(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 October 2010 (14.10.2010)

PCT

(10) International Publication Number
WO 2010/117872 A2

(51) International Patent Classification:
F03D 11/02 (2006.01) *F03D 1/00* (2006.01)

(21) International Application Number:
PCT/US2010/029610

(22) International Filing Date:
1 April 2010 (01.04.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/166,791 6 April 2009 (06.04.2009) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: COAXIAL WIND TURBINE

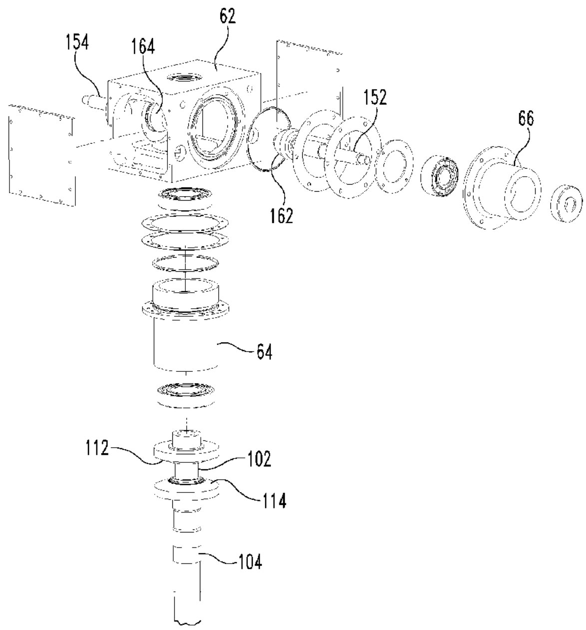

Fig. 6

(57) Abstract: Disclosed is a gearbox with two driver gears that are phase shifted 180 degrees with respect to a driven gear so that counter-rotation of the driver gears combine to rotate the driven gear together. The gearbox can be used to couple a counter-rotating, coaxial wind turbine rotors by coupling the driver gears to the counter-rotating rotors and the driven gear to a generator so that the counter-rotating rotors on the wind turbine rotate the driven gear in the same direction. The driven gear can be coupled to a generator to produce electricity.

WO 2010/117872 A2

COAXIAL WIND TURBINE

FIELD OF THE INVENTION

[0001] This disclosure is related to coaxial wind turbines.

BACKGROUND

[0002] A wind turbine converts the kinetic energy in wind into mechanical energy that is then converted by a generator into electricity. A coaxial wind turbine utilizes a second counter-rotating rotor to increase the amount of kinetic energy converted from a particular patch of sky.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a horizontal wind turbine.

FIG. 2 is a front elevational view of the FIG. 1 wind turbine.

FIG. 3 is a top plan view of the FIG. 1 wind turbine.

FIG. 4 is a side elevational view of a gearbox.

FIG. 5 is a cross-sectional view of the FIG. 4 gearbox along section lines 5-5.

FIG. 6 is an exploded perspective assembly view of the FIG. 4 gearbox.

FIG. 7 is a perspective view of the FIG. 4 gearbox with a cut away section.

FIG. 8 is a perspective view of the FIG. 4 gearbox.

FIG. 9 is a perspective view of a vertical wind turbine.

FIG. 10 is a front elevational view of the FIG. 9 wind turbine.

FIG. 11 is a top plan view of the FIG. 9 wind turbine.

DETAILED DESCRIPTION OF THE DRAWINGS

[0003] For the purpose of promoting an understanding of the claims, reference will now be made to certain embodiments thereof and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of this disclosure and the claims is thereby intended, such alterations, further modifications and further applications of the principles described herein being contemplated as would normally occur to one skilled in the art to which the disclosure relates. In several figures, where there are the same or similar elements, those elements are designated with the same or similar reference numerals.

[0004] FIGs. 1-3 illustrate horizontal wind turbine 50 which includes gear box 60, generators 70 and 72, counter-rotating rotors 80 and 82 and support structure 90. As illustrated, rotors 80 and 82 are pitched to rotate in opposite directions when both are coaxially mounted in an airflow (wind). Generators 70 and 72 are positioned at a substantially right angle to gear box 60. Wind turbine 50 is a horizontal-axis wind turbine with rotors 80 and 82 pointed into the wind. While not specifically discussed here, the means for maintaining the orientation of rotors 80 and 82 with respect to the wind can be any means known in the art, including use of a wind sensor coupled to a servo motor (not illustrated) or even a simple wind vane (not illustrated).

[0005] In other embodiments, generators 70 and 72 can be remotely located with appropriate transmission between rotors 80 and 82 and generators 70 and 72.

[0006] Referring now to FIGs. 4-7, gear box 60 is illustrated. Gear box 60 includes mounting bracket 61, housings 62, 64, 66 and 68, inner drive shaft 102, outer drive shaft 104, driver gears 112 and 114, output shafts 152 and 154, driven gears 162 and 164.

[0007] Driver gear 112 is coupled to inner drive shaft 102 and driver gear 114 is coupled to outer drive shaft 104. Inner drive shaft 102 and outer drive shaft 104 are coupled to rotors 80 and 82. As such, inner drive shaft 102 and outer drive shaft 104 are counter-rotating. Driven gears 162 and 164 are positioned on opposite sides of inner drive shaft 102 and are engaged between driver gears 112 and 114. Counter rotation of driver gears 112 and 114 rotates driver gears 112 and 114 because the location where driver gear 112 engages each driven gear is phase shifted 180 degrees from the location where driver gear 114 engages each driven gear (the driver gears are located on opposing sides of the driven gears). This configuration permits both driver gears 112 and 114 to power rotation of the driven gears.

[0008] Driver gears 112 and 114 and driven gears 162 and 164 are beveled friction gears. In one embodiment, these beveled friction gears are constructed of a hardened steel material. In yet another embodiment, they may be constructed of a ceramic material. In other embodiments, other materials appropriate for friction gears may be utilized. In yet other embodiments, driver gears 112 and 114 and driven gears 162 and 164 are beveled gears with intermeshing teeth.

[0009] Output shafts 152 and 154 are coupled either directly or indirectly to generators 70 and 72. For example, in one embodiment output shafts 152 and 154 are directly coupled to generators 70 and 72. In this embodiment, generator 70 and 72 could be controllably engaged or disengaged with gear box 60 by moving driven gear 162 and/or 164 into or out of engagement with driven gears 162 and 164. As illustrated in FIG. 7, friction clutches 172 and 174 are optionally located between output shaft 152 and generator 70 and output shaft 154 and generator 72. This embodiment permits controlled engagement and disengagement of generator 70 and/or 72 with output shaft 154 and/or 152 via operation of friction clutches 172 and/or 174. In addition, additional gearing can be included between gear box 60 and generators 70 and 72 to match the generator operational RPM to the rotation speed of rotors 80 and 82.

