US 20210129984A1

(19) United States

(12) Patent Application Publication

TAKAO

(10) Pub. No.: US 2021/0129984 A1

(43) Pub. Date: May 6, 2021

(54) UNMANNED AERIAL VEHICLE

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(21) Appl. No.: **16/475,729**

(22) PCT Filed: **Jan. 30, 2018**

(86) PCT No.: **PCT/JP2018/002856**

§ 371 (c)(1),
(2) Date: **Jul. 3, 2019**

Related U.S. Application Data

(60) Provisional application No. 62/451,892, filed on Jan. 30, 2017.

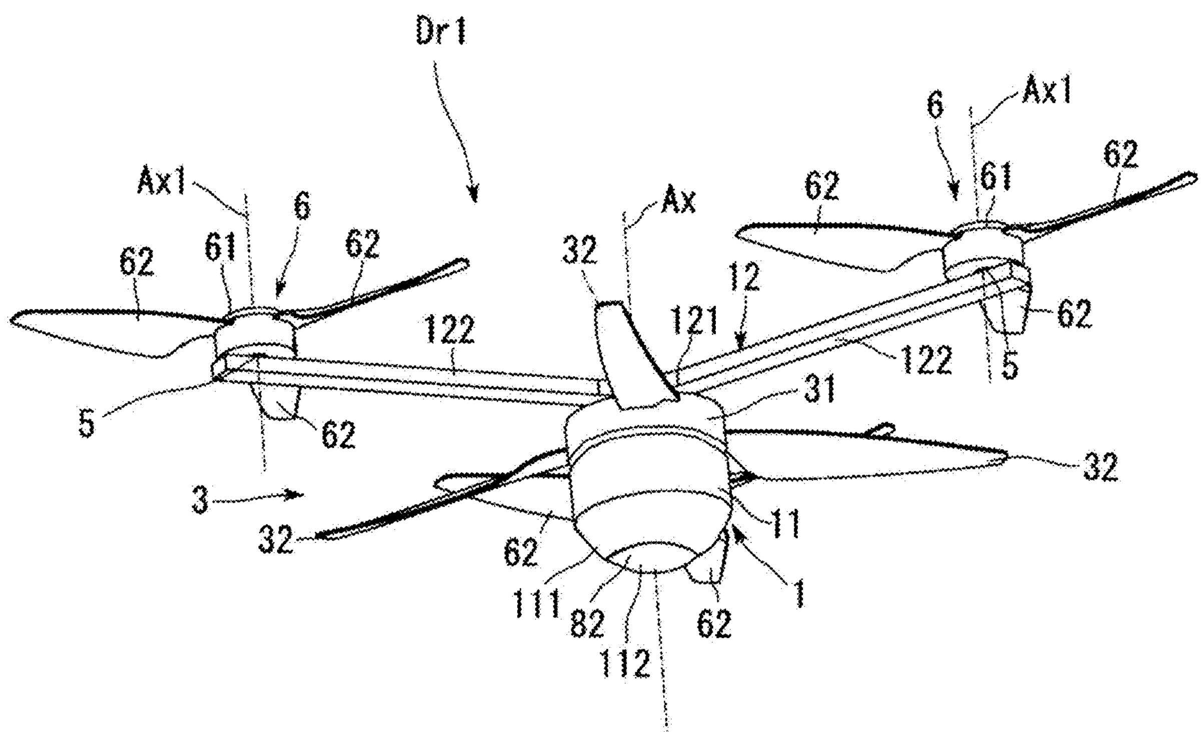
Publication Classification

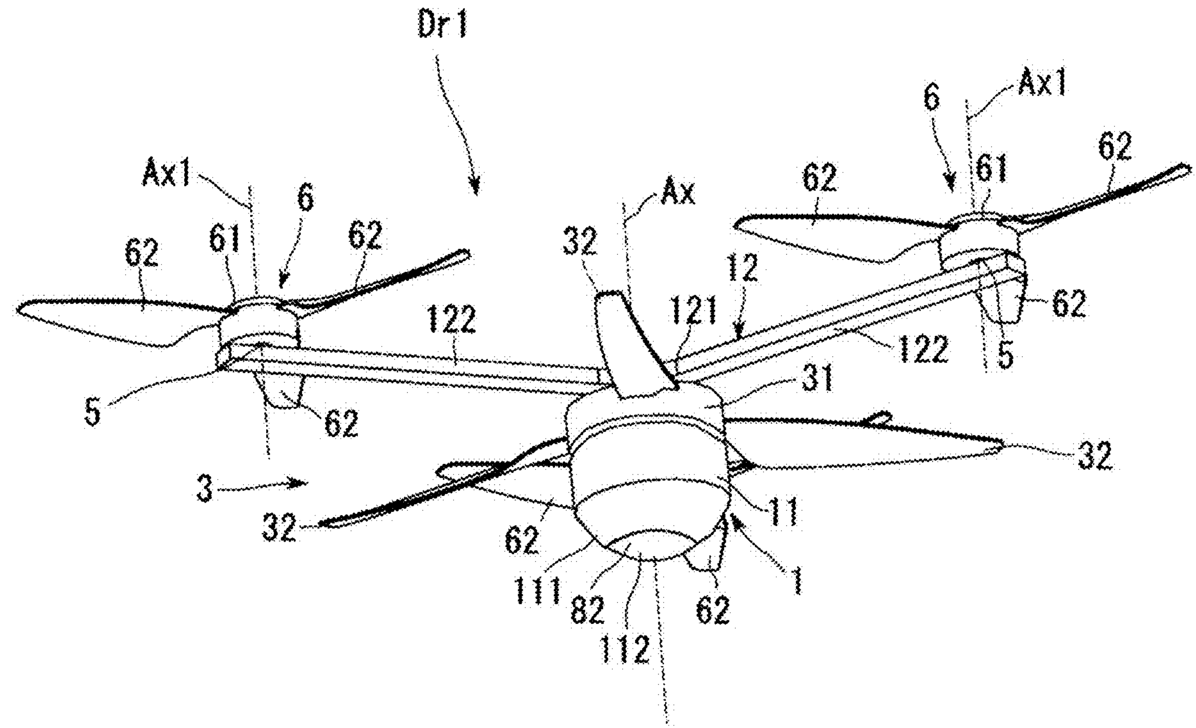
(51) **Int. Cl.**
B64C 39/02 (2006.01)
B64D 27/24 (2006.01)
B64D 47/08 (2006.01)
B60L 50/60 (2006.01)

(52) **U.S. Cl.**
CPC ***B64C 39/024*** (2013.01); ***B64D 27/24*** (2013.01); ***B64D 47/08*** (2013.01); *B64C 2201/108* (2013.01); *B60L 2200/10* (2013.01); *B64C 2201/027* (2013.01); *B64C 2201/042* (2013.01); ***B60L 50/60*** (2019.02)

(57) **ABSTRACT**

An unmanned aerial vehicle in which a circle drawn by a tip of a main propeller and a circle drawn by a tips of each of a plurality of auxiliary propellers axially overlap at least partially, a rotational direction of the plurality of auxiliary propellers is opposite to a rotational direction of the main propeller when viewed from one axial side of a main shaft, and a torque acting on a body from the main propeller when the body is hovering in the air is equal or substantially equal to a sum of torque acting on the body from the plurality of auxiliary propellers.

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6
61
62
62
62
5
62
Ax1
6
61
62
62
62
5
Ax
32
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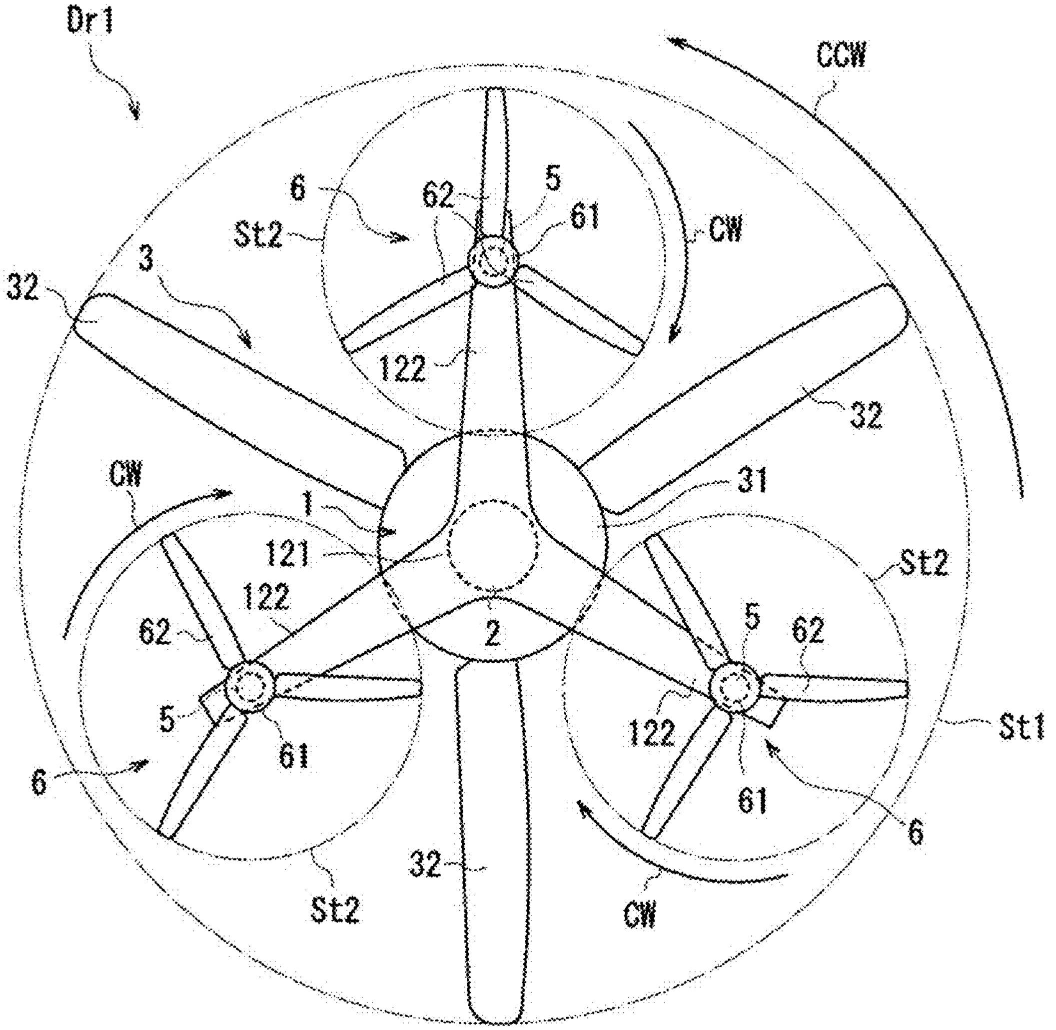
122
122
31
32
3
32
11
62
111
82
112
1
62

Fig.1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6
62
5
61
St2
CW
3
32
122
32
31
CW
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St1
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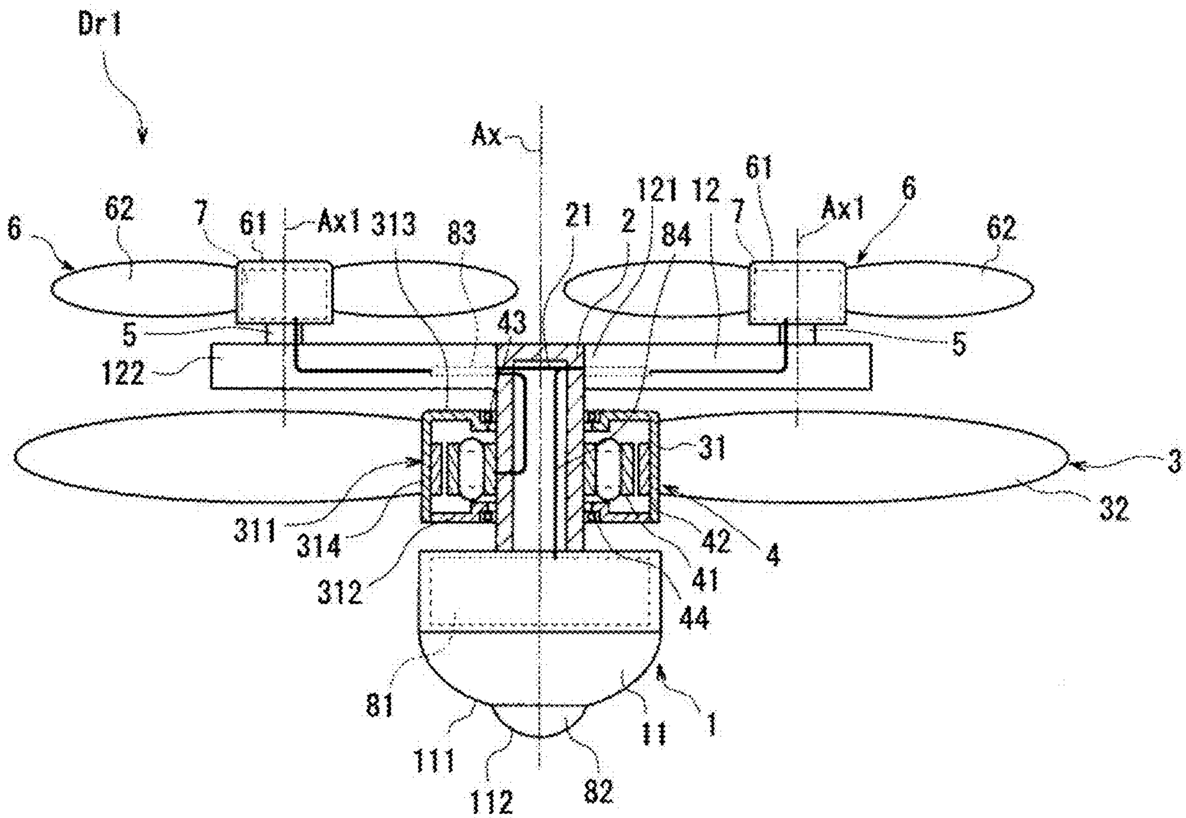
32
St2
CW

