side wall. Optionally, a heat-conduction paste is used, for improving the conductive cooling.

[0049] According to a further or alternative embodiment, the ceramic materials has a Knoop hardness value of at least 500 $kg.mm^2$. More preferably, the Knoop hardness value of the ceramic material is at least 600 $kg.mm^2$, still more preferably at least 700 $kg.mm^2$, still more preferably at least 800 $kg.mm^2$, still more preferably at least 900 $kg.mm^2$, still more preferably at least 1000 $kg.mm^2$, still more preferably at least 1500 $kg.mm^2$, still more preferably at least 2000 $kg.mm^2$. More preferably, in this respect, one opts for one or more of the following ceramic materials: aluminium oxide, aluminium nitride, tungsten carbide, zirconium oxide, silicon nitride, silicon carbide, boron carbide and/or boron nitride.

[0050] An advantage is that these materials are harder and more wear-resistant than most types of steel. Preferably, these materials are enclosed by parts that mutually rotate in or along each other, and they are part of the bearing between both. More preferably, one or more of the above-mentioned ceramic materials are part of the bearing between the rotor and the housing. The parts that are moving along or over each other therefore have a longer life-time. Also, these ceramic materials offer less frictional resistance, so that there are less frictional losses.

[0051] According to a further or alternative embodiment, the ceramic material is diamagnetic. Preferably, in this respect, one opts for one or more of the following ceramic materials: silicon nitride, silicon carbide, zirconium oxide, aluminium oxide, aluminium nitride, boron nitride, boron carbide, polycrystalline diamond and/or boron nitride.

[0052] Whether or not a material is "diamagnetic", is further determined by the value of its "magnetic susceptibility". The latter variable, also indicated by X_m, indicates to which extent that material is magnetized when it is subjected to a magnetic field **H.** The magnetisation **M** in the material is then proportional to the magnetic field **H** as $\mathbf{M}=\mathbf{X_m}\mathbf{H}$. For diamagnetic materials in particular, the magnetic susceptibility is slightly negative, and in absolute value, much lower than the unitary value. As a result, diamagnetic materials barely react to the magnetic field **H** that is imposed. The magnetic induction **B,** that is, a measure for the total strength of the magnetic field, hence the combined result of the imposed field **H** and the material magnetisation **M**, is therefore only slightly influenced by the presence of diamagnetic material. In other words, diamagnetic materials barely disturb the magnetic field **H**, and all the less as their magnetic susceptibility is lower in absolute value. This clearly contrast with paramagnetic/ferromagnetic materials, such as most of the types of rust-free steel. Ferromagnetic materials significantly influence the magnetic field. These materials reinforce the field, but also canalize it. In AC magnetic applications, ferromagnetic materials can also cause important hysteresis losses.

[0053] An advantage of such materials is that they barely disturb the magnetic fields. More preferably, the side wall of the housing comprises such a diamagnetic, ceramic material. For example, it is largely composed of such diamagnetic, ceramic material. The side wall of the housing therefore only has a negligible influence on the electromagnetic interaction between the windings in its internal volume and the permanent magnets in the holder of the rotor.

[0054] According to a non-limiting embodiment, the side wall of the housing consists of such a diamagnetic, ceramic material. Preferably, the electromagnetic windings are mounted as far as possible from the shaft, hence as close as possible to the inner side of this side wall. The holder of the rotor thereby receives said housing; more in particular, this holder also comprises a side wall that radially encloses the side wall of the housing and comprises these permanent magnets. More preferably, the permanent magnets are mounted as close as possible to the shaft, hence as close as possible to the inner side of this side wall. As a result, the distance between the permanent magnets and the electromagnetic windings is minimal, and hence is the electromagnetic interaction between both maximal. The minimal separation between the electromagnetic windings on the one hand and the permanent magnets on the other hand is determined by the thickness of the side wall of the housing. More preferably, the chosen thickness is the result of the consideration between a minimal strength of the housing on the one hand, because the rotor sits bearing thereon, and a maximal electromagnetic interaction between the windings and the permanent magnets on the other hand. Optionally, the side wall of the housing is interrupted. For example, it relates to a cylindric side wall with elongated recesses extending according to the axial direction.

[0055] According to a further or alternative embodiment, the ceramic materials is silicon carbide. Preferably, the housing comprises a cylindric side wall that encloses the internal volume radially, said side wall comprising silicon carbide. More preferably, said side wall mainly consists of silicon carbide.

[0056] An advantage is that said side wall of the housing is hard and wear-resistant, and offers little frictional resistance. The rotor can thus, by means of the holder, sit bearing directly onto the housing. The outer side of the side wall of the housing thereby functions as a first sliding surface. According to a first, non-limiting embodiment, said bearing is a sliding bearing, and the inner side of the side wall of said holder is provided with a second sliding surface, that receives the first sliding surface in a form-fitting way. According to a second, non-limiting embodiment, said bearing is a rolling bearing, in which the side wall of said holder is provided along the inner side of axially oriented, rotating cylinders. According to a third, non-limiting embodiment, said bearing is a ball bearing, in which the side wall of said holder is provided with balls along the inner side. In the preceding two embodiments, the rolling elements - the cylinders and the balls - are preferably made of a ceramic material as described above, more preferably from silicon carbide, silicon nitride or aluminium oxide, with the known advantages that have been described throughout the document. A particular advantage is that it is not necessary to grease such bearings, they are greased by means of the stirred liquid or the stirred liquid mixture that surrounds them. Other advantages have been described above.

[0057] According to a further or alternative embodiment, the holder sits bearing onto the housing by means of a proximal sliding bearing. This sliding bearing then provides for a radial bearing of the rotor onto the housing, in a mutually rotating way around the axial direction. Preferably, said sliding bearing comprises a first sliding surface, that is the outer side of the side wall of the housing, and a second sliding surface, that is the inner side of the side wall of the holder. More preferably, at least the first sliding surface of both is a silicon carbide surface.

[0058] An advantage of a sliding gearing is that it is a very simple bearing. Moreover, such a bearing can be made very thin, so that the windings can be positioned as closely as possible to the permanent magnets.

[0059] According to a further or alternative embodiment, said sliding bearing moreover comprises a single or double axial bearing. An advantage is that, in mutual rotation, the axial movement of the rotor with respect to the housing is prevented in at least one direction.

[0060] In the case of a single axial bearing, the worker chooses the direction in which said axial bearing is operative, thus in which the movement of the rotor with respect to the housing is prevented. This choice is taken dependent on the situation. Thereby, it is taken into account how the axial direction of the stirring device is oriented, the weight of the rotor and the direction and size of the reaction force onto the rotor when stirring, which depends on the type of stirring element, the rotation speed and the rotation direction.