[0010] This configuration permits variations in the configuration of wind turbine 50. For example, because the power output from rotors 80 and 82 can be divided between multiple output shafts, generator 70 and 72 can be sized below the total output potential for wind turbine 50 permitting the use of comparatively smaller generators as compared to use of a single generator. In another embodiment, generator 70 and/or 72 can be optionally engaged to permit optimization of power output of wind turbine 50 for different wind conditions. For example, in comparatively lower speed wind operating conditions, one generator may be disengaged from gear box 70 permitting maximum power to the other generator. In comparatively higher wind speed operating conditions, generators 70 and 72 may be both engaged with gear box 60 to maximize the power output of wind turbine 50.

[0011] In other embodiments, additional output shafts may be added to increase this variable capacity beyond two generators. For example, additional output shafts and driven gears may be positioned at approximate perpendicular angle to output shafts 152 and 154 in a cruciform configuration. In other embodiments, housing 62 can be configured in other shapes (as viewed from the axis of drive shafts 102 and 104) such as hexagon, pentagon, octagon, decagon, etc., permitting the use of additional output shafts and the controllable engagement or disengagement of additional generators. As many output shafts as will fit between driver gears 112 and 114 may be used. In addition, the size of driver gears 112 and 114 can be varied to make space for additional output shafts.

[0012] In various embodiments, the number of output shafts are variable individually including having a single output shaft and driven gear coupled to driver gears 112 and 114.

[0013] Due to the friction coupling between driver gears 112 and 114 and driven gears 162 and 164, inner driver shaft 102 and outer driver shaft

104 will generally be constrained to revolve at approximately the same rotation speed which in turn generally constrains rotors 80 and 82 to revolve at the same speed.

[0014] In the illustrated embodiment rotors 80 and 82 are configured with two blades. In other embodiments, other rotor configurations can be three or four blades. Other embodiments can use any number of blades that may be desired for rotors 80 and 82. In one embodiment, rotor 82 may have a slightly increased surface area as compared to rotor 80 to more efficiently capture air flow that has been disrupted by rotor 80. In yet other embodiments, the comparative pitch between rotor 80 and rotor 82 may be varied. These embodiments may optimize performance with gear box 60 that generally constrains rotor 80 and rotor 82 to revolve at the same speed.

[0015] Referring now to FIGs. 9-11, vertical wind turbine 200 is illustrated. Vertical wind turbine 200 includes gear box 60, generators 70 and 72, counter rotating supports 220 and 222 mounting rotors 230, 232, 234 and 236. Rotors 230 and 232 are mounted on support 220 and rotors 234 and 236 are mounted on support 222. Rotors 230, 232, 234 and 236 are configured and arranged so that supports 220 and 222 rotate in opposite directions when in a wind.

[0016] Support 220 is rotationally coupled to gear box 60 via inner drive shaft 210 and support 220 is rotationally coupled to gear box 60 via outer drive shaft 212. Inner drive shaft 210 and outer drive shaft 212 interface in gear box 60 in the same way that inner drive shaft 102 and outer drive shaft 104, described above, do. Gear box 60 and generators 70 and 72 are functionally the same as those described above with regard to figures 1-8, although the orientation is different (vertical instead of horizontal).

[0017] In the illustrated embodiment, rotors 230, 232, 234 and 236 are helically shaped members. Alternative embodiments can use other rotor configurations. In one embodiment, rotors 230, 232, 234 and 236 can be constructed of a solar cell membrane capable of converting light into electricity to augment the power production of vertical wind turbine 200.

[0018] In alternative embodiments, rotors 230 and 232 can be configured differently from rotors 234 and 236 to account for the disruption of the air flow by rotors 234 and 236 before encountering rotors 230 and 232 and also to account for differences in the distance from the center in which the rotors are mounted to achieve substantially equal angular velocities for supports 210 and 212.

[0019] While not illustrated, vertical wind turbine 200 can include structural supports. For example, additional horizontal supports can be located on top of rotors 230, 232, 234 and 236 to reduce deflection of individual rotors 230, 232, 234 and 236 in high wind conditions.

[0020] It should be understood that FIGs. 1-3 disclose but one embodiment of a counter-rotating horizontal wind turbine and FIGs. 9-11 disclose but one embodiment of a counter-rotating vertical wind turbine. Other embodiments can be used with gear box 60. For example, many different rotor designs for counter-rotating wind turbines have been developed that can be used in lieu of the rotor configurations disclosed herein.

[0021] While the disclosure has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected.

CLAIMS

I claim:

1. An apparatus comprising:

a first rotor;

a second rotor configured coaxially and counter-rotating to the first rotor;

a first driver gear rotationally coupled to the first rotor;

a second driver gear rotationally coupled to the second rotor; and

a first driven gear positioned between the first and second driver gears so that the point the first driver gear engages the first driven gear is phase shifted approximately 180 degrees from the point the second driver gear engages the first driven gear.

2. The apparatus of claim 1, further comprising a first generator rotationally coupled to the first driven gear.

3. The apparatus of any of claims 1-2, further comprising a second driven gear positioned between the first and second driver gears so that the point the first driver gear engages the second driven gear is phase shifted approximately 180 degrees from the point that the second driver gear engages the second driven gear.

4. The apparatus of claim 3, further comprising a second generator rotationally coupled to the second driven gear.

5. The apparatus of any one of claims 1-4, wherein the first and second driver gears are beveled friction gears.

6. The apparatus of claim 5, wherein the first and second driver gears comprise a hardened steel.

7. A gearbox comprising:

a first driver gear constructed and arranged to rotate in a first direction on an axis of rotation;

a second driver gear constructed and arranged to rotate in a second direction opposite said first direction on said axis of rotation; and

a first driven gear constructed and arranged to engage said first driver gear and said second driver gear, wherein the engagement between the first driven gear and the second driver gear is phase shifted approximately 180 degrees from where the first driven gear engages the first driver gear.

8. The gearbox of claim 7, further comprising a second driven gear constructed and arranged to engage said first driver gear and said second driver gear, wherein the engagement between the second driven gear and the second driver gear is phase shifted approximately 180 degrees from where the second driven gear engages the first driver gear.

9. The gearbox of claim 8, wherein the second driven gear is constructed and arranged to controllably engage and disengage from said first and second driver gears.

10. The gearbox of any one of claims 7-8, further comprising a third driven gear constructed and arranged to engage said first driver gear and said second driver gear, wherein the engagement between the third driven gear and the second driver gear is phase shifted approximately 180 degrees from where the third driven gear engages the first driver gear.

11. The gearbox of claim 10, further comprising a fourth driven gear constructed and arranged to engage said first driver gear and said second

driver gear, wherein the engagement between the fourth driven gear and the second driver gear is phase shifted approximately 180 degrees from where the fourth driven gear engages the first driver gear.