Fig.2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Ax
62
7
61
Ax1
313
83
21
121
12
2
84
61
7
Ax1
6
62
6
5
43
5
122
31
3
32
311
314
42
4
312
41
44
81
11
1
111
112
82

Fig.3

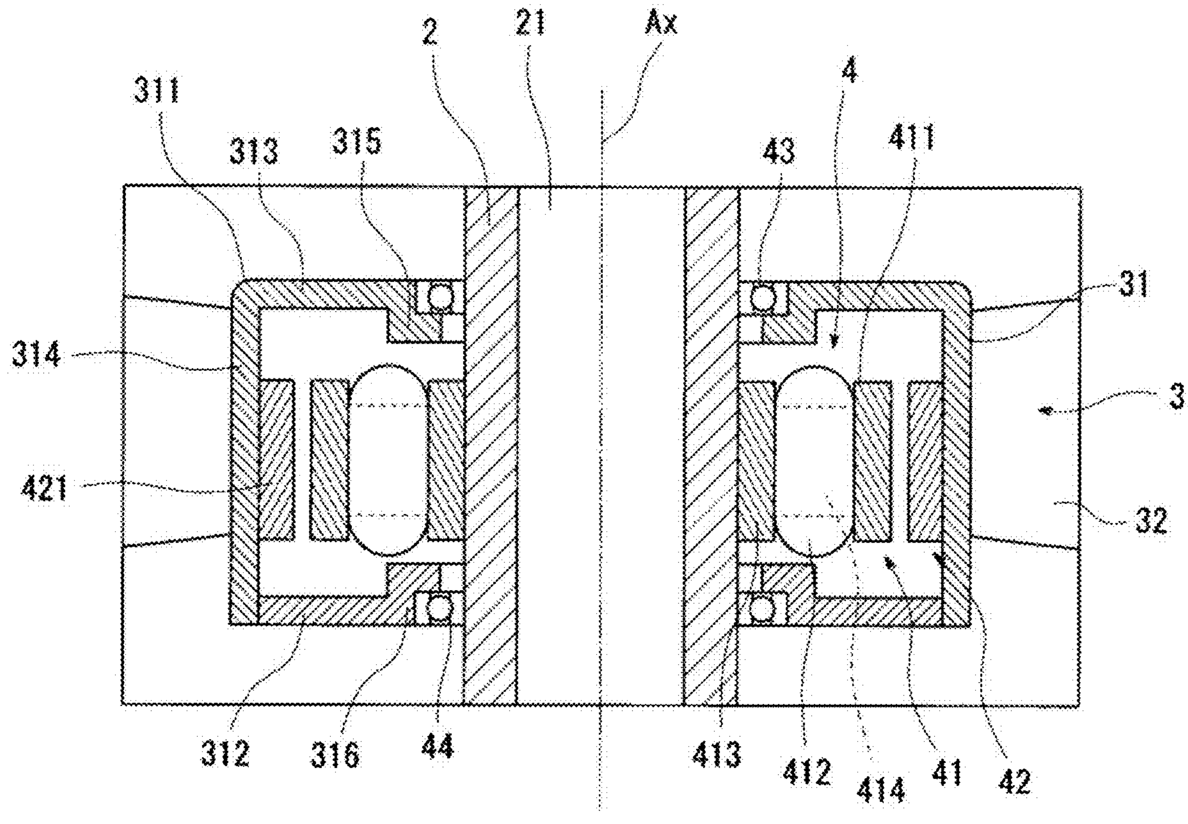

2
21
Ax
4
311
313
315
43
411
31
314
3
421
32
312
316
44
413
412
414
41
42

Fig.4

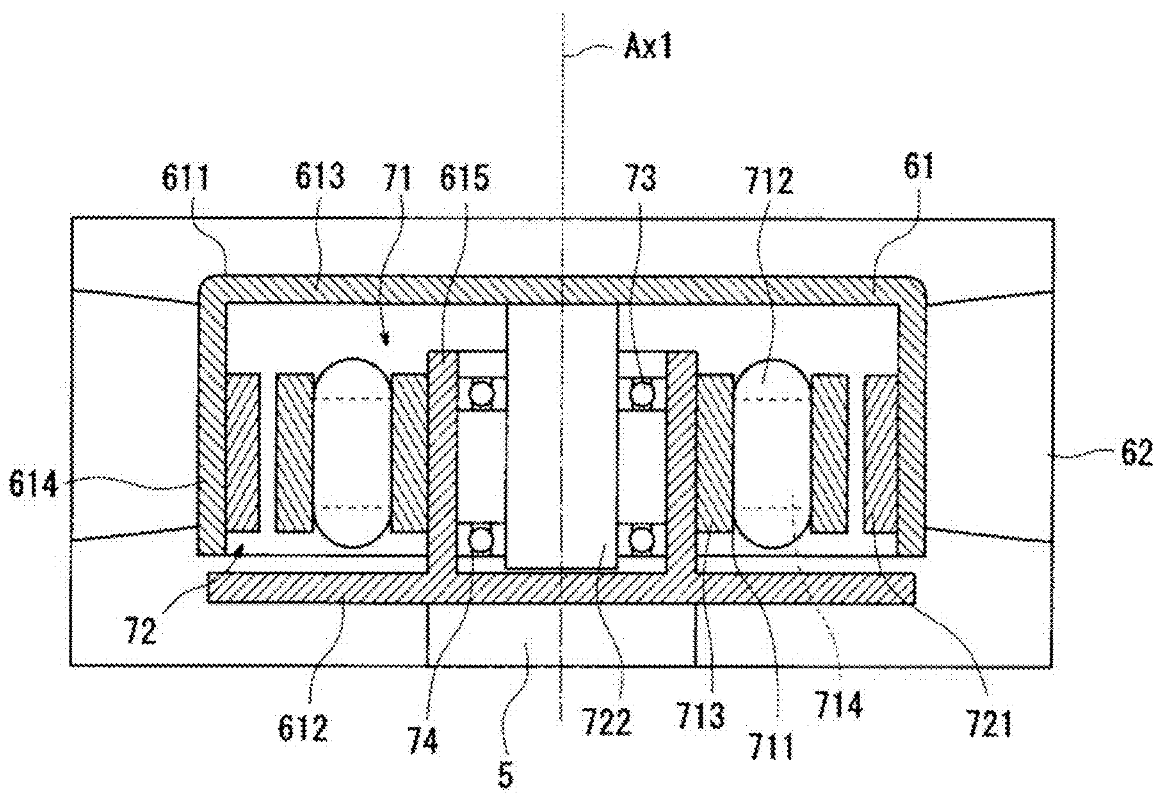
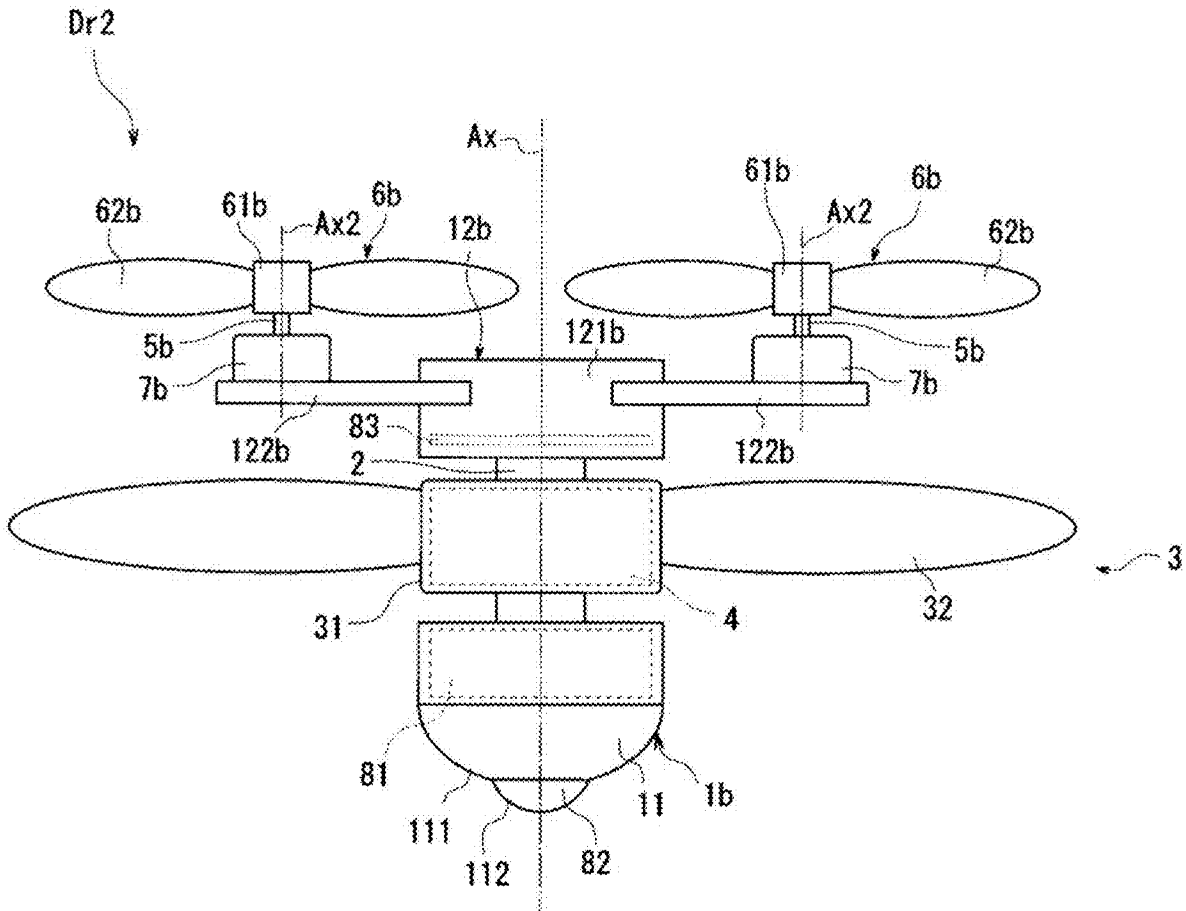


Fig.5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61b
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6b
12b
61b
Ax2
6b
62b
5b
121b
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7b
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31
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32
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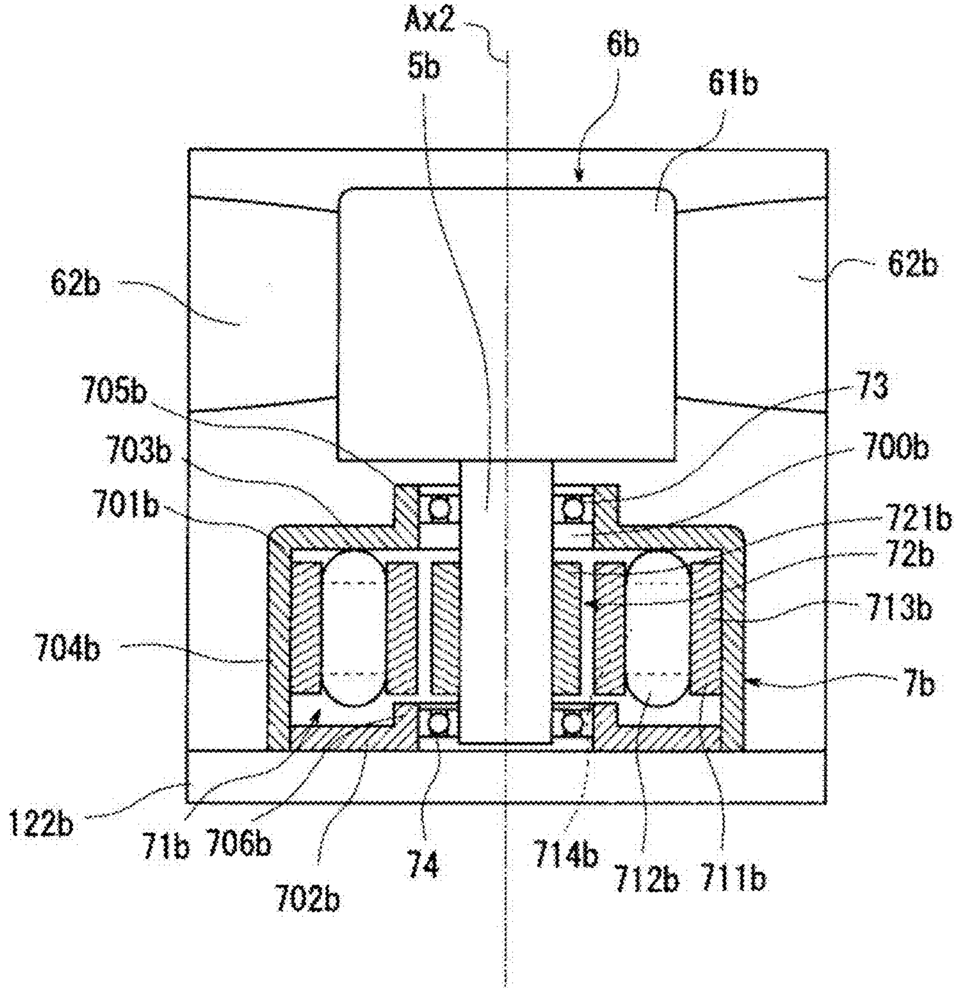
1b
111
112
82