[0061] According to a non-limiting embodiment, the housing and/or the holder of the rotor is provided with at least one flange, for avoiding the axial movement of the rotor with respect to the housing. Preferably, said flange comprises a ceramic material as described above. More preferably, the flange comprises silicon carbide. According to a further, non-limiting embodiment, the side wall of the housing constitutes an integral part made of silicon carbide, comprising zero, one or two flanges. Said side wall is thereby significantly cylindric and is preferably along one or both ends (distal and/or proximal) provided with the flange, which results in a single respectively double axial bearing. Said flanges have the shape of a silicon carbide edge that extends radially.

[0062] An advantage of a single axial bearing with respect to a double axial bearing is that the production and assembly of the stirring device is easier. Thereby, the side wall with flange is made in one single part of silicon carbide. The holder of the rotor is slit over this, and this along that end that is not provided with a flange.

[0063] An advantage of a double axial bearing is that, in mutual rotation, the axial movement of the rotor with respect to the housing is prevented in both axial directions.

[0064] According to a further or alternative embodiment, said holder comprises a distal end, in which the holder is provided with at least one opening nearby this distal end. In line with the above-mentioned definitions, a "proximal end" of the holder can also be indicated, that is the end along which the holder receives the housing. The "distal end" of the holder is opposite to that "proximal end". The opening at the distal end of the holder preferably allows a passage of the stirred liquid or of the stirred liquid mixture, between the proximal end of the holder and the opening nearby the distal end of the holder. This passage takes place through the narrow separation between the outer side of the side wall of the housing on the one hand and the inner side of the side wall of the holder on the other hand.

[0065] An advantage of this passage is that it greases the sliding bearing between the rotor and the housing with the stirred liquid or with the stirred liquid mixture. Another advantage is that this passage continuously and automatically cleans said narrow separation, which is more hygienic and more maintenance-friendly. Another advantage is that his passage withdraws heat from the device, in particular at the current-transporting electromagnetic windings, through the material of the housing, in particular through the side wall of the housing. It is thereby additionally advantageous that the housing comprises a material with a high thermal conduction coefficient such as, but not limited to, silicon carbide.

[0066] A even better flow can be obtained with a holder of which the side wall is interrupted, as has been described above. For example, it relates to a cylindrical side wall with recesses extending according to the axial direction.

[0067] According to a further or alternative embodiment, said holder encloses a semi-open space, that is positioned between the distal end of the holder and the distal end of the housing, and in which said opening realizes a fluid connection of the semi-open space with the environment of the stirring device. When installed in a stirring container, said opening realizes a fluid connection of the semi-open space with the rest of the stirring container volume. The space is thereby "semi-open", in that sense that it occupies a volume of which the outer surface is limited by the distal end of the housing, the distal end of the holder and a possible distal side wall of the holder. The distal end of the holder or the distal side wall of the holder is thereby at least provided with said opening. The total surface of the openings thereby takes maximal 98% of the distal end and the possible distal side wall of the holder, preferably maximal 90%, more preferably minimal 5%, still more preferably minimal 10%, still more preferably minimal 20%, and even more preferably minimal 50%. The worker will be able to consider between a maximal flow on the one hand, and a robust coupling of the stirring element or the stirring shaft to the holder of the rotor on the other hand.

[0068] In a further or alternative embodiment, the holder connects with the distal head, by means of axially extending spokes between which openings have been formed. In a possible embodiment, the spokes essentially extend along the extensions of a regular polygon that is centred onto the central axis. Possibly, it is about a regular triangle, a regular square or a regular pentagon. In any case, this promotes decentral passage and further, radial pump operation.

[0069] When driving the rotor, the rotation movement of the holder is partially transferred to the liquid in the semi-open space. As a result of centrifugal force onto this rotating liquid, there is a radial pressure gradient within the semi-open space. At usual rotation speeds between 20 min^{-1} and 5000 min^{-1}, for example at a rotation speed of 400 min^{-1}, this results in a significant radial pump operation. Dependent on the position of the opening nearby the distal end of the holder, the liquid is therefore either suck in or flung away through the opening. In the first case, this results in a flow from the semi-open space to the proximal end of the holder, through the narrow separation between the outer side of the side wall of the housing on the one hand and the inner side of the side wall of the holder on the other hand. In the second case, this results in a flow from the proximal and of the holder to the semi-open space, through that same narrow separation, and finally through said opening.

[0070] An advantage thereof is that the self-cleaning, self-cooking and/or self-greasing operation of the stirring device is further reinforced, because the flow along the side wall of the housing is more powerful.

[0071] According to a further or alternative embodiment, said opening is positioned decentral. In particular, the opening is preferably not positioned centrally axially. The radial pump operation then consists in flinging away the liquid from the semi-open space, via the opening. At the same time, liquid is suck in from the proximal end of the holder to the semi-open space, further promoting the flow along the side wall of the housing. An advantage thereof is again that the self-cleaning, self-cooking and/or self-greasing operation of the stirring device is further reinforced.

[0072] According to a further or alternative embodiment, said opening is oriented partially radially. In particular, the opening is preferably not positioned not completely axially. For example, the opening is oriented radially, away from the axis, or the normal to the opening forms an angle of 45° with the axial direction. More in general, the angle between this normal and the axial direction is minimal 5°, preferably minimal 10°, more preferably minimal 20°, still more preferably minimal 30°. An advantage is that the radial pump operation is further promoted. According to a non-limiting embodiment, the openings are provided with blades, to reinforce the effect of radial pumping even more.

[0073] According to a further or alternative embodiment, said stirring element is connected removable with the rotor. An advantage is that the stirring element can simply be replaced when it is worn. Another advantage is that the production process takes place as efficiently and generally as possible, while the stirring element is chosen specifically, dependent on the kind of stirring action.

[0074] According to a further or alternative embodiment, the device comprises at least two stirring elements that are each configured for being removable connected with the rotor. An advantage is that the end-user himself can choose and vary the appropriate stirring element dependent on the kind of required stirring action.

[0075] In a second aspect, the invention relates to a stirring container for stirring liquids and liquid mixtures; in particular, the stirring container is provided with the above-described device. The above-mentioned advantages of the device can be repeated in this respect.

[0076] In a further aspect, the invention still relates to a method for stirring liquids and liquid mixtures, using a device according to the first aspect, and/or a stirring container according to the second aspect.

EXAMPLES AND FIGURES

[0077] In the following, the invention will be described by means of non-limiting examples and figures illustrating the invention, and not meant to be interpreted as limiting the scope of the invention.