12. The gearbox of any one of the preceding claims, wherein the first and second driver gears are beveled friction gears.

13. A power generation system comprising:

a first wind turbine rotor;

a second wind turbine rotor;

a gearbox comprising:

a first driver gear rotationally coupled to the first wind turbine rotor, wherein the first driver gear is constructed and arranged to rotate in a first direction on an axis of rotation;

a second driver gear rotationally coupled to the second wind turbine rotor, wherein the second driver gear is constructed and arranged to rotate in a second direction opposite said first direction on said axis of rotation;

a first driven gear constructed and arranged to engage said first driver gear and said second driver gear, wherein the engagement between the first driven gear and the second driver gear is phase shifted approximately 180 degrees from where the first driven gear engages the first driver gear; and

a first generator rotationally coupled to said first driven gear.

14. The power generation system of claim 13, wherein the second wind turbine rotor is constructed and arranged coaxially and counter-rotating to the first wind turbine rotor.

15. The power generation system of claim 14, wherein said second wind turbine rotor has a greater surface area than said first wind turbine rotor.

16. The power generation system of claim 14, wherein said second wind turbine rotor has a different pitch than said first wind turbine rotor such that said first and second wind turbine rotor rotates at substantially the same speed.

17. The power generation system of any of the preceding claims, wherein the gearbox further comprises a second driven gear constructed and arranged to engage said first driver gear and said second driver gear, wherein the engagement between the second driven gear and the second driver gear is phase shifted approximately 180 degrees from where the second driven gear engages the first driver gear.

18. The power generation system of claim 17, further comprising a second generator rotationally coupled to said second driven gear.

19. The power generation system of any one of claims 17-18, wherein the second driven gear is constructed and arranged to controllably engage and disengage from said first and second driver gears.

20. The power generation system of claim 18, further comprising a clutch between said second driven gear and said second generator permitting controlled engagement and disengagement of the rotational coupling between said second generator and said second driven gear.

21. The power generation system of any one of the preceding claims, wherein the first and second driver gears are beveled friction gears.