Fig.6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62b
62b
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703b
700b
701b
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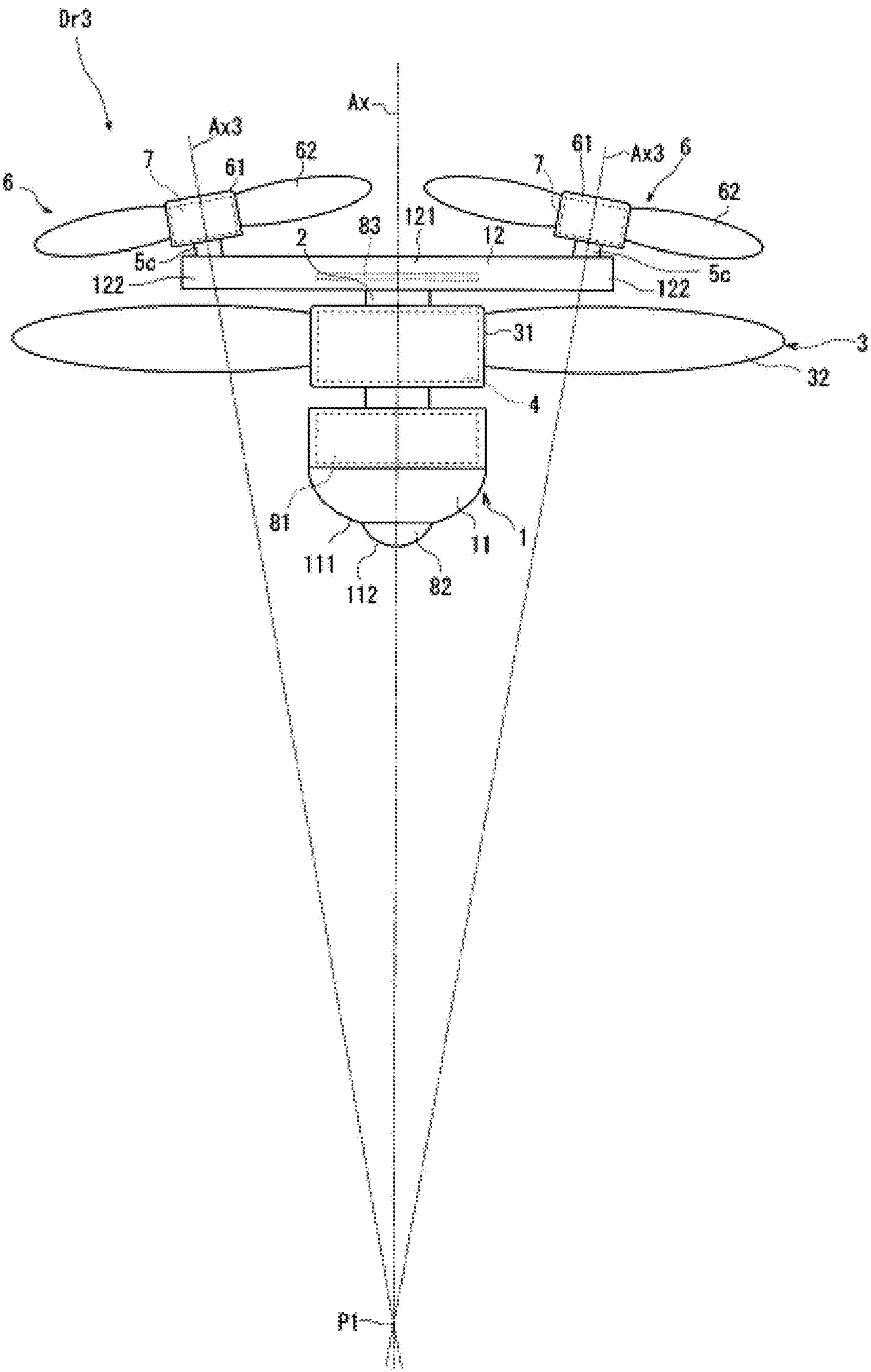
714b
712b
711b

Fig.7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Ax3
Ax3
6
7
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7
6
62
83
121
12
2
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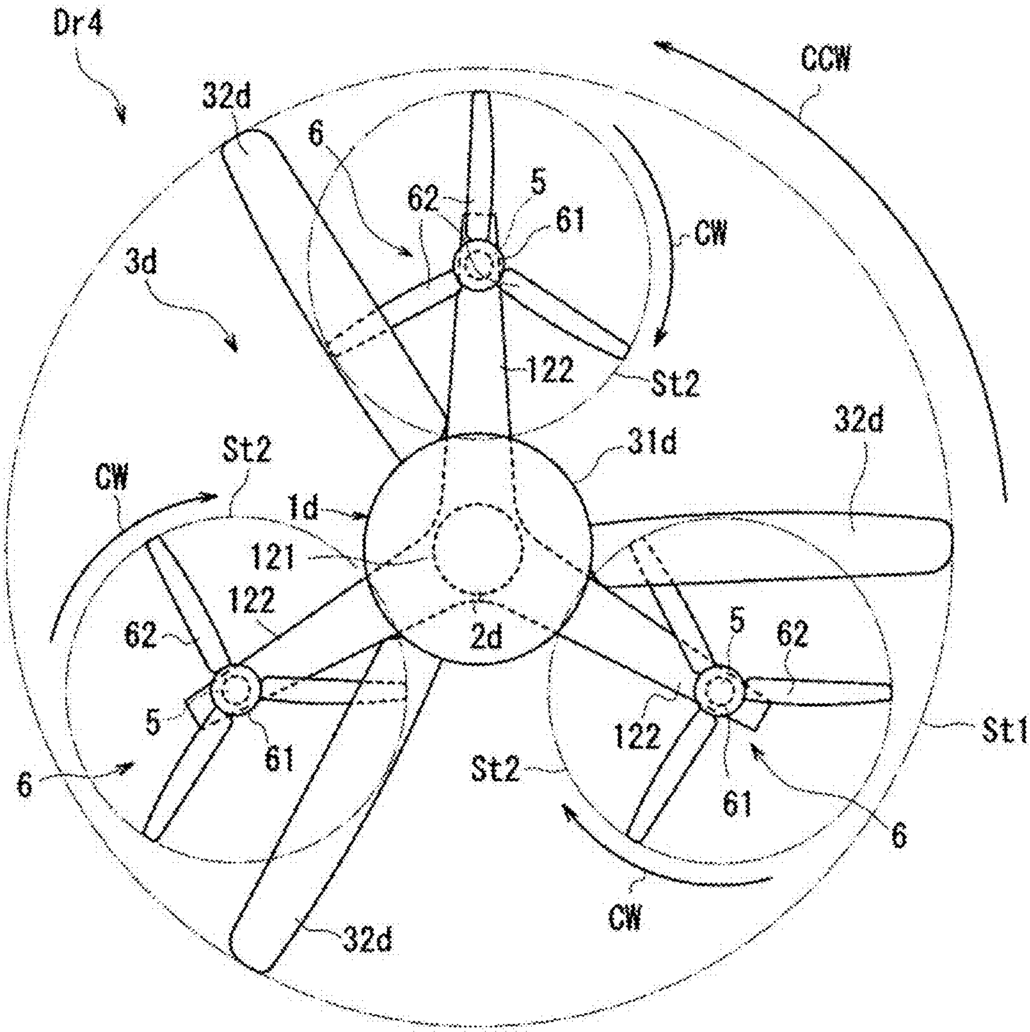
5c
122
122
31
3
32
4
81
11
1
111
112
82
P1

Fig.8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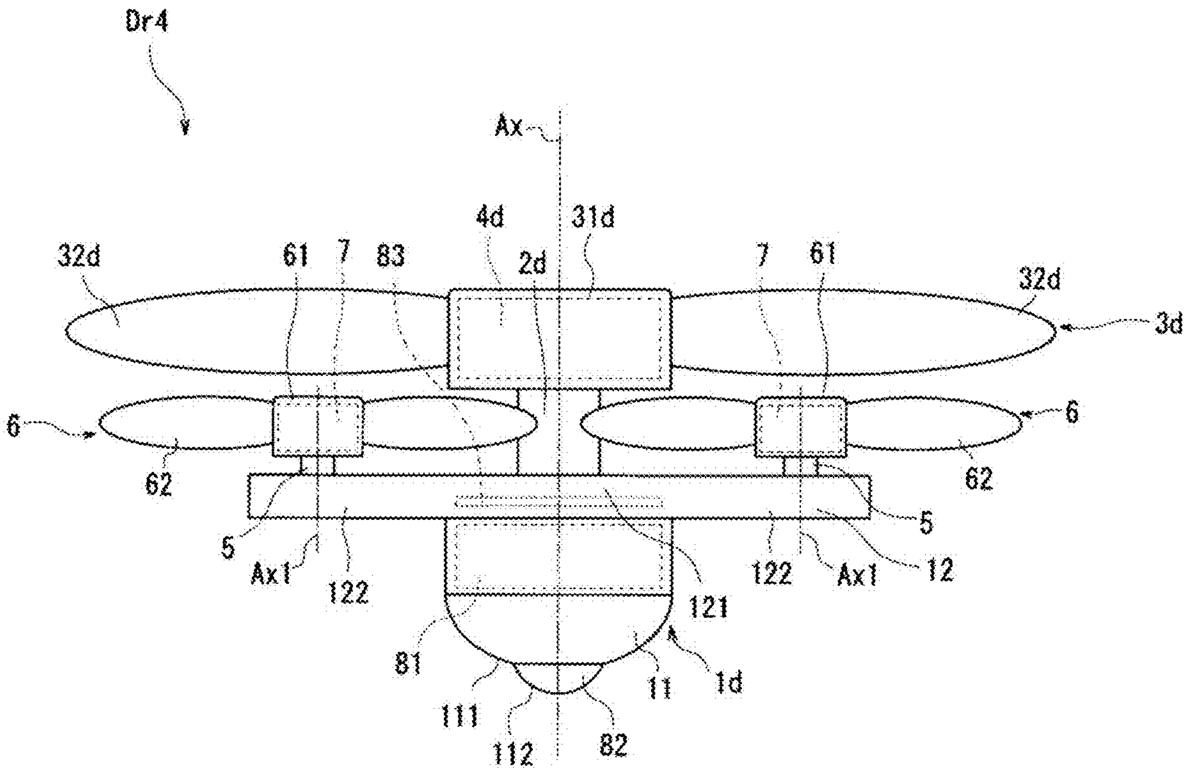
32d
6
62
5
61
CW
3d
122
St2
32d
31d
St2
CW
1d
121
122
2d
5
62
62
5
122
St1
61
St2
6
61
6
CW
32d

Fig.9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4d
31d
32d
61
7
83
2d
7
61
32d
3d
6
6
62
62
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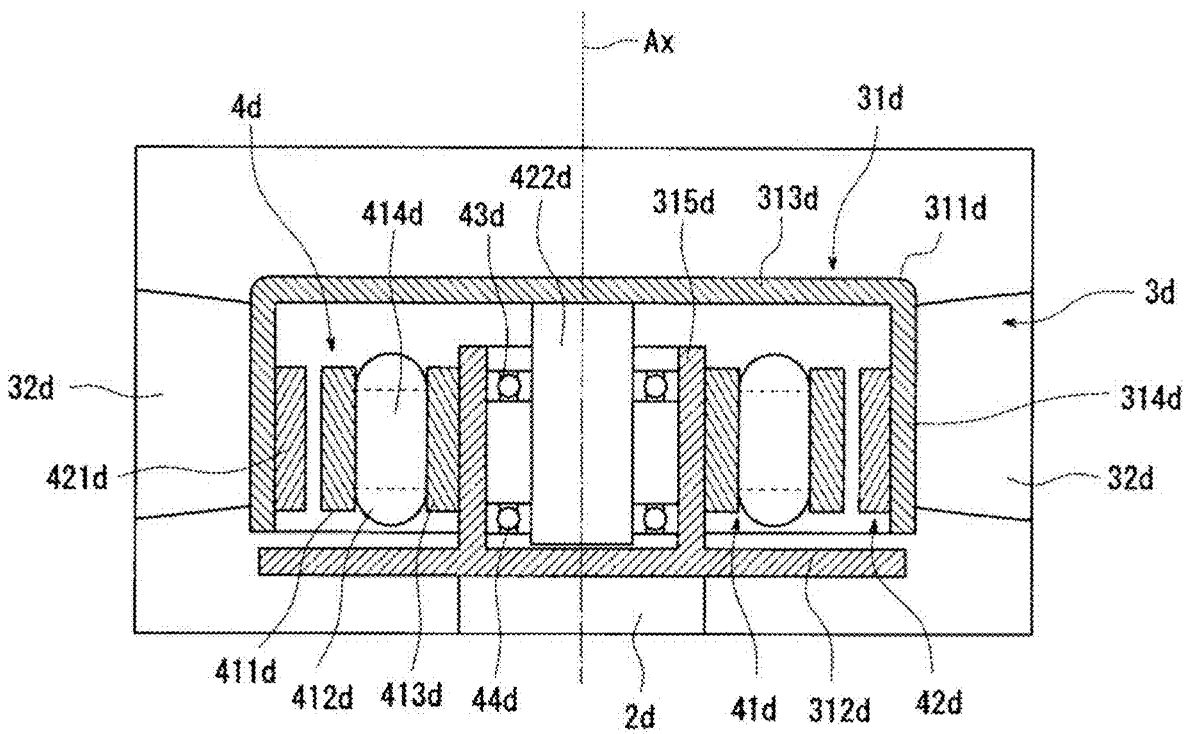
5
Ax1
122
122
Ax1
12
121
81
1d
11
111
112
82