[0078] **Figure 1** shows, in cross-section, an embodiment of the device 21 according to the present invention, for stirring liquids and liquid mixtures. Hereby, the stirring device 21 is mounted in an stirring container, along the inner side of the stirring container wall 1. Said wall 1 is thereto provided with a fixation flange 2, and the device 21 comprises a wall flange 3. Both flanges 2, 3 are provided with a corresponding set of holes, for mutual attachment by means of bolts 4, in which the holes in the attachment flange 2 are threaded. In order to avoid that this attachment would vibrate loose when using the device 21, the bolts 4 are locked by means of spring rings 5. Moreover, a sealing ring 6 is used, so that the connection between wall flange 3 and attachment flange 2 is impenetrable for the stirred liquids and mixtures.

[0079] The stirring device 21 further comprises a housing 7 that extends axially from said wall flange 3. Thereby, the housing 7 is composed of a cylindrical side wall 7a, and is distally closed-off by means of a circular, distal cover 7b. Sealing rings 6' secure the fluid-tight connection of that side wall 7a with the wall flange 3 on the one hand, and of the distal cover 7b on the side wall 7a on the other hand. The whole is kept together by means of a central bolt 4' with spring ring 5'. Thus, the housing 7 defines an internal volume, which volume is closed-off fluid-tightly from the content of the stirring container. Along the outer side of the stirring container, that internal volume is further closed-off by means of a proximal cover 8. Moreover, inside the volume, a plurality of electromagnets 9 are provided, that have been connected to an electric terminal block 10.

[0080] This stirring device 21 now further still comprises a rotor 11 that is adapted for being enclosed directly by the liquids and liquid mixtures to stir. This rotor 11 is connected to a stirring shaft 12 that is extending axially from that rotor 11, and is in turn connected to a stirring element 13. That stirring element 13 is here realized as a rudder propeller with three propeller blades - of which only two are visible on the shown cross-section. The rotor 11 itself defines a holder 11a, for receiving said housing 7, along its distal end. Thereby, the holder 11a radially, and in a mutually formfitting way, encloses the side wall 7a of that housing 7. In this way, this holder 11a provides a radial sliding bearing of the rotor 11 onto the housing 7, around the axial direction. At its distal end, the holder 11a is partially closed-off by means of a distal cap 11b. This cap 11b provides for a connection with and support of the stirring shaft 12.

[0081] In the shown embodiment, the holder 11a forms a cylindrical side wall, which side wall radially encloses the cylindric side wall 7a of the housing 7. The holder 11a is provided with a plurality of permanent magnets 14 along the inner side of the cylindric side wall. The electromagnets 9 inside the housing 7 interact, when they transport current, with the permanent magnets 14 of the rotor, through the material of the side wall 7a of the housing 7; thereby, they exercise a force-couple onto the rotor 11, around the axial direction. For optimization of this electromagnetic coupling, the side wall 7a of the housing 7 is realized in a diamagnetic materials such as silicon carbide. Also, the permanent magnets 14 are provided as closely as possible to the electromagnets 9, at the inner side of the side wall of the holder 11a. Preferably, only a small air gap 15 separates the permanent magnets 14 from the side wall 7a of the housing 7. This air gap 15 can of course be occupied by a vacuum or any other substance, for example a greasing means, a cooling means or for example by the mixture to stir.

[0082] For a wear-resistant, at least radial sliding bearing of the rotor 11 onto the housing 7, the rotor 11 comprises two silicon carbide sliding rings 16. Moreover, the side wall 7a of the housing 7 forms a flange 17. This flange 17 additionally provides an axial sliding bearing of the rotor 11 onto that housing 7. Thereby, the side wall

7a of the housing 7, together with the flange 17, forms one integral part from silicon carbide. In particular, the flange 17 only avoids axial movement of the rotor 11 with respect to the housing 7, towards the stirring container wall 1. This arrangement can be cleaned simply, in which the rotor 11 is simple slit from the housing 7. Such a sliding bearing is for example appropriate for stirrers that are provided in a vertical upward direction in an stirring container, and in which the reaction forces onto the rotor 11 when stirring are not sufficient for tilting the rotor 11 from the housing 7. Said reaction forces are thereby sufficiently low, compared to the weight of the rotor 11, and/or these reaction forces are oriented downwardly.

[0083] The respective distal cap 11b, for closing off the distal end of the holder 11a, substantially has the shape of a hollow, truncated cone. Thereby, the side wall of this cap 11b forms an angle of about 45° with respect to the axial direction, and this side wall is moreover provided with at least one opening 19. The opening is thus not precisely axial, and more in particular oriented in an angle of about 45° with respect to the axial direction; it is thus oriented partially radially. The hollow, distal cap 11b now encloses a semi-open space 18, which space 18 is partially limited by the cap 11b with opening 19, and by the distal cap 7b of the housing 7. For driving the rotor 11 by rotating around this housing 7, this design ensures a radial pump operation. The liquid that is present in the semi-open space 18 is hereby swung away to the outside through the opening 19. As a result, new liquid is suck, from the proximal end of the holder 11a, along said air gap 15 and up to the semi-open space 18. The result is a self-cleaning, self-cooking and self-greasing stirring device 21.

[0084] For reinforcing this effect, said openings 19 in the distal cap 11b are preferably as large as possible. For example, the total surface of the openings 19 is about 80% of the distal end 11b and the possible distal side wall of the rotor 11. In the configuration of the figure, the distal cap 11b will however have to be sufficiently robust, for the direct support of the stirring axis 12. In alternative embodiments, they are made of two or more spokes extending between the holder 11a and the stirring axis 12.

[0085] **Figure 2** shows, again in cross-section, an embodiment of the device 21 according to the present invention, for stirring liquids and liquid mixtures. The most significant difference with the embodiment of figure 1 is that the rotor 11 sits now bearing double axially around the housing 7. The side wall 7a of the housing 7, like the flange 17, are hereby still integrally made of silicon carbide. This part is however turned with respect to the axial direction. Additionally, a separate, silicon carbide foot flange 20 is now provided. The two flanges 17, 20 thereby limit the axial movement of the rotor with respect to the housing 7 in two directions, by a sliding cooperation with the two sliding rings 16. Three sealing rings 6 provide for a fluid-tight connection of this foot flange 20, on the wall flange 3 on the one hand and on the side wall 7a of the housing 7 on the other hand.

[0086] **Figure 3** shows in a schematic way an stirring container provided with four stirring devices 21, according to an embodiment of the present invention. Each of the stirring devices 21 comprises a wall flange 3 for attachment along the inner side of the stirring container wall 1. This stirring container wall 1 thereby provides the corresponding attachment flange 2. Depending on the embodiment, the wall flange 3 itself is attached along the inner side or along the outer side to the attachment flange 2; in the present embodiment, that is along the outer side. Each of the stirring devices 21 now further comprises a rotor 11 that ends in a stirring shaft 12. This stirring shaft 12 is now provided with one or more stirring elements 13, under de form of rudder propellers. The length of the stirring shaft 12 can vary. Of course, other stirring elements 13 can be chosen and/or parts thereof, such as propellers blades, can also be provided directly along the outer side of the holder 11a. The stirring devices 21 are mounted out of centre in the stirring container.