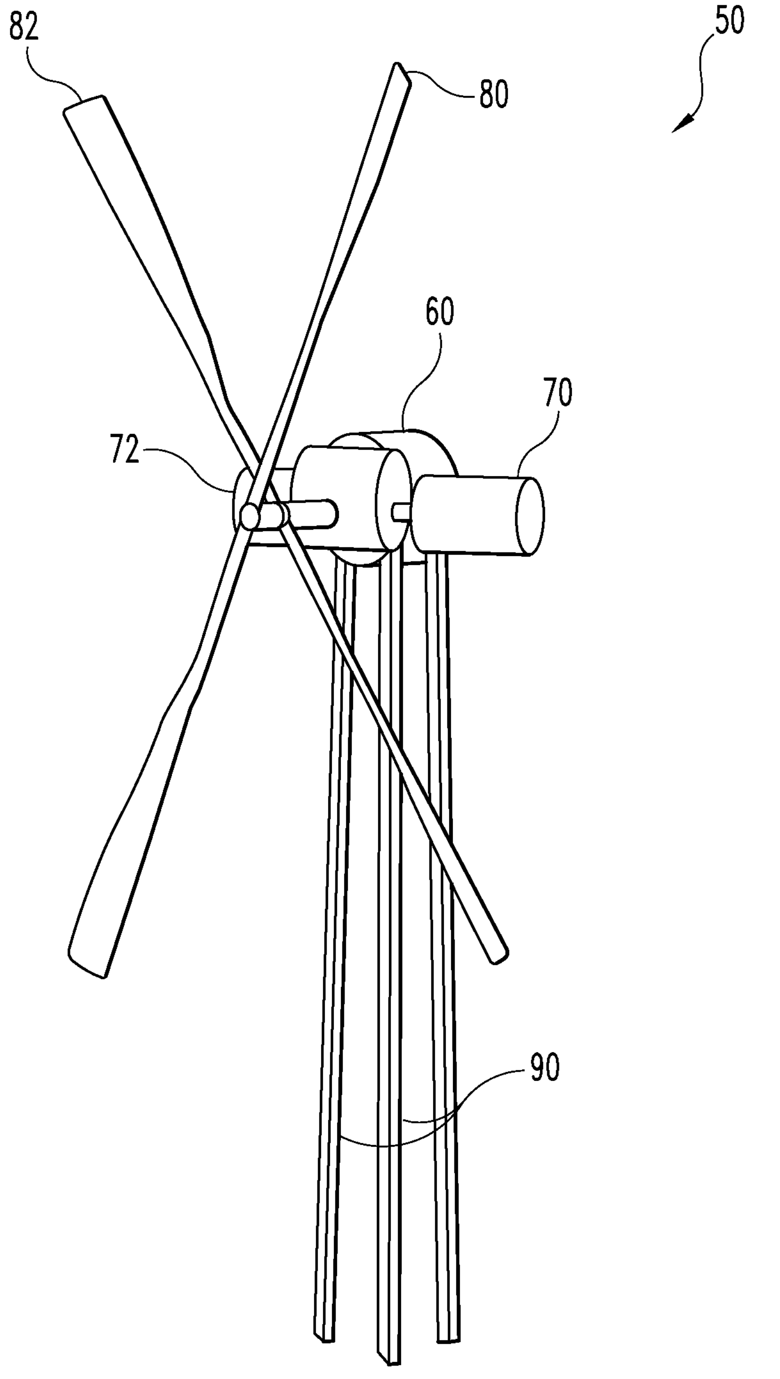

Fig. 1

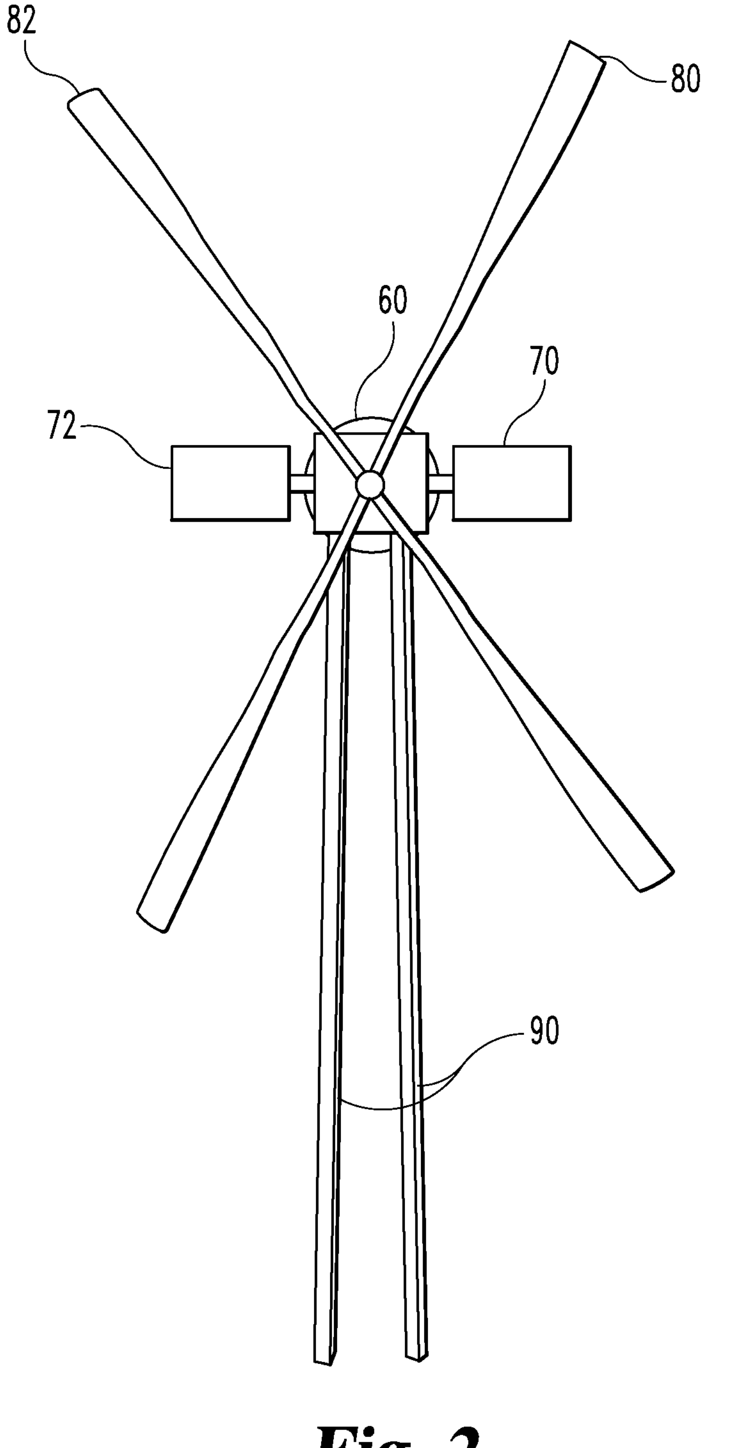

Fig. 2

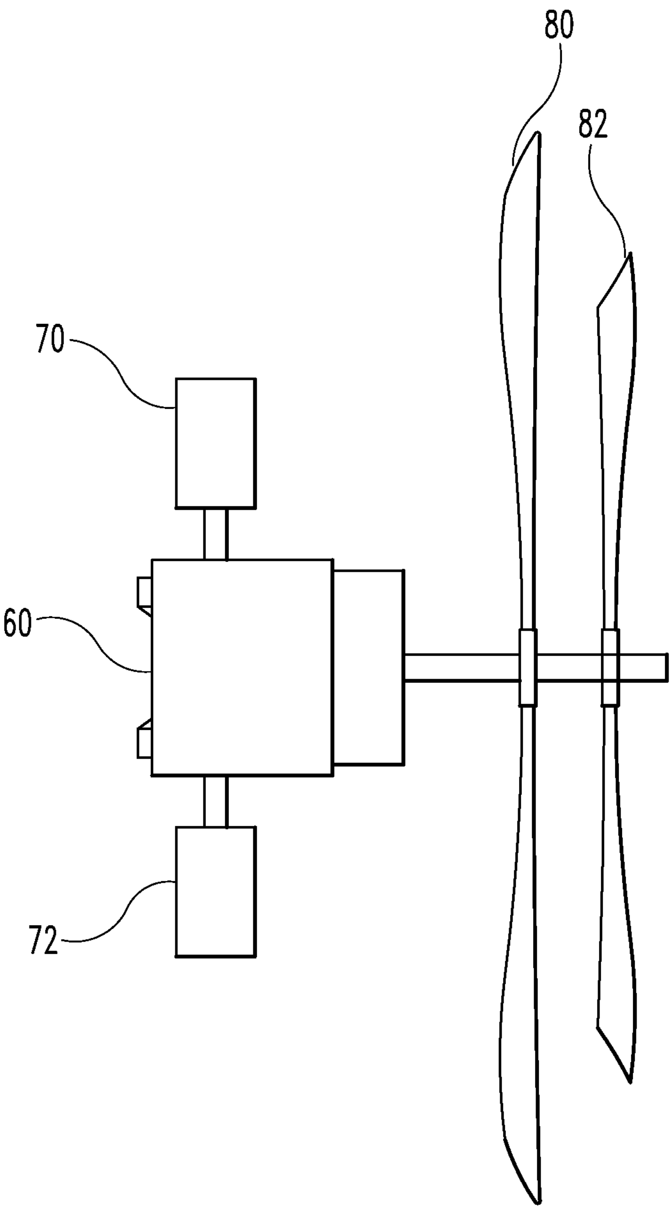

Fig. 3

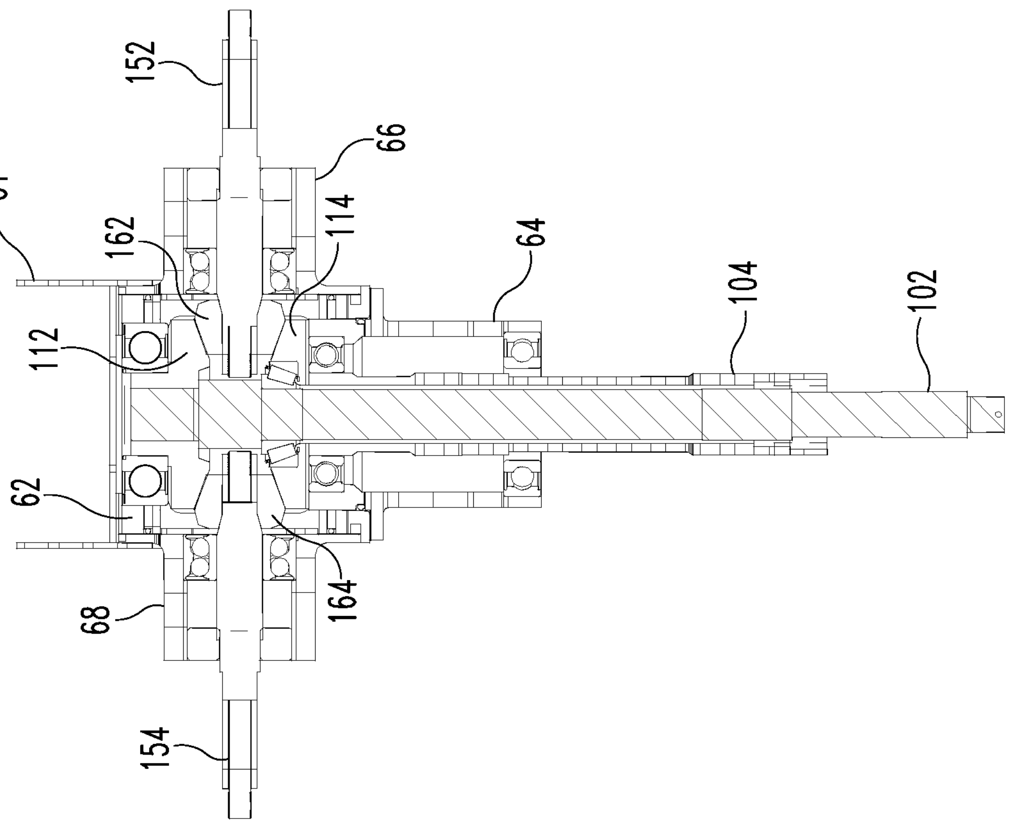
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Fig. 5