Fig.10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31d
422d
414d
43d
315d
313d
311d
3d
32d
314d
421d
32d
411d
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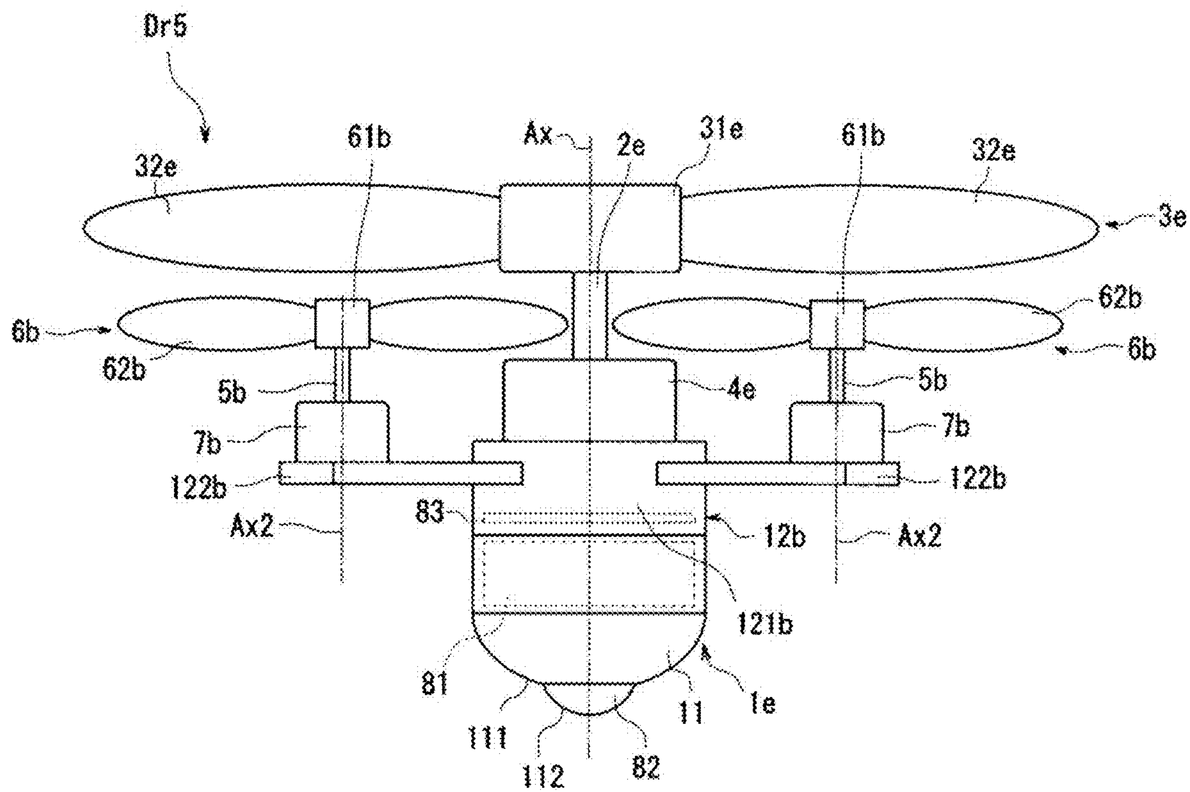
41d
312d
42d

Fig.11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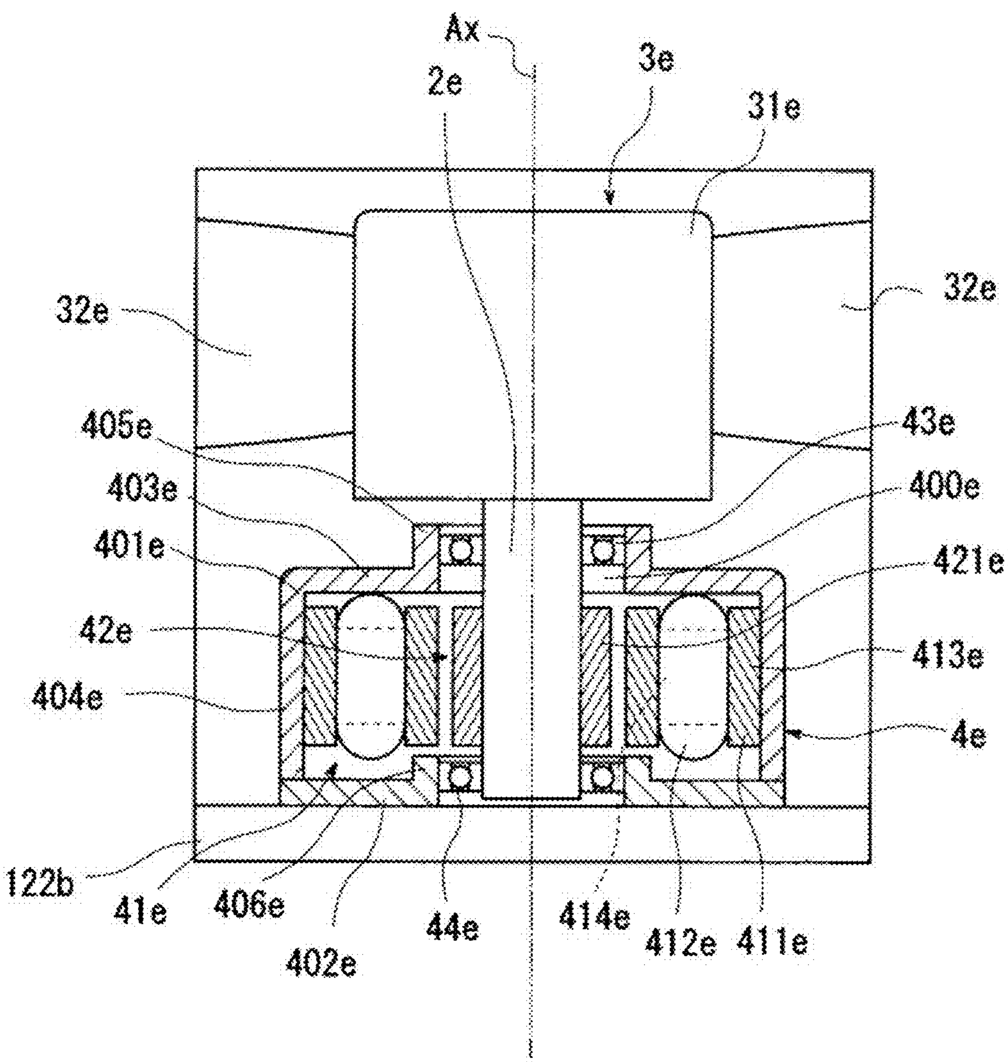
61b
Ax
2e
31e
61b
32e
3e
6b
62b
62b
6b
5b
4e
5b
7b
7b
122b
122b
83
12b
Ax2
Ax2
121b
81
1e
11
111
112
82

Fig.12



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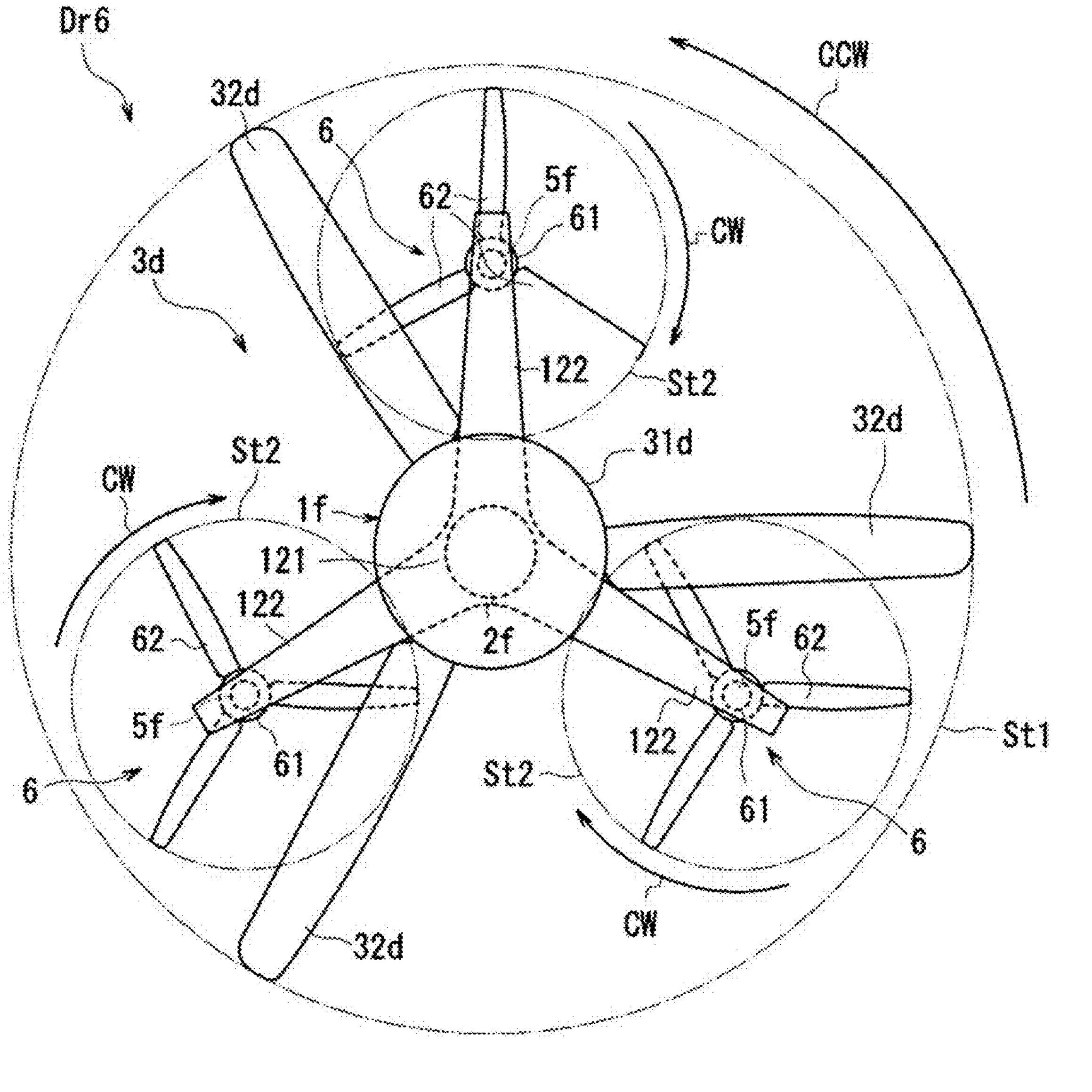
2e
31e
32e
32e
405e
43e
403e
400e
401e
421e
42e
413e
404e
4e
122b
41e
406e
402e
44e
414e
412e
411e