[0087] **Figures 4A and 4B** show, in a schematic way, an plan view and a side view of an stirring container provided with two stirring devices 21, according to an embodiment of the present invention. This time, the stirring devices 21 are provided centrally in the stirring container. Moreover, the inner side of the stirring container wall 1 forms four partitions 22. These partitions 22 allow for a steady, chaotic mixing of the content of the stirring container, as is known from the stirring technique.

[0088] **Figures 5A and 5B** respectively show a cross-section and a partially cut-away, perspective view of a stirring device 21 according to another alternative embodiment of the invention.

[0089] An important difference with the embodiments of figures 1 and 2 is that the housing 7 is now further provided with thermally conductive pillar 7c. Optionally, this comprises stainless steel. Said pillar 7c is provided centrally and extends axially in a distal sense. The pillar 7c thereby connects in a thermally conductive way to the distal cover 7a, in which the pillar 7c offers support to that cover 7a. In the shown design, both have been realized as an integral part. Together with the side wall 7b of the housing 7, the thermally conductive pillar 7c and the distal cover 7a define an internal (circumferential) volume that is closed at its distal end, and that has an essentially toroidal shape. Inside that internal volume, a plurality of electromagnetic windings 9 have been provided, as is for example described above. Possibly, these windings 9 enclose one or more cores (made of a soft ferromagnetic material), and these cores connect in a thermally conductive way to said pillar 7c. Hereby, the thermally conductive pillar 7c offers additional paths for heat discharge, both in distal and proximal sense. In particular, this is advantageous for the discharge of joule heat (generated in the current-transporting electromagnetic windings 9), as well as for the discharge of heat that is generated as a result of iron losses in the cores. In particular, the pillar 7c makes a thermally conductive contact with the stirring container wall 1 in a proximal sense.

[0090] Another difference is that the distal surface of the distal cover 7b is shaped conically. This promotes the radial pump operation, from the semi-open space 18. Moreover and/or as a result, it promotes the convective heat transfer of the distal cover 7b, towards the stirred liquid. The holder 11a, distal cover 11b and three spokes 11c are realized as an integral part in the present embodiment. Thereby, they offer a rigid support to the stirring element 13. With only three spokes 11c (see figure 5B), and with relatively large openings 18 in between, the semi-open space 18 provides a relatively large openness of minimal 70%. Since the spokes 11c extend towards the axis, the openings 19 are partially directed radially. This further promotes the radial pump operation, from the semi-open space 18, as has been described therein. As is further shown in figure 5B, seen from the proximal direction, the spokes 11c essentially extend according to the extensions of a regular triangular, that is centred to the central axis. This decentral path promotes a further, radial pump operation, from the semi-open space 18.

[0091] Another difference is that the device 21 now comprises two separate bearing systems that are indicated for a good understanding as respectively the proximal sliding bearing 23 and the distal sliding bearing 24: The distal sliding bearing 24 is provided centrally onto the distal cover 7b, and is supported in a rigid way from said pillar 7c. Preferably, the distal sliding bearing 24 comprises a diameter that is significantly smaller than the diameter of the proximal sliding bearing 23, preferably at least half of it. In particular, the distal sliding bearing 24 should not enclose the housing. Also, less heat will have to be removed; it is essentially about frictional heat. Furthermore, as to design and material use, the distal sliding layer 24 can have the same characteristics as the proximal sliding bearing 23 (or shortly: the sliding bearing) as has been described herein. In particular, it is possible for the distal sliding bearing 24 to comprise one or more flanges 17, in which a one-sided or two-sided axial bearing is provided. In case the distal sliding bearing 24 comprises a bearing sheath / bus, provided with a one-sided flange, this can be turned. In this way, an axial bearing can be obtained either in distal sense or in proximal sense, as has been described above. Furthermore, the rotor 11 still provides one or more transverse passage channels 11d. Thereby, the distal sliding bearing 24 can be cooled by means of a flow.

[0092] Optionally, the proximal sliding bearing is as in figures 1 and 2. However, in the shown embodiments of figures 5A-B, the rotor 11 is only provided with one proximal sliding ring 16. This ensures only a radial sliding bearing, with respect to the side wall 7a of the housing 7. In this embodiment, only one proximal sliding ring 16 can already be sufficient, since the distal sliding bearing 24 further contributes to the global bearing of the rotor 11 around the housing 7. This configuration moreover provides a particularly stable bearing of the rotor 11, since the ends of the holder 11a and distal cap 11b sit bearing: (a) in proximal sense by means of a proximal sliding ring 16, and (b) in distal sense by means of a central, distal sliding bearing 24. The single, proximal sliding ring 16 will only minimally disturb the flow along the air gap 15. All axial bearing means (e.g. flanges, optionally present for axial bearing in proximal and/or in distal sense) are preferably enclosed by the distal sliding ring 24. Thereby, they do not hinder the flow along the air gap 15 at all. In particular, the proximal sliding ring 16 is positioned proximally with respect to the permanent magnets 14. In this way, the distance between permanent magnets 14 and EM windings 9 can be minimized.

[0093] Preferably, essentially the complete side wall of the housing is made of ceramic material. The side wall 7a of the housing hereby has a multiple function: (a) the fluid-tight protection of the electromagnets 9 with respect to the content of the stirring container, without thereby hindering the passage of EM fields all too much (ceramic material can indeed be realized thinner), (b) the direct (and at least partial) bearing of the rotor 11, for which the rotor 11 provides a proximal sliding ring 16, (c) the discharge of heat as a result of copper losses, iron losses, frictional losses, (minimal) circular currents in ceramic material etc., towards the passage in the air gap 15. Preferably, the side wall 7a of the housing 7 is realized as a ceramic material, with the above-mentioned advantages. Preferably, the electromagnets 9 connect in a thermally conductive way to the side wall 7a of the housing 7. Optionally, a thermally conductive paste is provided therefor. Preferably, the ceramic bus, that constitutes the side wall 7a of the housing 7, is higher than the proximal sliding ring 16, preferably at least 5 times as high, optionally at least 10 times as high.

The shown proximal cover 8 is largely closed. Optionally, a one-sided condensation membrane (not shown) is still provided there, for the discharge of condensation from the space with the electric terminal block 10 to the outside. Condensation can indeed occur at repeated heating (e.g. during sterilisation of the stirring container) and cooking (e.g. when mixing). Optionally, such a condensation membrane is also provided from the internal space. Preferably, the proximal cover 8 is further closed. It is also not necessary to provide cooling fins, since the heat can already be discharged fairly good as has been described above. However, optionally, the proximal cover 7 is provided with cooling openings, cooling fins and/or a ventilator for forced convection.