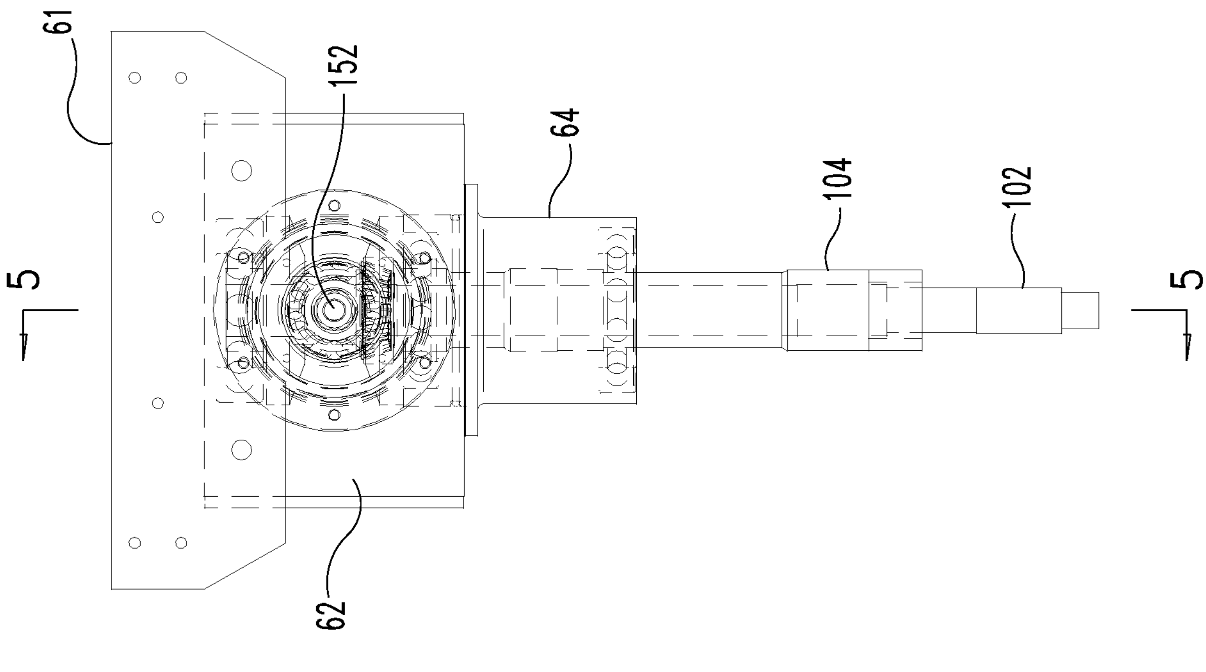
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Fig. 4