Fig.13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1f
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St2
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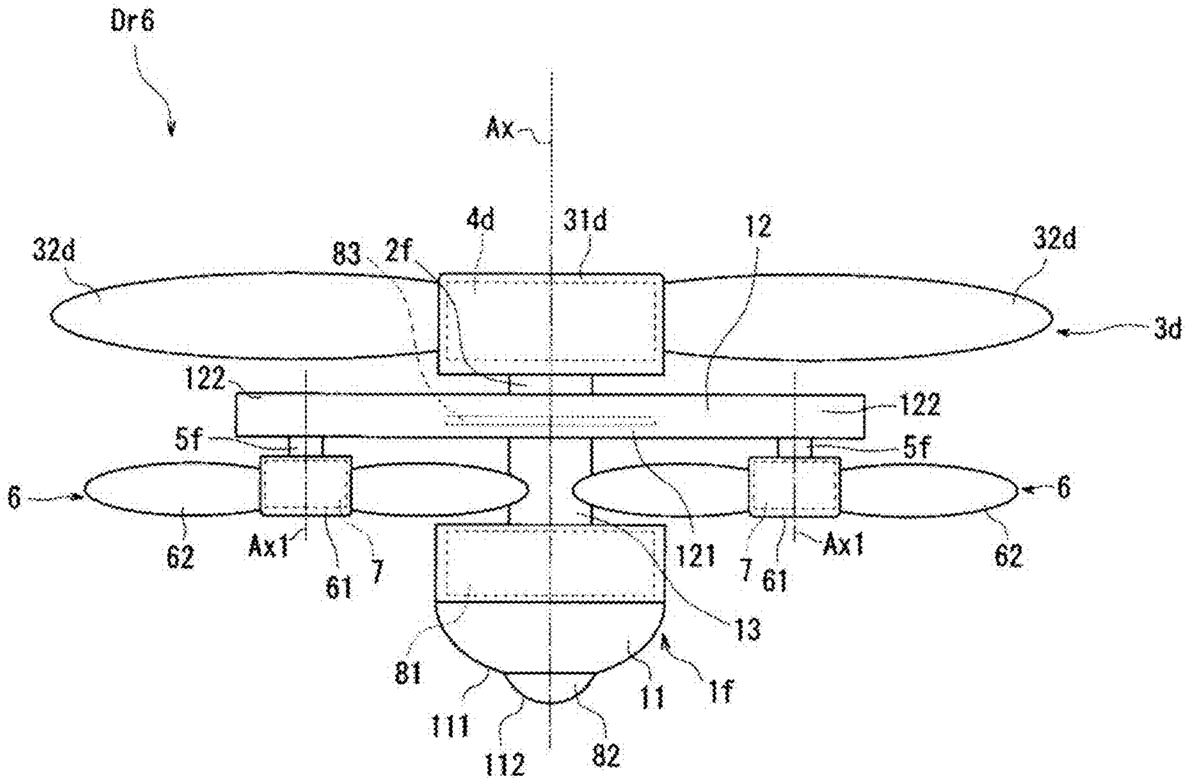
6
CW
32d

Fig.14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32d
3d
122
122
5f
5f
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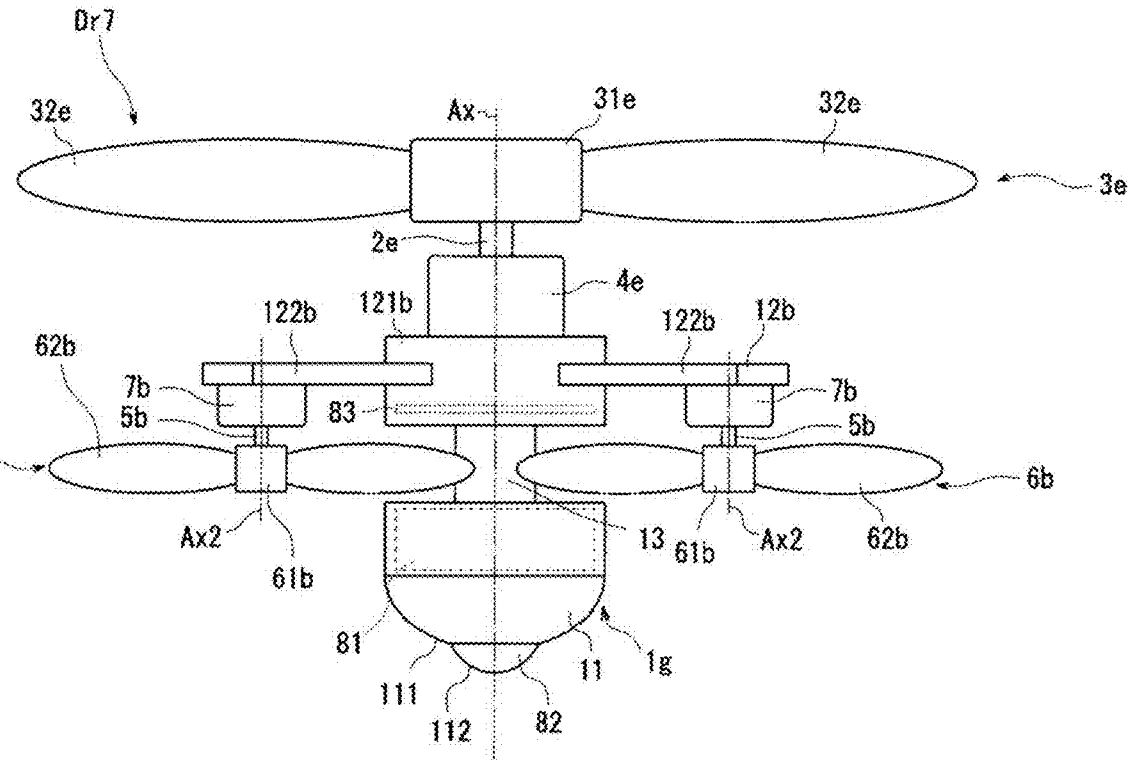
7
121
7
61
Ax1
62
13
81
11
1f
111
112
82

Fig.15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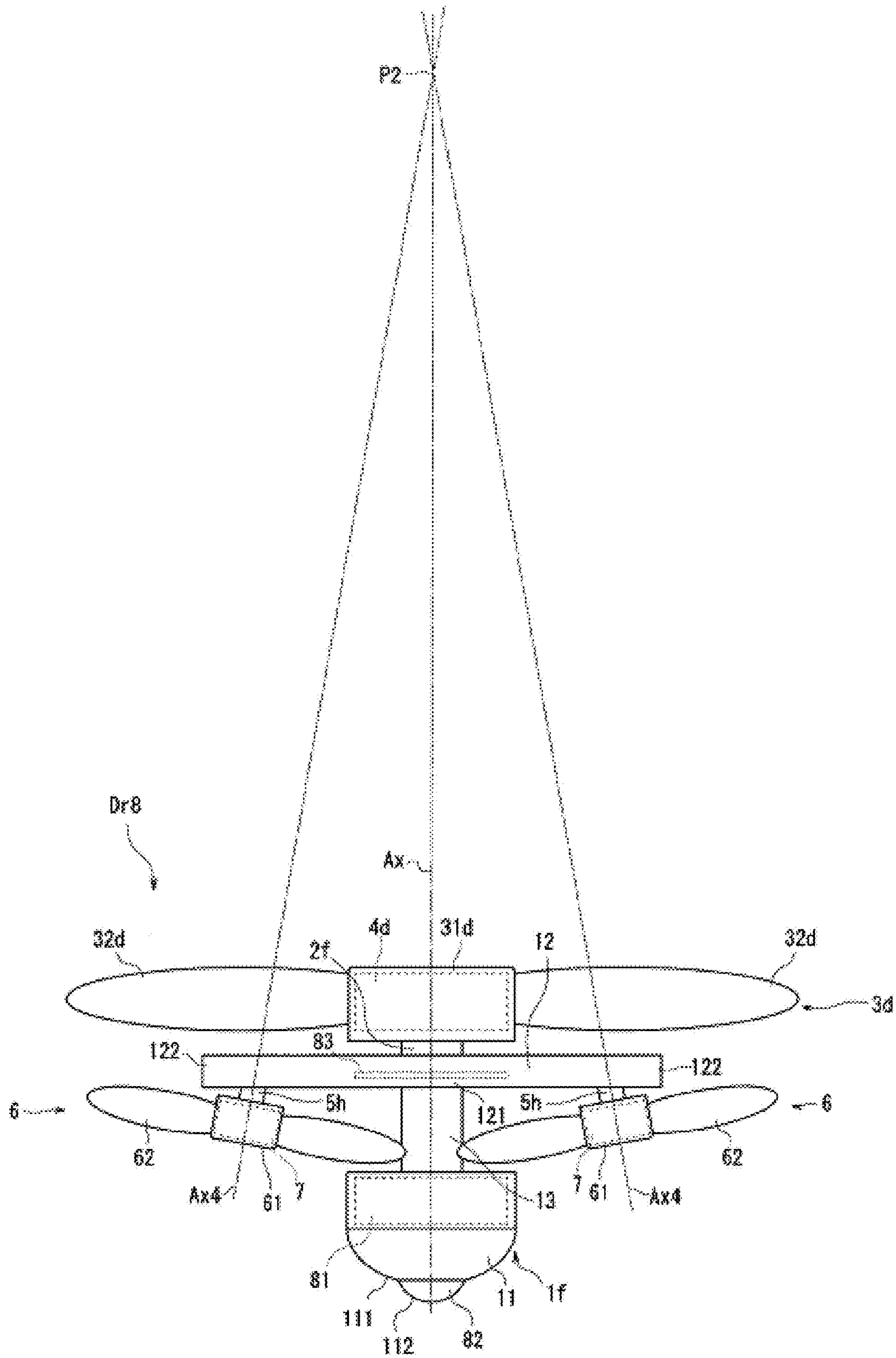
111
112
82

Fig.16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4d
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12
32d
2f
3d
83
122
122
6
5h
121
5h
6
62
62
Ax4
61
7
13
7
61
Ax4
81
11
1f
111
112
82

Fig.17

UNMANNED AERIAL VEHICLE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is the U.S. national stage of PCT Application No. PCT/JP2018/002856, filed on Jan. 30, 2018, and priority under U.S.C. § 119(a) and 35 U.S.C. § 365(b) is claimed from U.S. Provisional Patent Application No. 62/451,892, filed Jan. 30, 2017; the entire disclosures of each application are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present disclosure relates to an unmanned aerial vehicle that includes a plurality of propellers.

BACKGROUND

[0003] A conventional unmanned aerial vehicle is disclosed in Japanese Laid-Open Patent Publication No. 2016-88121. This aerial vehicle has a base on which an observation unit is attached, a plurality of thrusters, an actuator, an inertial measurement unit, and a control unit. The plurality of thrusters generate lift. The actuator makes the direction of propulsion generated by the thruster variable relative to the base. The inertial measurement unit detects the attitude of the base relative to the ground surface. The control unit controls the thrusters and the actuator based on the attitude of the base detected by the inertial measurement unit. Then, the aerial vehicle flies at any attitude relative to the ground surface due to a combination of the propulsion of each of the thrusters and the direction of the propulsion. The aerial vehicle with such a configuration flies unmanned. The thruster has a propeller unit and a motor unit that rotates the propeller unit.

[0004] A conventional unmanned aerial vehicle rotates the propeller unit at high speed in order to obtain sufficient lift. Therefore, there is a problem of loud noise of the propeller unit. In particular, when used indoors or in an unmanned aerial vehicle equipped with an audio device, the noise of the propeller unit may cause an operational problem.

SUMMARY

[0005] An example embodiment of an unmanned aerial vehicle of the present disclosure includes a body, a main shaft, a main propeller, a plurality of auxiliary shafts, a plurality of auxiliary propellers, and a plurality of drivers. The main shaft extends axially from the body. The main propeller is connected to the main shaft. The plurality of auxiliary shafts extend axially from the body. The plurality of auxiliary propellers are connected to the plurality of auxiliary shafts respectively. The plurality of drivers drive the main propeller and the plurality of auxiliary propellers. A circle drawn by a tip of the main propeller and a circle drawn by tips of each of the plurality of auxiliary propellers axially overlap at least partially. The rotational direction of the plurality of auxiliary propellers is opposite to the rotational direction of the main propeller, when viewed from one axial side of the main shaft. A torque acting on the body from the main propeller when the body portion is hovering in the air is equal or substantially equal to the sum of the torque acting on the body portion from the plurality of auxiliary propellers.

[0006] The above and other elements, features, steps, characteristics and advantages of the present disclosure will become more apparent from the following detailed description of the example embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a perspective view of an unmanned aerial vehicle according to an example embodiment of the present disclosure as viewed from below.

[0008] FIG. **2** is a schematic plan view of the unmanned aerial vehicle shown in FIG. **1**.

[0009] FIG. **3** is a schematic side view of the unmanned aerial vehicle shown in FIG. **1**.

[0010] FIG. **4** is an enlarged sectional view of a main propeller and a main motor according to an example embodiment of the present disclosure.

[0011] FIG. **5** is an enlarged sectional view of an auxiliary propeller and an auxiliary motor according to an example embodiment of the present disclosure.

[0012] FIG. **6** is a schematic side view of another example embodiment of the unmanned aerial vehicle according to the present disclosure.

[0013] FIG. **7** is a schematic view of the auxiliary propeller and the auxiliary motor.

[0014] FIG. **8** is a schematic side view of yet another example embodiment of the unmanned aerial vehicle according to the present disclosure.

[0015] FIG. **9** is a schematic plan view of yet another example embodiment of the unmanned aerial vehicle according to the present disclosure.

[0016] FIG. **10** is a schematic side view of the unmanned aerial vehicle shown in FIG. **9**.

[0017] FIG. **11** is an enlarged sectional view of the main propeller and the main motor.

[0018] FIG. **12** is a schematic side view of yet another example embodiment of the unmanned aerial vehicle according to the present disclosure.

[0019] FIG. **13** is an enlarged sectional view of the main propeller and the main motor of the unmanned aerial vehicle shown in FIG. **12**.

[0020] FIG. **14** is a plan view of yet another example embodiment of the unmanned aerial vehicle according to the present disclosure.

[0021] FIG. **15** is a schematic side view of the unmanned aerial vehicle shown in FIG. **14**.