[0094] The enumerated elements on the figures are:

1. Stirring container wall
2. Attachment flange
3. Wall flange
4. Bolt
5. Spring ring
6. Sealing ring
7. Housing

    a. Side wall

b. Distal cover
c. Pillar

8. Proximal cover
9. Electromagnet
10. Electric terminal block
11. Rotor

a. Holder
b. Distal cap
c. Spoke
d. Passage channel

12. Stirring shaft
13. Stirring element
14. Permanent magnet
15. Air gap
16. Sliding ring
17. Flange
18. Semi-open space
19. Opening
20. Foot flange
21. Stirring device
22. Partition
23. Proximal sliding bearing
24. Distal sliding bearing

[0095] It will be understood that the present invention is not limited to the embodiments described above and that some adjustments or changes can be added to the described examples without changing the scope of the enclosed claims.

Claims

1. A device 21 for stirring liquids and liquid mixtures, said device 21 comprising:

- a housing 7 extending in an axial direction, in which the housing 7 comprises a proximal end and a distal end, and defines an internal volume that is closed at its distal end,
- a rotor 11, that is adapted for being enclosed by liquids and liquid mixtures and that is connected with at least one stirring element 13, in which the rotor 11 defines a holder 11a that receives said housing 7 along its distal end, in such a way that the rotor 11 sits onto the housing 7, mutually rotatable about the axial direction, forming radial rotary bearing,

said holder 11a further comprising a plurality of permanent magnets 14 and said device 11 further comprising a plurality of electromagnetic windings 9, **characterized in that** said electromagnetic windings 9 are comprised by said internal volume and are configured for interacting electromagnetically with the permanent magnets 14, thereby exercising a force-couple onto the rotor 11, around the axial direction.

2. The device 21 of the previous claim 1, **characterized in that** the housing 7 and/or the rotor 11 comprise a ceramic material.

3. The device 21 of the previous claim 2, **characterized in that** the housing 7 comprises a cylindrical side wall 7a that radially encloses the internal volume, said side wall 7a comprising the ceramic material.

4. The device 21 of any one of the previous claims 1 to 3, **characterized in that** the holder 11a sits onto the side wall 7a of the housing 7 by means of a proximal sliding bearing 23.

5. The device of the previous claim 4, **characterized in that** a distal cap 11b sits onto the distal cover 7b of the housing 7 by means of a distal sliding bearing 24.

6. The device 21 of the previous claim 4 or 5, **characterized in that** said proximal or distal sliding bearing 23, 24 moreover comprises a single or double axial bearing.

7. The device 21 of any one of the previous claims 1 to 6, **characterized in that** said holder 11a comprises a distal end, in which the holder 11a is provided nearby that distal end of at least one opening 19.

8. The device 21 of the previous claim 10, **characterized in that** said holder 11a encloses a semi-open space 18, that is positioned between the distal end of the holder 11a and the distal end of the housing 7, and in which said opening 19 realizes a fluid connection of the semi-open space 18 to the environment of the stirring device 21.

9. The device 21 of any one of the previous claims 10 and 11, **characterized in that** said opening 19 is positioned out of centre.

10. The device 21 of any one of the previous claims 10 and 12, **characterized in that** said opening 19 is oriented partially radially.

11. The device of any one of the previous claims, **characterized in that** a distal surface of the distal cover 7b takes a conical shape.

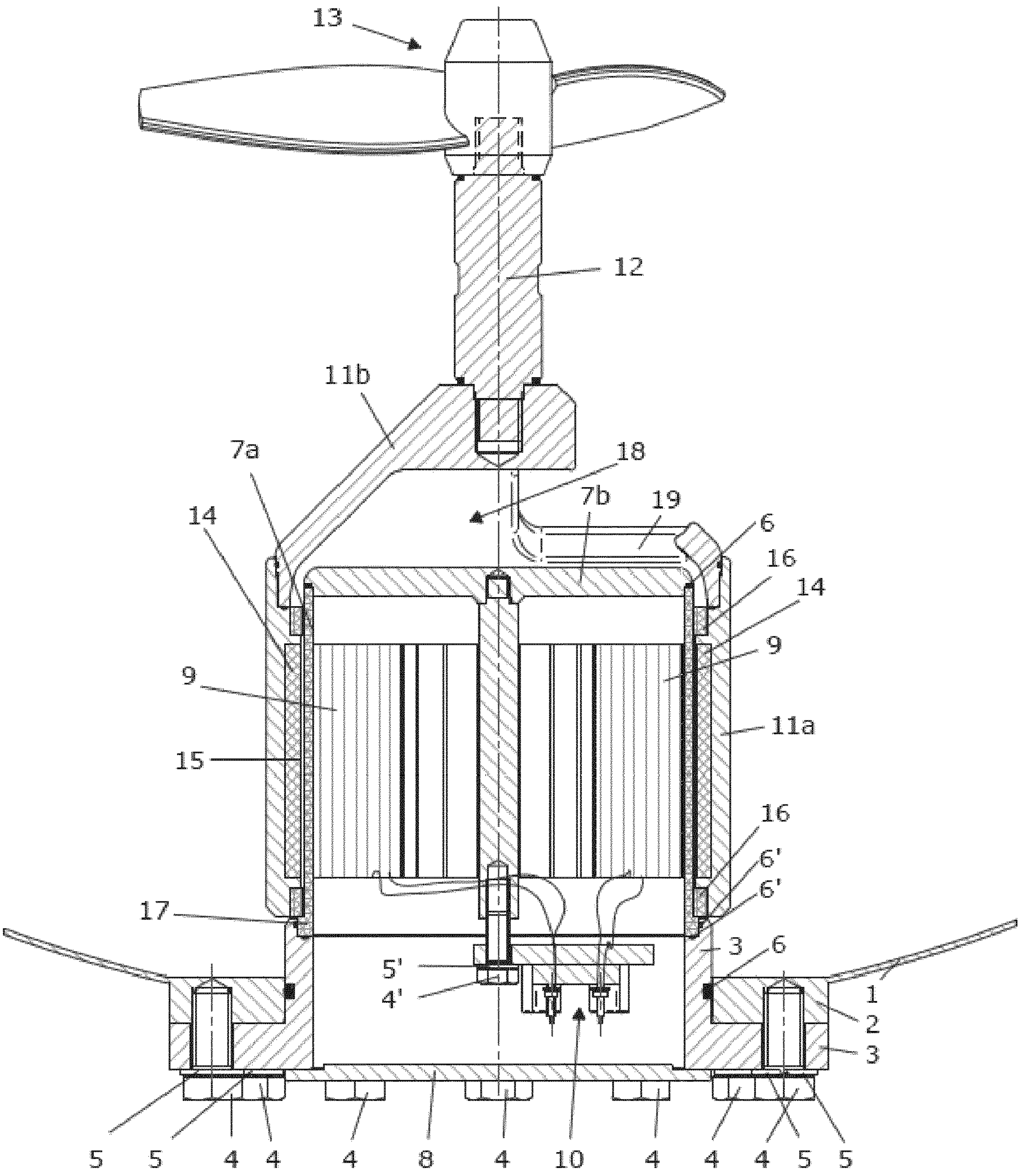
12. The device of any one of the previous claims, **characterized in that** the housing 7 comprises a pillar 7c extending in axial direction between the proximal end and the distal end, and that is enclosed by the internal volume.