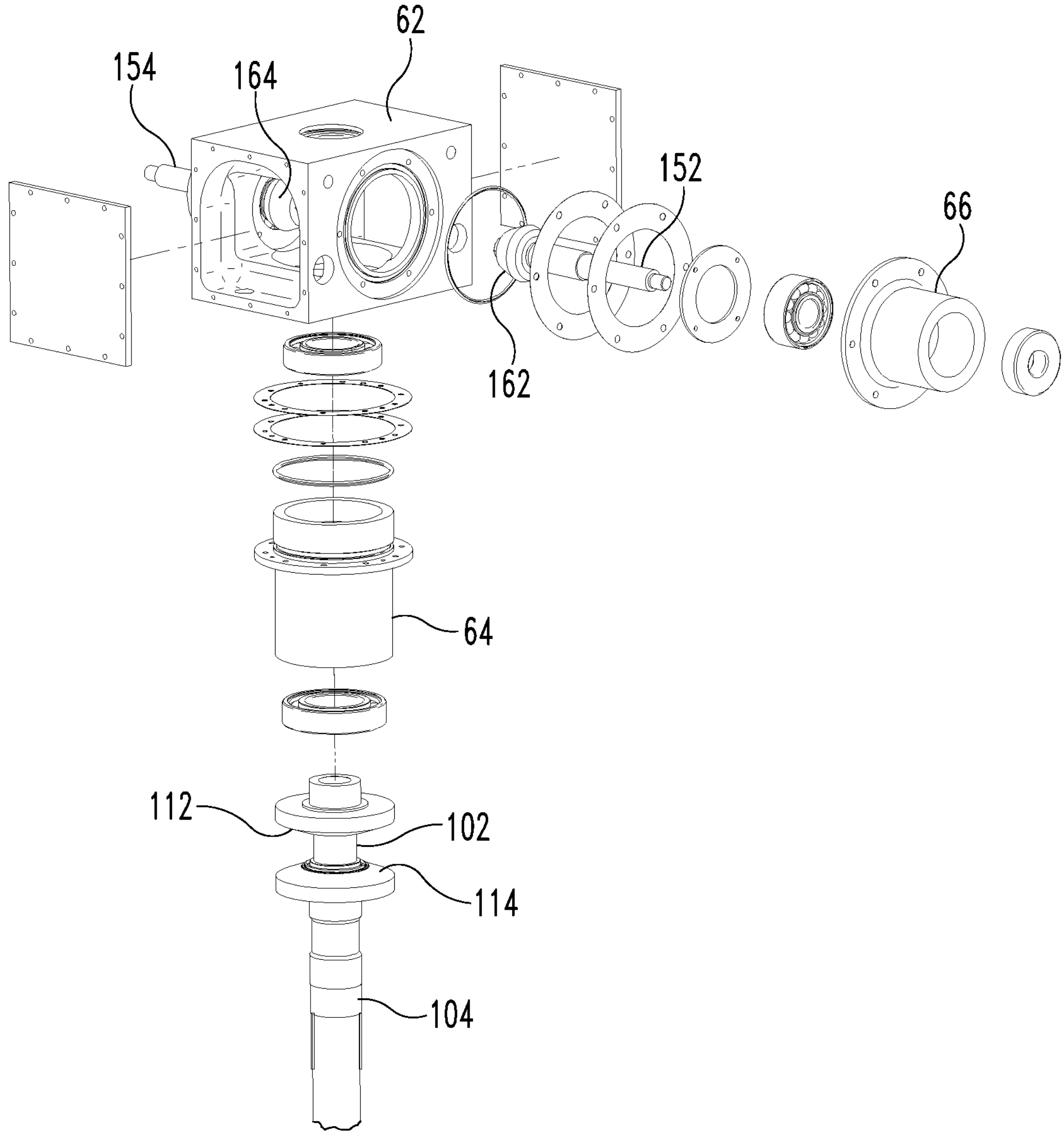

Fig. 6

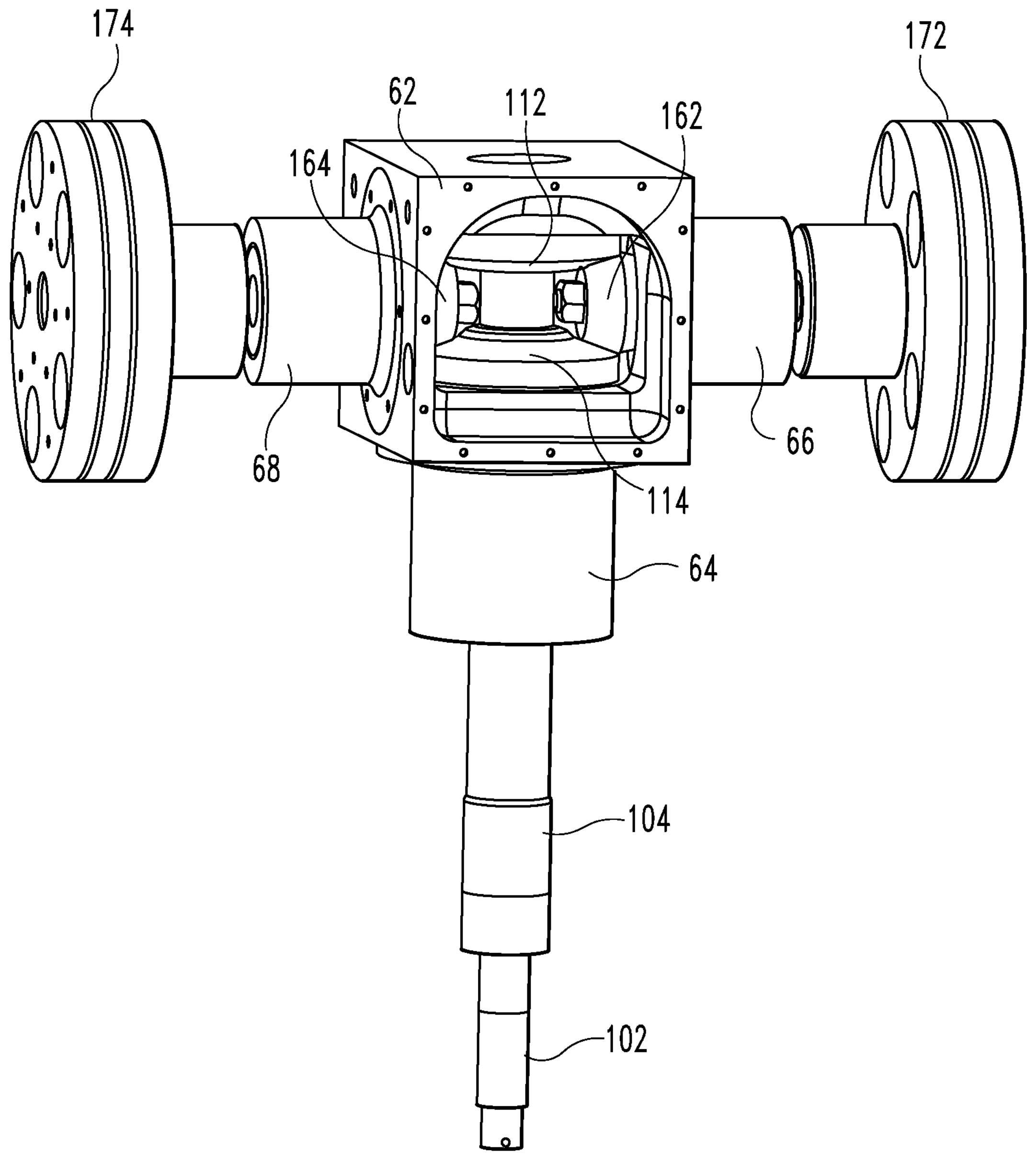

Fig. 7