[0022] FIG. **16** is a schematic side view of yet another example embodiment of the unmanned aerial vehicle according to the present disclosure.

[0023] FIG. **17** is a schematic side view of yet another example embodiment of the unmanned aerial vehicle according to the present disclosure.

DETAILED DESCRIPTION

[0024] Hereinafter, example embodiments of the present disclosure will be described in detail with reference to the drawings. In this description, a direction parallel to a central axis Ax of an unmanned aerial vehicle Dr**1** is called an "axial direction/axial/axially", a direction orthogonal to the central axis Ax of the unmanned aerial vehicle Dr**1** is called a "radial direction/radial/radially", and a direction along the arc centering on the central axis of the unmanned aerial vehicle Dr**1** is called a "circumferential direction/circumferential/circumferentially". Also as for unmanned aerial vehicles other than the unmanned aerial vehicle Dr**1**, similarly, directions corresponding to the axial direction, the radial direction, and the circumferential direction of the unmanned aerial vehicle Dr**1** are simply called an "axial direction/axial/axially", a "radial direction/radial/radially", and a "circumferential direction/circumferential/circumferentially", respectively.

[0025] In this description, the shape and positional relationship of each portion of the unmanned aerial vehicle Dr**1** will be explained with the upward direction in FIG. **1** as "upward" and the downward direction in FIG. **1** as "downward". Note that these directions are merely names used simply for explanation, and do not limit the positional relationship and direction in the flight state of the unmanned aerial vehicle Dr**1**.

[0026] The unmanned aerial vehicle of an example embodiment of the present disclosure will be described below. FIG. **1** is a perspective view of an unmanned aerial vehicle according to the present example embodiment as viewed from below. FIG. **2** is a schematic plan view of the unmanned aerial vehicle shown in FIG. **1**. FIG. **3** is a schematic side view of the unmanned aerial vehicle shown in FIG. **1**. In order to facilitate understanding, FIG. **3** indicates a part of cross section.

[0027] As shown in FIGS. **1** to **3**, the unmanned aerial vehicle Dr**1** includes a body portion **1**, a main shaft **2**, a main propeller **3**, a main motor **4**, three auxiliary shafts **5**, three auxiliary propellers **6**, three auxiliary motors **7**, a battery **81**, a camera **82**, and a circuit board **83**. In the unmanned aerial vehicle Dr**1**, the main shaft **2** and the three auxiliary shafts **5** extend axially from the body portion **1**. Then, the main propeller **3** connected to the main shaft **2** and the auxiliary propeller **6** connected to each of the three auxiliary shafts **5** are rotated by the main motor **4** and the three auxiliary motors **7**. The rotation of the main propeller and the three auxiliary propellers **6** generates an air flow axially downward. The unmanned aerial vehicle Dr**1** is lifted by air flow generated by the rotation of the main propeller **3** and the three auxiliary propellers **6**, and floats in the air. Although the unmanned aerial vehicle Dr**1** includes the three auxiliary propellers **6**, the number of the auxiliary propellers is not limited to three, and it may be two or be four or more. Although the number is not restricted as long as attitude control, movement control, and the like can be easily performed, at least a plurality of them are included. The rotation radius of the main propeller **3** with respect to the rotation axis is larger than the rotation radius of the auxiliary propeller **6** with respect to the rotation axis. That is, the main propeller **3** is a larger propeller than the auxiliary propeller **6**.

[0028] The body portion **1** includes a main body portion **11** and a frame portion **12**. The main body portion **11** has an axially extending tubular shape. The center of the main body portion **11** coincides with the central axis Ax. The main body portion **11** has, for example, a waterproof structure, a dustproof structure, or the like, i.e., a structure in which foreign substances such as water and dust do not easily enter inside, and the battery **81** is disposed inside the main body portion **11**. That is, the body portion **1** includes the battery **81**. Doing this allows the battery **81**, which is heavy, to be disposed at the radial center of the unmanned aerial vehicle Dr**1**, and hence the unmanned aerial vehicle Dr**1** can be well balanced. This can improve the operability of the unmanned aerial vehicle Dr**1**. The battery **81** is a power source that supplies power to the main motor **4** and the three auxiliary motors **7**. The battery **81** may be charged via a connector (not illustrated) provided in the main body portion **11** or may be charged with the battery **81** removed from the main body portion **11**.

[0029] An axial lower surface **111** of the main body portion **11** is a downwardly convex curved surface that is radially inward as going axially downward. That is, in the lower surface **111**, the radially central portion is the axially lowermost end. A translucent window portion **112** is provided at the radial center portion of the lower surface **111**. The gap between the lower surface **111** and the window portion **112** also has a structure that suppresses entry of foreign substances. Inside the main body portion **11** is provided with the camera **82**. That is, the body portion **1** includes the camera **82**. Doing this allows the camera **82**, which is heavy, to be disposed at the radial center of the unmanned aerial vehicle Dr**1**. This improves the balance of the unmanned aerial vehicle Dr**1** and can thus improve the operability. The camera **82** photographs the outside of the main body portion **11** through the window portion **112**. Due to this, the camera **82** is less likely to be exposed to foreign substances such as water and dust, and the camera **82** can be operated stably.

[0030] The frame portion **12** expands in the direction orthogonal to the central axis Ax. That is, the body portion **1** includes the main body portion **11** and the frame portion **12**, which expands in the direction orthogonal to the central axis Ax of the main shaft **2**. The frame portion **12** includes a frame body portion **121** and three arm portions **122**. The frame body portion **121** is disposed at the radial center as the frame portion **12** is viewed axially. As shown in FIG. **2** and the like, in the frame portion **12**, the three arm portions **122** each extend radially outward from the frame body portion **121**, and are disposed at equal intervals in the circumferential direction. That is, the frame portion **12** includes the frame body portion **121** and the plurality of arm portions **122**, which radially extend from the frame body portion **121**. By the frame portion **12** including the arm portion **122**, the frame portion **12** extends radially outward, and an axial projection area can be reduced. As a result, the position of the auxiliary propeller **6** is separated from the central axis Ax, and the air flow due to the rotation of the main propeller **3** and the three auxiliary propellers **6** is hardly hindered. Therefore, the unmanned aerial vehicle Dr**1** can be driven efficiently.

[0031] The unmanned aerial vehicle Dr**1** is preferably lightweight. Therefore, the main body portion **11** and the frame portion **12** may each be integrally molded of resin or metal. Provided as an integrally molded body, screws and other joining members and welding, adhesion, and other joining agents are unnecessary, and the weight can be reduced accordingly. As shown in FIG. **3**, the main body portion **11** and the frame portion **12** are connected via the main shaft **2**. Next, the main shaft **2** will be described.

[0032] As shown in FIGS. **2** and **3**, the main shaft **2** is a cylindrical body extending axially upward from an axial upper surface of the main body portion **11**. That is, the main shaft **2** extends axially from the body portion **1**. The central axis of the main shaft **2** coincides with the central axis Ax of the unmanned aerial vehicle Dr**1**. Therefore, the central axis Ax of the main shaft **2** may be described as the central axis of the main shaft **2**. The main shaft **2** is fixed with the main body portion **11** and the frame portion **12**. The main shaft **2** is hollow and has an internal space **21**. The lower end portion of the main shaft **2** is connected to the main body portion **11**, and the upper end portion of the main shaft **2** is connected to the frame portion **12**. The internal space **21** of the main shaft **2** communicates with the inside of the main body portion **11**.

[0033] A lead wire **84** is connected to the battery **81** disposed inside the main body portion **11**. The lead wire **84** is wired in the internal space **21** of the main shaft **2**. The lead wire **84** connects the battery **81** and the circuit board **83** included in the frame portion **12**. The frame portion **12** includes a space that can accommodate the circuit board **83** inside. The circuit board **83** may be attached to the outer surface of the frame portion **12** if the circuit board **83** has a configuration in which malfunction due to foreign substances is less likely to occur or if the unmanned aerial vehicle Dr**1** is used in an environment with few foreign substances.

[0034] The main motor **4** and the auxiliary motor **7** are controlled by a control circuit (not illustrated) mounted on the circuit board **83**. Therefore, the main motor **4** and the auxiliary motor **7** and the circuit board **83** are connected via the lead wire **84**. That is, the lead wire **84** connects the battery **81** and the circuit board **83**, at the same time, it is an example of a connection wire that electrically connects the main motor **4**, which is the main driver, with at least one of the auxiliary motors **7**, which are the three auxiliary drivers. By disposing the lead wire **84** in the internal space **21** of the main shaft **2**, the lead wire **84** is protected. Although the lead wire **84** connects the battery **81** with the circuit board **83**, it is not limited to this. For example, the battery **81** and at least one of the main motor **4** and the auxiliary motor **7** may be directly connected. However, in order to easily control the main motor **4** and the auxiliary motor **7**, it is preferable that the main motor **4** and the auxiliary motor **7** are connected to the circuit board **83** via the lead wire **84** and power is supplied from the control circuit of the circuit board **83** to the main motor **4** and the auxiliary motor **7**.

[0035] The main motor **4** is attached to the main shaft **2**. The main propeller **3** is connected to the main shaft **2** via the main motor **4**. That is, the main propeller **3** is connected to the main shaft **2**. The main motor **4** is an example of a main driver. FIG. **4** is an enlarged sectional view of the main propeller and the main motor.

[0036] First, the main propeller **3** will be described. As shown in FIGS. **2** and **3**, the unmanned aerial vehicle Dr**1** includes one main propeller **3**. As shown in FIGS. **1** to **4**, the main propeller **3** includes a main propeller body portion **31** and three main blade portions **32**. That is, the main propeller **3** includes the propeller body portion **31** and the plurality of main blade portions **32**, which extend radially outward from the propeller body portion **31** and are circumferentially disposed. Although the main propeller **3** includes the three main blade portions **32**, it is not limited to this. As long as it can generate sufficient lift, the number of main blade portions may be two or be four or more.

[0037] As shown in FIGS. **3** and **4**, the main propeller body portion **31** includes an upper cover **311** and a lower cover **312**. The upper cover **311** has a lidded tubular shape. The upper cover **311** includes an annular upper lid portion **313** expanding in a direction orthogonal to the central axis Ax, and a cylindrical main propeller tubular portion **314** extending axially downward from a radial outer edge of the upper lid portion **313**. The radial center of the upper lid portion **313** is provided with an upper bearing holding portion **315** that axially penetrates. An upper bearing **43** of the main motor **4** is held by the upper bearing holding portion **315**.

[0038] The lower cover **312** has an annular shape expanding in a direction orthogonal to the central axis Ax. The lower cover **312** includes a lower bearing holding portion **316** that axially penetrates at the radial center. A lower bearing **44** of the main motor **4** is held by the lower bearing holding portion **316**. The lower cover **312** is fixed with the main propeller tubular portion **314** of the upper cover **311** at a radial outer edge portion. The upper cover **311** and the lower cover **312** may be fixed by press fitting. Alternatively, the lower cover **312** may be fixed by screwing into the upper cover **311** with a male screw formed on a radial outer surface of the lower cover **312** and a female screw formed on an inner surface of the main propeller tubular portion **314**. Furthermore, adhesion, welding, or the like may be used. A wide range of methods capable of securely fixing the upper cover **311** and the lower cover **312** can be adopted.

[0039] An inner ring of the upper bearing **43** and an inner ring of the lower bearing **44** are fixed to the main shaft **2** at positions separated vertically in the axial direction. That is, the main propeller **3** is rotatably connected to the main shaft **2** via the upper bearing **43** and the lower bearing **44**.

[0040] The three main blade portions **32** extend radially outward from the radial outer surface of the main propeller tubular portion **314**. The three main blade portions **32** are fixed to the main propeller tubular portion **314**. The main propeller tubular portion **314** and the three main blade portions **32** may be formed by integral molding. The three main blade portions **32** are disposed at equal intervals in the circumferential direction.

[0041] Next, the main motor **4** will be described. The main motor **4** is disposed at an axial intermediate portion of the main shaft **2**. The main motor **4** is disposed inside the main propeller body portion **31** of the main propeller **3**. That is, a driver **4** is housed inside the propeller body portion **31**. The main motor **4** is an outer rotor type motor. The main motor **4** includes a stator **41** and a rotor **42**. The stator **41** includes a stator core **411** and a coil **412**. The stator core **411** is a laminate in which, for example, electromagnetic steel sheets are axially laminated. Note that the stator core **411** is not limited to a laminate in which electromagnetic steel sheets are laminated, and may be a single member such as a fired body of powder or a casting.

[0042] The stator core **411** includes an annular core back **413** and a plurality of teeth **414**. The main shaft **2** is press-fitted into the central penetration portion of the annular core back **413**. Thus, the stator core **411** is fixed to an axial intermediate portion of the main shaft **2**. That is, the stator **41** is fixed to the main shaft **2**. The plurality of teeth **414** extend radially outward from the radial outer surface of the core back **413**, and are formed radially. The coil **412** is configured by winding a wire around each of the teeth **414**.

[0043] The rotor **42** includes a cylindrical rotor magnet **421**. The rotor magnet **421** radially faces the teeth **414** of the stator core **411**. The rotor magnet **421** is fixed to a radial inner surface of the main propeller tubular portion **314**. That is, the main motor **4** uses the main propeller tubular portion **314** as a rotor housing. In the rotor magnet **421**, N poles and S poles are alternately disposed in the circumferential direction.