13. The device 21 of any one of the previous claims 1 and 13, **characterized in that** said stirring element 13 is removably connected to the rotor 11.

14. The device 21 of the previous claim 14, **characterized in that** the device comprises at least two stirring elements 13, each configured for being removably connected to the rotor 11.

15. A stirring container for stirring liquids and liquid mixtures, **characterized in that** the stirring container is provided with the device 21 of any one of the claims 1 to 15.

FIG. 1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7b
19
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14
16
14
9
9
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15
16
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6'
17
3
6
5'
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4
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5
5

FIG. 2

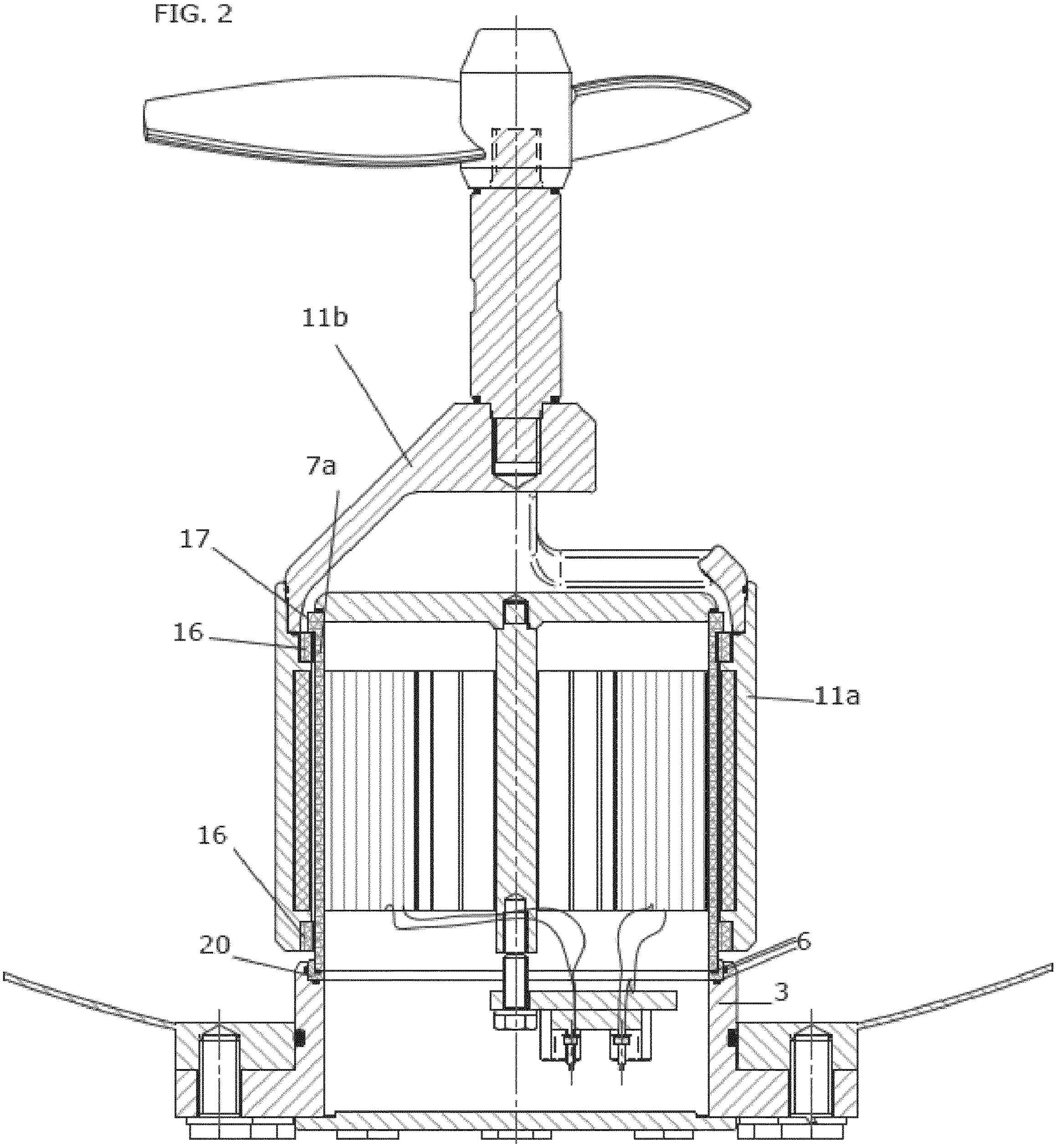


FIG. 3

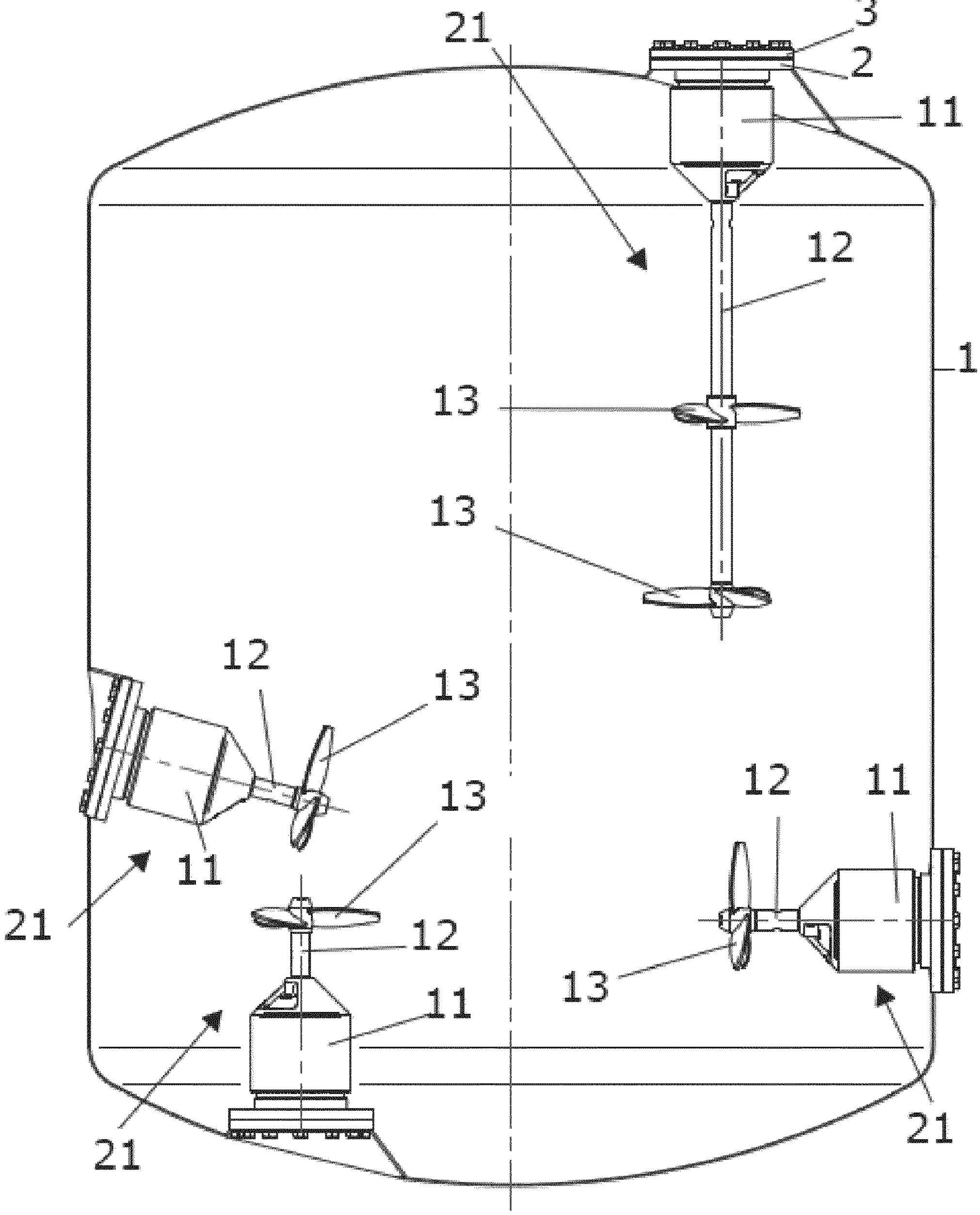


FIG. 4A

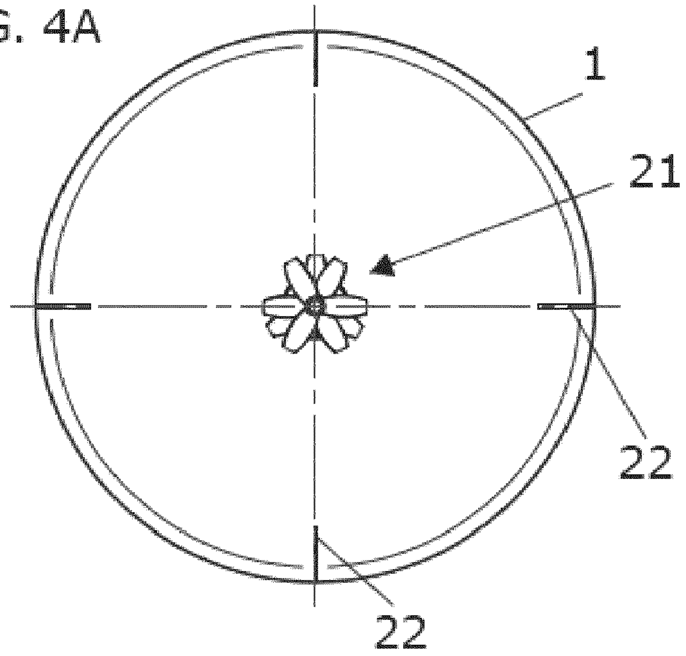
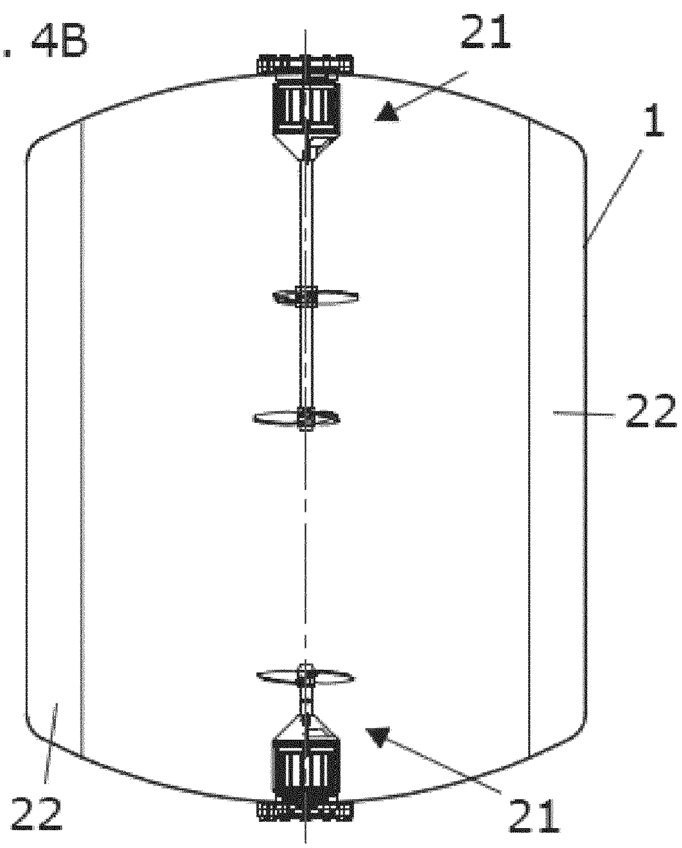
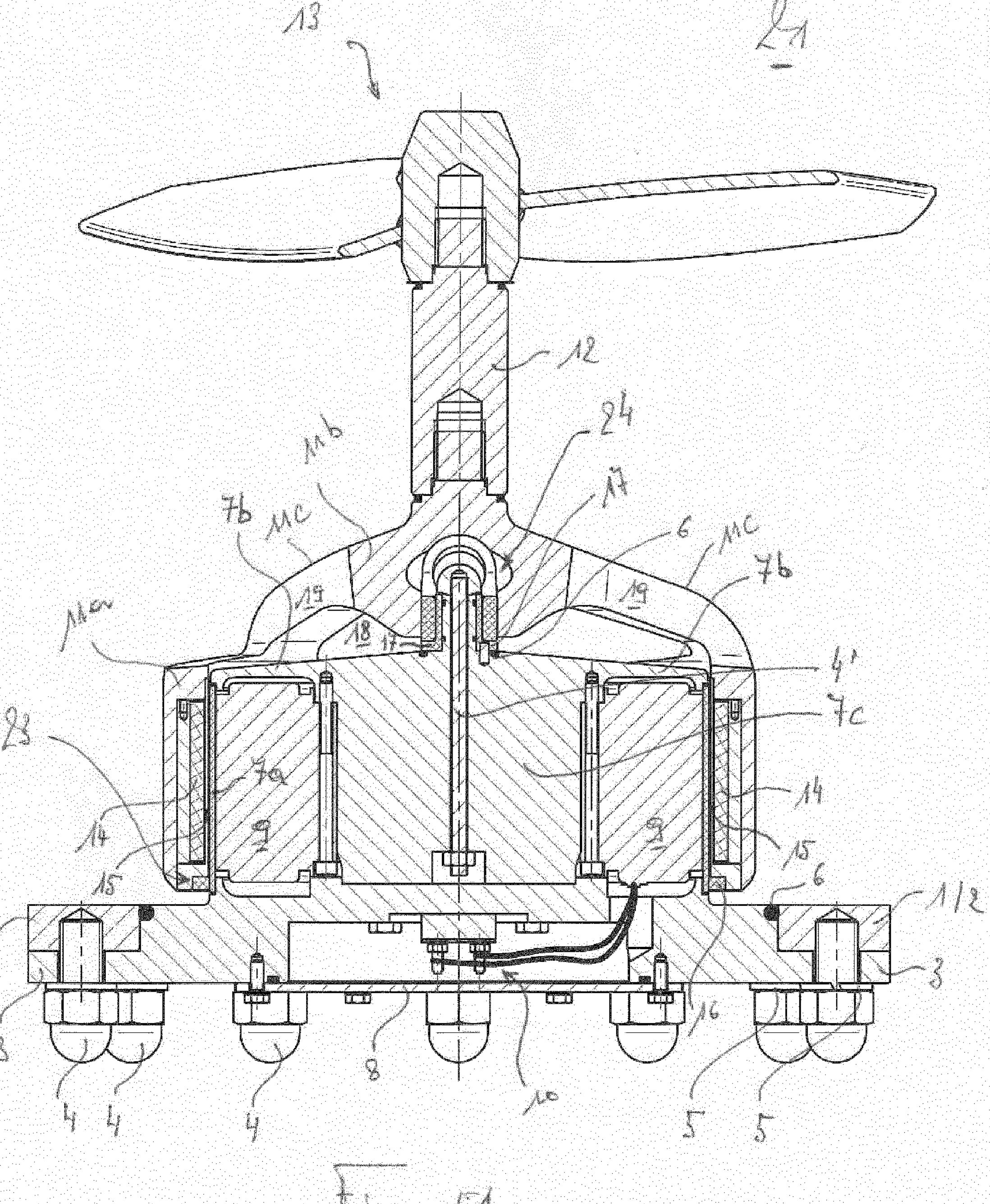