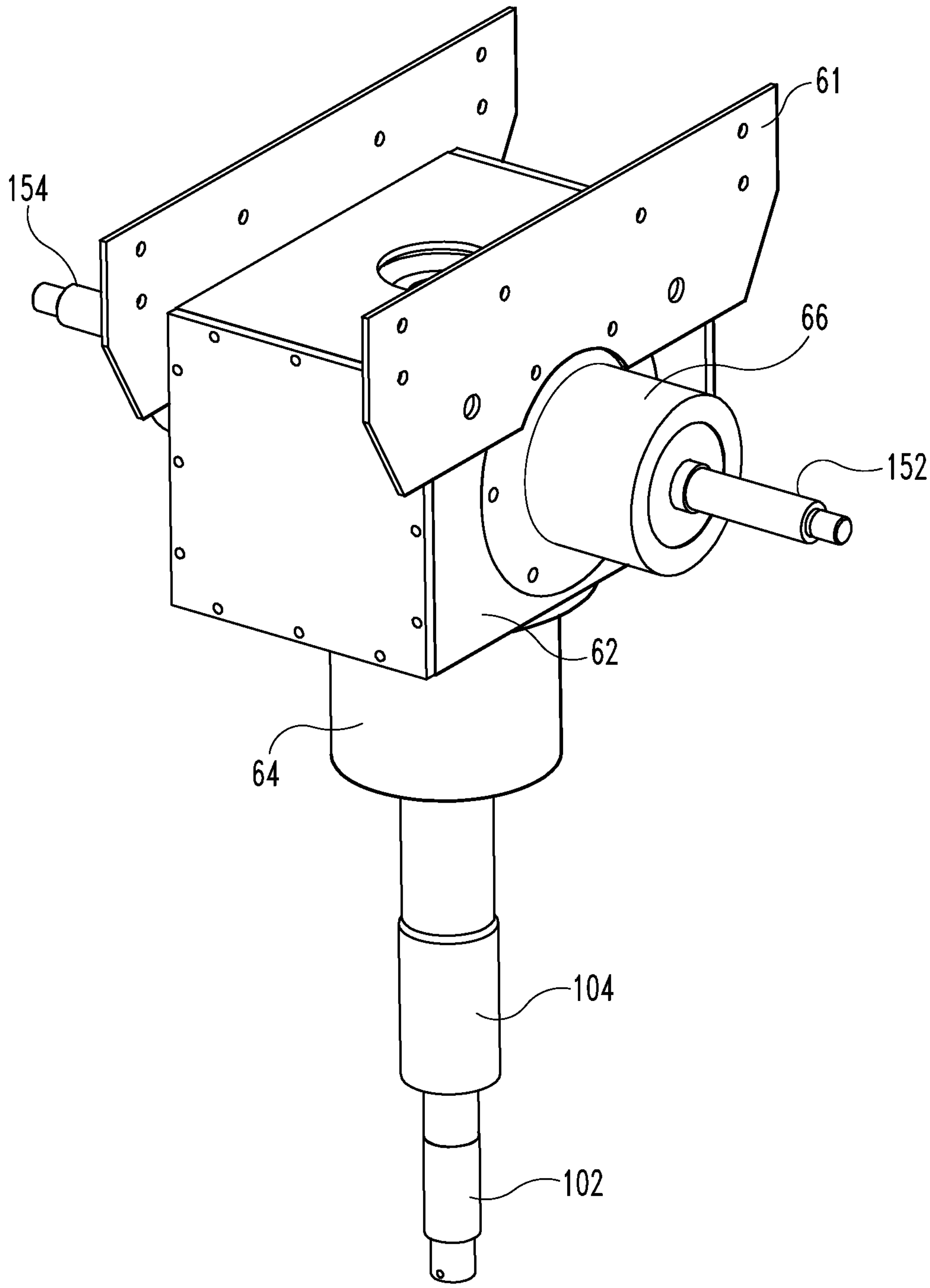

Fig. 8

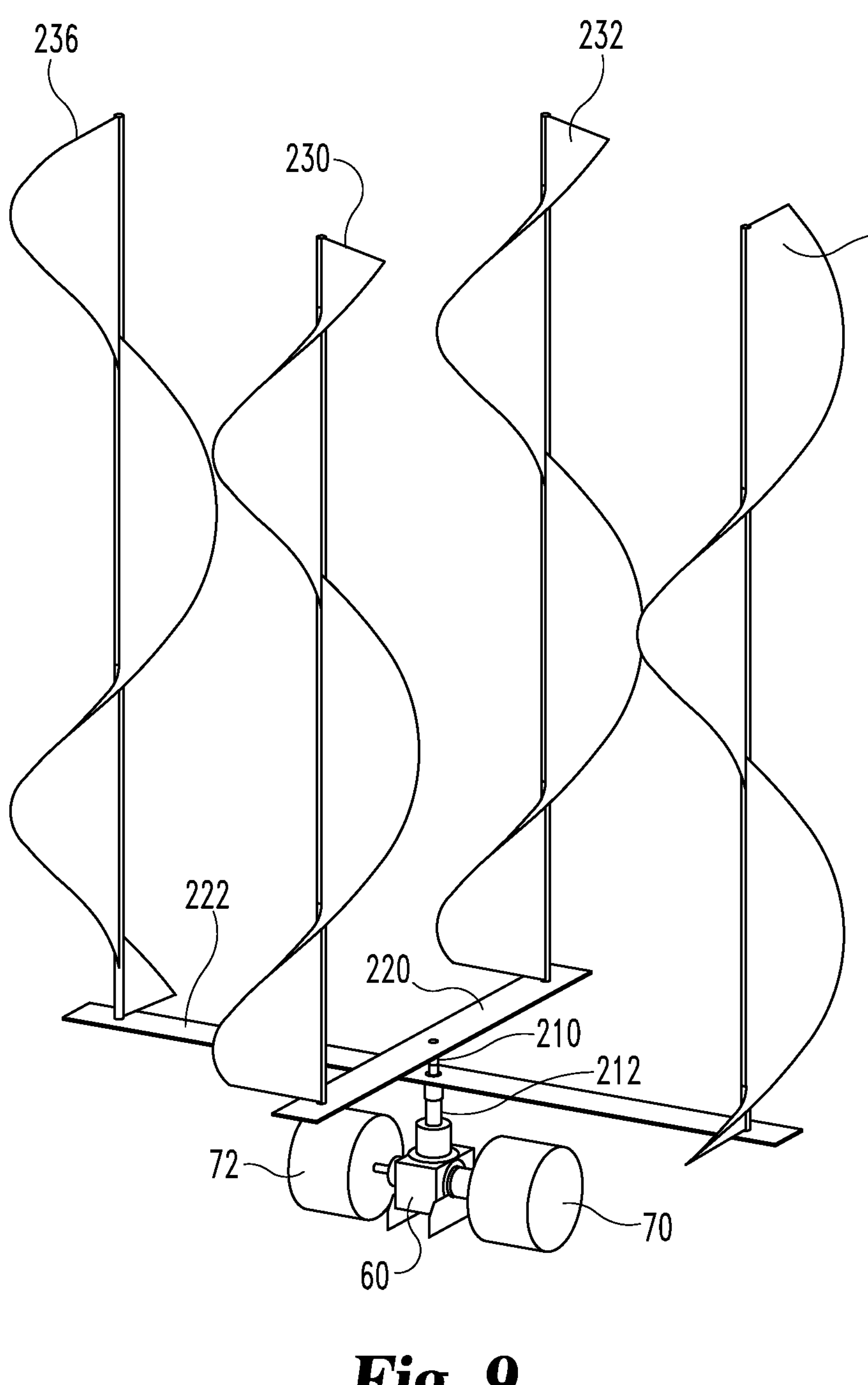

Fig. 9