[0044] The upper bearing **43** and the lower bearing **44** are ball bearings. The upper bearing **43** and the lower bearing **44**

include an outer ring, the inner ring, and a plurality of balls disposed between the outer ring and the inner ring. The outer ring of the upper bearing **43** is fixed to the upper bearing holding portion **315** of the upper cover **311**. The outer ring of the lower bearing **44** is fixed to the lower bearing holding portion **316** of the lower cover **312**. The inner rings of the upper bearing **43** and the lower bearing **44** are fixed to axially separated portions of the main shaft **2**. The outer rings of the upper bearing **43** and the lower bearing **44** and the upper bearing holding portion **315** and the lower bearing holding portion **316** are fixed by press-fitting, for example. However, fixation is not limited to this. Moreover, although the inner rings of the upper bearing **43** and the lower bearing **44** and the main shaft **2** are fixed also by press-fitting, fixation is not limited to this.

[0045] In the main motor **4**, the coil **412** is excited by supplying a current to the coil **412**. As a result, an attractive force or a repulsive force due to the magnetic force is generated between the coil **412** and the rotor magnet **421**. By adjusting the timing of the current supplied to the coil **412**, a circumferentially rotating force acts on the rotor magnet **421**. The upper cover **311** rotatably supported by the main shaft **2** via the upper bearing **43** by the force acting on the rotor magnet **421** and the lower cover **312** rotatably supported by the main shaft **2** via the lower bearing **44** rotate around the central axis Ax.

[0046] As a result, the main blade portion **32** fixed to the main propeller tubular portion **314** rotates around the central axis Ax. In other words, the main propeller **3** rotates around the central axis Ax. As the main propeller **3** rotates, air is pushed by the main blade portion **32** to generate an axially downward air flow. As a result, the unmanned aerial vehicle Dr**1** obtains an axially upward force (lift). The rotational direction of the main propeller **3** is a counterclockwise CCW direction as viewed from axially above, in other words, in FIG. **3**.

[0047] In the unmanned aerial vehicle Dr**1**, the main propeller **3** and the main motor **4** are disposed between the main body portion **11** and the frame portion **12**. Disposing in this manner allows the axial length of the unmanned aerial vehicle Dr**1** to be shortened. Since the main motor **4** is an outer rotor motor and configured to be attached to the main shaft **2**, the drive power of the main motor **4** is reliably transmitted to the main propeller **3**, and hence the drive efficiency is high.

[0048] The three auxiliary shafts **5** included in the unmanned aerial vehicle Dr**1** are identical-shaped members formed of an identical material. Therefore, in the following description, the same features will be described for all the auxiliary shafts **5** unless otherwise stated. As shown in FIG. **3**, the auxiliary shaft **5** extends axially upward from the radially outward end portion of the arm portion **122**. That is, the plurality of auxiliary shafts **5** extend axially from (the arm portion **122** of the frame portion **12** included in) the body portion **1**. The auxiliary shaft **5** is fixed to the arm portion **122**. A central axis Ax**1** of the auxiliary shaft **5** is parallel to the central axis Ax of the main shaft **2**, that is to say, the central axis Ax of the unmanned aerial vehicle Dr**1**. That is, the central axes Ax**1** of the plurality of auxiliary shafts **5** are parallel to the central axis Ax of the main shaft **2** . Thus, the axial length of the auxiliary propeller **6** can be shortened, and the axial height of the unmanned aerial vehicle Dr**1** can be suppressed.

[0049] The auxiliary shaft **5** and the arm portion **122** may be formed to be hollow, and the internal space of each may be continuous. By doing this, the lead wire connecting the circuit board **83** and the auxiliary motor **7** can be housed inside the arm portion **122** and the auxiliary shaft **5**.

[0050] The auxiliary propeller **6** and the auxiliary motor **7** will be described with reference to the drawings. FIG. **5** is an enlarged sectional view of the auxiliary propeller **6** and the auxiliary motor **7**. The auxiliary motor **7** is attached to the axial upper end of the auxiliary shaft **5**. That is, the plurality of auxiliary drivers **7** that drive the plurality of auxiliary propellers **6** are connected to the frame portion **12**. Furthermore, the plurality of auxiliary drivers **7** are connected to the respective arm portions **122**. The auxiliary propeller **6** is connected to the axial upper end of the auxiliary shaft **5** via the auxiliary motor **7**. The three auxiliary propellers **6** are connected to the three auxiliary shafts **5** respectively. That is, the plurality of auxiliary propellers **6** are connected to the plurality of auxiliary shafts **5** respectively. The auxiliary motor **7** is an example of the auxiliary driver.

[0051] First, the auxiliary propeller **6** will be described. As shown in FIGS. **2** and **3**, the unmanned aerial vehicle Dr**1** includes the three auxiliary propellers **6**. The auxiliary propeller **6** includes an auxiliary propeller body portion **61** and three auxiliary blade portions **62**. As shown in FIG. **5**, the auxiliary propeller body portion **61** includes an upper cover **611** and a lower cover **612**. The upper cover **611** has a lidded tubular shape. The upper cover **611** includes an annular upper lid portion **613** expanding in a direction orthogonal to the central axis Ax**1** of the auxiliary shaft **5**, and a cylindrical auxiliary propeller tubular portion **614** extending axially downward from the radial outer edge of the upper lid portion **613**. The axial upper surface of the rotor shaft **722** is fixed to the axial lower surface of the upper lid portion **613**. That is, the rotor shaft **722** extends axially downward from the radial middle portion of the axial lower surface of the upper lid portion **613**. The upper lid portion **613** may be provided with an axially penetrating hole portion, and the upper end portion of the rotor shaft **722** may be fixed to the hole portion. The upper lid portion **613** and the rotor shaft **722** may be an integral member.

[0052] The lower cover **612** is in a disc form expanding in a direction orthogonal to the central axis Ax**1** of the auxiliary shaft **5**. The radial center portion of the lower cover **612** is provided with a tubular bearing holding portion **615** extending axially upward. An upper bearing **73** and a lower bearing **74** of the auxiliary motor **7** are held by the bearing holding portion **615**. The lower cover **612** axially faces the lower surface of the auxiliary propeller tubular portion **614** of the upper cover **611** at the radial outer edge portion.

[0053] The three auxiliary blade portions **62** extend radially outward from the radial outer surface of the auxiliary propeller tubular portion **614**. That is, at least one of the plurality of auxiliary propellers **6** includes the propeller body portion **61** and the plurality of blade portions **62**, which extend radially outward from the propeller body portion **61** and are circumferentially disposed. Note that although the auxiliary propeller **6** includes the three auxiliary blade portions **62**, it is not limited to this. It may be two or be four or more as long as it can generate sufficient lift.

[0054] The three auxiliary blade portions **62** are fixed to the auxiliary propeller tubular portion **614**. The auxiliary propeller tubular portion **614** and the three auxiliary blade portions **62** may be formed by integral molding. The three auxiliary blade portions **62** are disposed at equal intervals in the circumferential direction. The lower cover **612** is fixed to an axial upper end of the auxiliary shaft **5**.

[0055] Next, the auxiliary motor **7** will be described. The auxiliary motor **7** is disposed at an axial upper end portion of the auxiliary shaft **5**. The auxiliary motor **7** is disposed inside the auxiliary propeller body portion **61** of the auxiliary propeller **6**. That is, at least one of the plurality of auxiliary propellers **6** radially faces the driver **7**. The driver **7** is housed inside the propeller body portion **61**. This configuration allows the axial length of the rotor shaft **722** to be shortened, and the transmission efficiency of the driving force to be enhanced. The auxiliary motor **7** is an outer rotor type motor. The auxiliary motor **7** includes a stator **71** and a rotor **72**. The stator **71** includes a stator core **711** and a coil **712**. The stator core **711** is a laminate in which, for example, electromagnetic steel sheets are axially laminated. Note that the stator core **711** is not limited to a laminate in which electromagnetic steel sheets are laminated, and may be a single member such as a fired body of powder or a casting.

[0056] The stator core **711** includes an annular core back **713** and a plurality of teeth **714**. The bearing holding portion **615** is press-fitted into the central penetration portion of the annular core back **713**. Thus, the stator core **711** is fixed to an axial intermediate portion of the bearing holding portion **615**. That is, the stator **71** is fixed to the lower cover **612** via the bearing holding portion **615**. The plurality of teeth **714** extend radially outward from the radial outer surface of the core back **713**, and are formed radially. The coil **712** is configured by winding a wire around each of the teeth **714**.

[0057] The rotor **72** includes a cylindrical rotor magnet **721** and a rotor shaft **722**. The rotor magnet **721** radially faces the teeth **714**. The rotor magnet **721** is fixed to a radial inner surface of the auxiliary propeller tubular portion **614**. In the rotor magnet **721**, N poles and S poles are alternately disposed in the circumferential direction. That is, the auxiliary motor **7** uses the auxiliary propeller tubular portion **614** as a rotor housing.

[0058] The rotor shaft **722** is fixed to the upper lid portion **613** of the upper cover **611**. The rotor shaft **722** rotates together with the upper cover **611**.

[0059] The upper bearing **73** and the lower bearing **74** are ball bearings. The upper bearing **73** and the lower bearing **74** include an outer ring, the inner ring, and a plurality of balls disposed between the outer ring and the inner ring. In the upper bearing **73** and the lower bearing **74**, the inner ring and the outer ring relatively rotate as the balls rotate. The outer ring of the upper bearing **73** is fixed to the bearing holding portion **615**. In addition, the outer ring of the lower bearing **74** is also fixed to the bearing holding portion **615**. Although fixation of the outer rings of the upper bearing **73** and the lower bearing **74** and the bearing holding portion **615** may include press-fit, it is not limited to this. The inner rings of the upper bearing **73** and the lower bearing **74** are fixed to axially separated portions of the rotor shaft **722**. Although fixation of the outer rings of the upper bearing **73** and the lower bearing **74** and the rotor shaft **722** may include press-fit, it is not limited to this.

[0060] This causes the rotor shaft **722** to be rotatably supported by the bearing holding portion **615** via the upper bearing **73** and the lower bearing **74**. More specifically, the rotor shaft **722** and the upper cover **611** fixed to the rotor shaft **722** are rotatably supported relative to the lower cover **612**.

[0061] In the auxiliary motor **7**, the coil **712** is excited by supplying a current to the coil **712**. As a result, an attractive force or a repulsive force due to the magnetic force is generated between the coil **712** and the rotor magnet **721**. By adjusting the timing of the current supplied to the coil **712**, a circumferentially rotating force acts on the rotor magnet **721**. Then, a force acting on the rotor magnet **721** acts on the upper cover **611**. Due to this, the upper cover **611** rotates around the central axis Ax**1** of the auxiliary shaft **5** together with the rotor shaft **722**.

[0062] As a result, the auxiliary blade portion **62** fixed to the auxiliary propeller tubular portion **614** of the upper cover **611** rotates around the central axis Ax**1** of the auxiliary shaft **5**. In other words, the auxiliary propeller **6** rotates around the central axis Ax**1** of the auxiliary shaft **5**. As the auxiliary propeller **6** rotates, air is pushed by the auxiliary blade portion **62** to generate an axially downward air flow. This causes the unmanned aerial vehicle Dr**1** to obtain upward lift along the central axis Ax**1** of the auxiliary shaft **5**.

[0063] The rotational direction of the auxiliary propeller **6** is a clockwise CW direction as viewed from axially above, in other words, in FIG. **3**. Note that currents are supplied to the three auxiliary motors **7** from the respective different lead wires **84**. Therefore, each of the three auxiliary motors **7** can rotate at a rotation speed different from that of the other auxiliary motors **7**. That is, each of the plurality of auxiliary propellers **6** can be driven at a rotation speed different from that of the other auxiliary propellers **6**.

[0064] The relationship between the main propeller **3** and the main motor **4** and the auxiliary propeller **6** and the auxiliary motor **7** will be described. As shown in FIGS. **2**, **3**, and the like, the radial length of the main blade portion **32** of the main propeller **3** is longer than that of the auxiliary blade portion **62** of the auxiliary propeller **6**. Then, as shown in FIGS. **2** and **3**, as the unmanned aerial vehicle Dr**1** is viewed axially, at least a part of a locus St**2** of the radial outer edge portion of the auxiliary blade portion **62** of the auxiliary propeller **6** is positioned inside a locus St**1** of the radial outer edge portion of the main blade portion **32** of the main propeller **3**. That is, the circle St**1** drawn by the tip of the main propeller and the circle St**2** drawn by the tip of each of the plurality of auxiliary propellers **6** axially overlap at least partially. This configuration allows the unmanned aerial vehicle Dr**1** to be downsized as compared with an unmanned aerial vehicle having a configuration in which not all propellers axially overlap.