FIG. 4B




13
21
12
24
11b
17
7b
11c
6
11c
7b
19
19
11a
18
17
4'
7c
23
7a
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9
9
15
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1/2
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3
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Fig. 5A

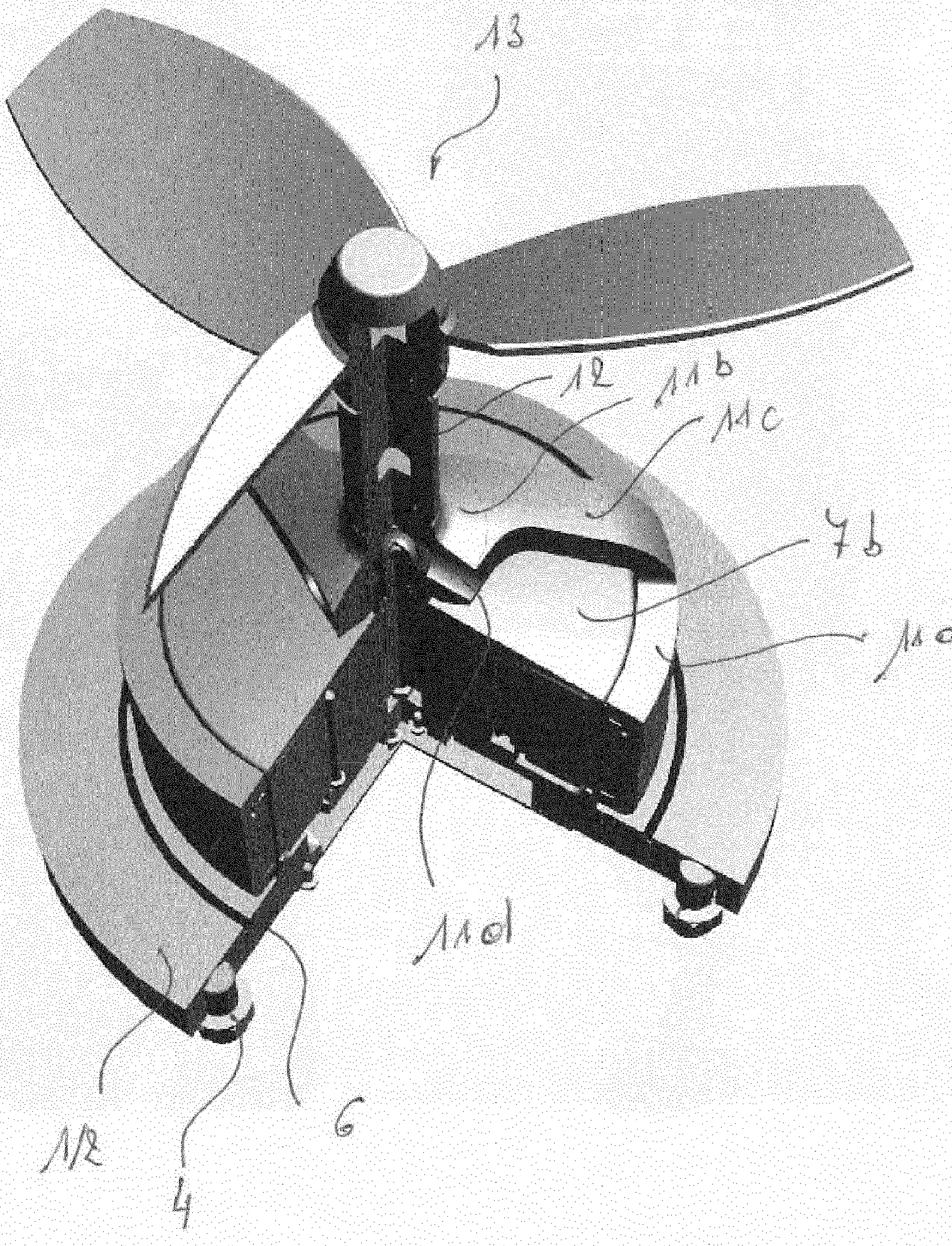

Fig. 5B

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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 3658

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Place of search	Date of completion of the search	Examiner
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