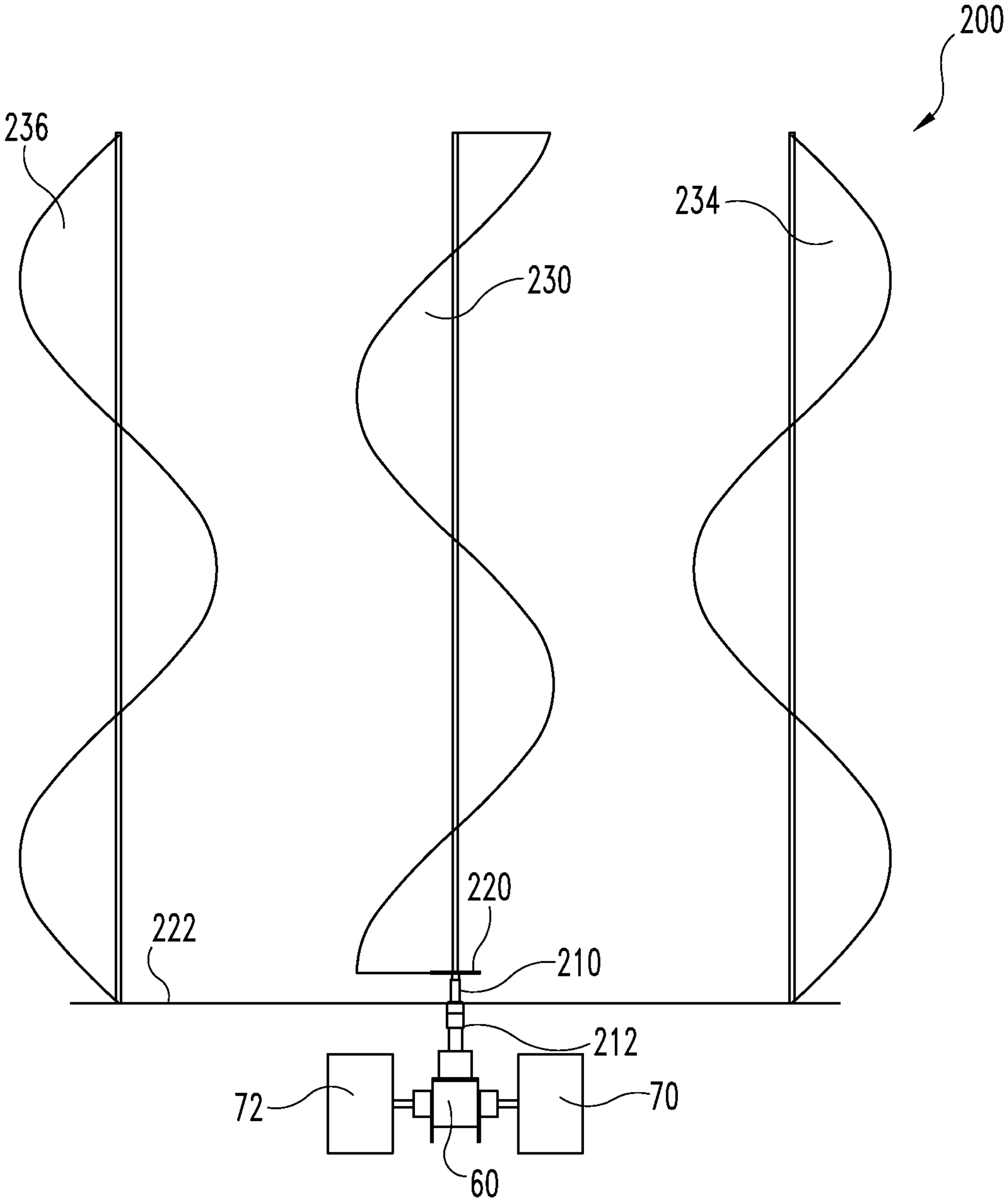

Fig. 10

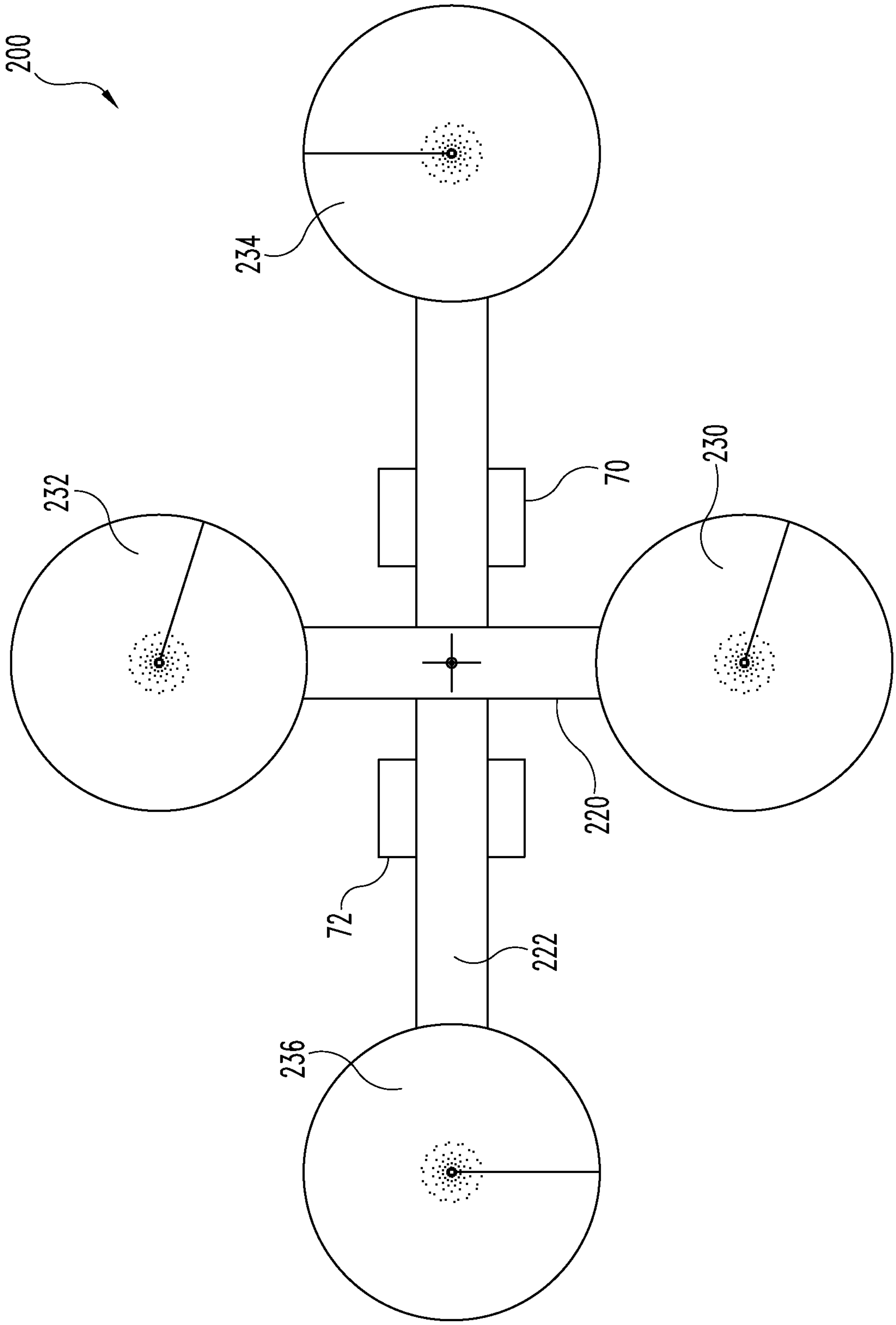

Fig. 11