[0065] In the unmanned aerial vehicle Dr**1**, the main body portion **11** and the frame portion **12** are connected via the main shaft **2**, and the main motor **4** and the main propeller **3** are attached to the axial intermediate portion of the main shaft **2**. The auxiliary motor **7** and the auxiliary propeller **6** are attached to the auxiliary shaft **5** that protrudes axially upward from the frame portion **12**. That is, the frame portion **12** is disposed axially between the main propeller **3** and the plurality of auxiliary propellers **6**. Then, the plurality of auxiliary drivers **7** that drive the plurality of auxiliary propellers **6** among the plurality of drivers **3** and **7** are connected to the frame portion **12**. By disposing the main motor **4** in the intermediate portion of the main shaft **2**, a force generated in the main motor **4** can be efficiently transmitted to the main propeller **3**. Due to this, the rotation accuracy of the main propeller **3** can be enhanced, and thus noise generated when the propeller rotates can be reduced.

[0066] The main propeller **3** rotates around the central axis Ax of the unmanned aerial vehicle Dr**1** by the main motor **4**. Therefore, the rotation of the main propeller **3** causes an axial upward force to act on the radial center of the main body portion **11**, that is, the body portion **1**. On the other hand, the three auxiliary propellers **6** respectively rotate by the three auxiliary motors **7** around the central axis Ax**1** of the auxiliary shaft **5** radially offset from the central axis Ax of the unmanned aerial vehicle Dr**1**. Therefore, the rotation of the three auxiliary propellers **6** causes an upward force to act on, along the central axis Ax**1** of the auxiliary shaft **5**, the frame portion **12**, that is, the position where each of the three auxiliary shafts **5** of the body portion **1** is connected. That is, the plurality of drivers (motors) **4** and **7** drive the main propeller **3** and the plurality of auxiliary propellers **6**. Since the central axis Ax and the central axis Ax**1** are parallel, the direction of force acting on the body portion **1** from the main propeller **3** and the direction of force acting on the body portion **1** from each of the three auxiliary propellers **6** are the same.

[0067] The three auxiliary propellers **6** adjust an axial force acting on the body portion **1** by the rotation speed. As shown in FIG. **2**, the three auxiliary propellers **6** have equal radial lengths from the central axis Ax of the unmanned aerial vehicle Dr**1**, and are disposed at equal intervals in the circumferential direction. Therefore, by applying an equal force to the frame portion **12** from the three auxiliary propellers **6**, it is possible to maintain the attitude of the unmanned aerial vehicle Dr**1** with respect to the horizon. In addition, all the three auxiliary propellers **6** have the same shape. Therefore, by rotating all the three auxiliary propellers **6** at the same rotation speed, the forces acting on the frame portion **12** from the three auxiliary propellers **6** become equal.

[0068] The unmanned aerial vehicle Dr**1** can be kept horizontal by rotating the three auxiliary propellers **6** at the same rotation speed when the unmanned aerial vehicle Dr**1** is horizontal, for example. The attitude of the unmanned aerial vehicle Dr**1** with respect to the horizon can be changed by adjusting the rotation speeds of the three auxiliary propellers **6**. In addition, horizontal movement is also possible by changing the attitude of the unmanned aerial vehicle Dr**1** with respect to the horizon.

[0069] As described above, the radial length of the main blade portion **32** is larger than the radial length of the auxiliary blade portion **62**. Therefore, in order to rotate the main propeller **3**, a large force, that is, a large torque is required as compared with a case of rotating the auxiliary propeller **6**. In a case of an aerial vehicle that generates lift by wind power by the rotation of a propeller and moves vertically such as the unmanned aerial vehicle Dr**1**, on the other hand, a torque in the opposite direction to the rotational direction of the propeller to act on the body portion **1** due to the rotation of the propeller. The torque acting on the body portion **1** due to the rotation of the propeller is determined by the size and rotation speed of the propeller. That is, in the three auxiliary propellers **6**, the rotation speed, that is, the lift by the air flow generated from the auxiliary propeller **6** is proportional to the torque.

[0070] In the unmanned aerial vehicle Dr**1**, the rotational direction (CCW direction) of the main propeller **3** and the rotational direction (CW direction) of the auxiliary propeller **6** are opposite to each other. That is, as viewed from one axial side of the main shaft **2**, the rotational direction (CW direction) of the plurality of auxiliary propellers **7** is opposite to the rotational direction (CCW direction) of the main propeller **3**. Due to this, a main torque Tr**1** acting on the body portion **1** from the main motor **4** by the rotation of the main propeller **3** and auxiliary torques Tr**21**, Tr**22**, and Tr**23** acting on the body portion **1** from the auxiliary motor **7** by the rotation of the three auxiliary propellers **6** cancel each other.

[0071] For example, with the three auxiliary propellers **6** rotating at the same rotation speed, if the sum of the force acting on the body portion **1** from the main propeller **3** and the force acting on the body portion **1** from the three auxiliary propellers **6** coincides with the weight of the unmanned aerial vehicle Dr**1**, the vertical position of the unmanned aerial vehicle Dr**1** is fixed. When the attitude of the unmanned aerial vehicle Dr**1** is horizontal and the main torque Tr**1** balances with the sum of the auxiliary torques Tr**21**, Tr**22**, and Tr**23**, the unmanned aerial vehicle Dr**1** stops also in the rotational direction with the horizontal attitude. Note that a state in which a horizontal attitude is maintained without rotation is referred to as a hovering state. That is, when the body portion **1** is hovering in the air, the torque Tr**1** acting on the body portion **1** from the main propeller **3** and the sum of the torques Tr**21**, Tr**22**, and Tr**23** acting on the body portion **1** from the plurality of auxiliary propellers **7** are the same.

[0072] That is, when in the hovering state, the unmanned aerial vehicle Dr**1** obtains a sufficient lift by the rotation of the main propeller **3** and the three auxiliary propellers **6**, and the main torque Tr**1** and the sum of the auxiliary torques Tr**21**, Tr**22**, and Tr**23** are balanced. In the unmanned aerial vehicle Dr**1**, when all the three auxiliary propellers **6** rotate at the same rotation speed, the main torque Tr**1** and the sum of the auxiliary torques Tr**21**, Tr**22**, and Tr**23** are balanced. Due to this, a stable operation of the unmanned aerial vehicle Dr**1** is made possible with simple control.

[0073] Also, as described above, when the unmanned aerial vehicle Dr**1** moves in the air, the rotation speeds of the three auxiliary propellers **6** are adjusted, in other words, controlled to different rotation speeds. That is, the unmanned aerial vehicle Dr**1** moves in the air by setting the rotation speed of at least one of the three auxiliary propellers **6** to a rotation speed different from that of the other auxiliary propellers **6**. And the torque acting on the flame portion **12** from the auxiliary propeller **6** changes with the rotation speed. Therefore, when the unmanned aerial vehicle Dr**1** is moving, at least one of the auxiliary propellers **6** rotates at a rotation speed different from that of the other auxiliary propellers **6**, and the main torque Tr**1** and the sum of the auxiliary torques Tr**21**, Tr**22**, and Tr**23** are different. That is, the torque Tr**1** acting on the body portion **1** from the main propeller **3** when the body portion **1** is moving in the air is different from the sum of the torques Tr**21**, Tr**22**, and Tr**23** acting on the body portion **1** from the plurality of auxiliary propellers **6**. This makes it easy to control the movement of the unmanned aerial vehicle Dr**1** in the air.

[0074] By making the radial length of the main blade portion **32** longer than the radial length of the auxiliary blade portion **62**, the main propeller **3** can generate an enough lift to cause the unmanned aerial vehicle Dr**1** to float at a lower rotation speed than that of the auxiliary propeller **6**. By providing the main propeller **3**, the lift required for each of the three auxiliary propellers **6** is also reduced. That is, the rotation speeds of the three auxiliary propellers **6** can also be kept low. This allows the unmanned aerial vehicle Dr**1** of the present disclosure to keep the rotation speed of each propeller lower as compared with an unmanned aerial vehicle using four same propellers.

[0075] Due to this, noise such as wind noise due to the rotation of the propeller can be reduced. By suppressing the noise of the unmanned aerial vehicle Dr**1**, it is possible to increase the convenience, for example, in a case of indoor use or in a case of mounting an acoustic device such as a speaker or a microphone. In addition, even in a case of outdoor use, by suppressing the noise of the unmanned aerial vehicle Dr**1**, the convenience is high for use in a place where the noise is desired to be suppressed.

[0076] In the unmanned aerial vehicle Dr**1**, the main propeller **3** is disposed axially between the main body portion **11** and the frame portion **12**. A main driver **4** that drives the main propeller **3** is disposed axially between the main body portion **11** and the frame portion **12**. The plurality of auxiliary drivers **7** are disposed in the frame portion **12**. The main body portion **11** and the frame portion **12** are connected via the hollow shaft **2**, and a connection wire **84** that electrically connects at least one of the main driver **4** and the plurality of auxiliary drivers **7** is disposed inside the hollow shaft **2**.

[0077] An actual example of the unmanned aerial vehicle Dr**1** of the present example embodiment will be described. An example of the unmanned aerial vehicle Dr**1** of the present example embodiment is taken as Example 1. The unmanned aerial vehicle Dr**1** of Example 1 is capable of generating a lift of 50 g. The unmanned aerial vehicle Dr**1** of Example 1 uses the main propeller **3** having an outermost diameter, that is, the outer diameter of the locus St**1** of the radially outer end of the main blade portion **32** of 120 mm. The unmanned aerial vehicle Dr**1** of Example 1 also uses the three auxiliary propellers **6** each having an outermost diameter, that is, the outer diameter of the locus St**2** of the radially outer end of the auxiliary blade portion **62** of 50 mm. The main motor **4** and the auxiliary motor **7** are outer rotor motors.

[0078] The weight of the body portion **1** and the like are 20 g. The weight of the main propeller **3** is 3 g and the weight of the main motor **4** is 4 g, thus the total of 7 g. The weight of the auxiliary propeller **6** is 1 g and the weight of the auxiliary motor **7** is 1.5 g, and the total of the three auxiliary propellers **6** and the three auxiliary motors **7** is 7.5 g. The weight of the battery **81** is 8 g, the weight of the camera **82** is 3 g, and the weight of the circuit board **83** is 1 g. Therefore, the total weight of Example 1 is 46.5 g. With this configuration, the unmanned aerial vehicle Dr**1** can fly.

[0079] Next, a comparison was made with an unmanned aerial vehicle also having four propellers. An example of the unmanned aerial vehicle Dr**1** of the present example embodiment is taken as Example 2. Example 2 uses the main propeller **3** having an outermost diameter, that is, the outer diameter of the locus St**1** of the radially outer end of the main blade portion **32** of 150 mm. The unmanned aerial vehicle Dr**1** of Example 1 also uses the three auxiliary propellers **6** each having an outermost diameter, that is, the outer diameter of the locus St**2** of the radially outer end of the auxiliary blade portion **62** of 100 mm. The main motor **4** and the auxiliary motor **7** are outer rotor motors.

[0080] As a comparative example, an unmanned aerial vehicle using four propellers having an outer diameter of 100 mm was prepared. For Example 2 and the comparative example, the rotation speed of the propeller, which is a main factor of noise during hovering, was examined. The rotation speed of all the propellers in the case of the comparative example was 10000 rpm meanwhile the rotation speed of the main propeller **3** was 5000 rpm and that of the auxiliary propeller **6** was 7500 rpm in Example 2. The rotation speeds of the main propeller **3** and the auxiliary propeller **6** of Example 2 are smaller than the rotation speed of the propellers of the comparative example. That is, the unmanned aerial vehicle according to the present disclosure is quieter than a conventional unmanned aerial vehicle in which all propellers have the same shape.

[0081] Another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **6** is a schematic side view of another example of the unmanned aerial vehicle according to the present disclosure. An unmanned aerial vehicle Dr**2** shown in FIG. **6** has the same configuration as that of the unmanned aerial vehicle Dr**1** of the first example embodiment except that a frame portion **12***b* of a body portion **1***b*, an auxiliary shaft **5***b*, an auxiliary propeller **6***b*, and an auxiliary motor **7***b* are different from the frame portion **12**, the auxiliary shaft **5**, the auxiliary propeller **6**, and the auxiliary motor **7**. For this reason, in the configuration of the unmanned aerial vehicle Dr**2**, the same components as those of the unmanned aerial vehicle Dr**1** are given the same reference numerals and detailed descriptions thereof will be omitted.

[0082] As shown in FIG. **6**, the frame portion **12***b* of the body portion **1***b* of the unmanned aerial vehicle Dr**2** includes a frame body portion **121***b* and three arm portions **122***b*. The frame body portion **121***b* has an axially extending cylindrical shape. The center of the frame body portion **121***b* coincides with the central axis Ax. The frame body portion **121***b* has a space inside, and the circuit board **83** is disposed in the internal space of the frame body portion **121***b*. The internal space of the main shaft **2** communicates with the internal space of the frame body portion **121***b*. Then, the lead wire disposed inside the main shaft **2** is connected to the circuit board **83** inside the frame body portion **121***b*.

[0083] The three arm portions **122***b* extend radially outward from a radial outer surface of the frame body portion **121***b*. The three arm portions **122***b* are disposed at equal intervals in the circumferential direction. Then, the auxiliary motor **7***b* is attached to the axial upper surface of the radial outer edge of the arm portion **122***b*. The arm portion **122***b* may include a hollow portion. Where the arm portion **122***b* includes the hollow portion, the lead wire connected from the circuit board **83** to the auxiliary motor **7***b* can be wired in the hollow portion.

[0084] The auxiliary propeller **6***b* and the auxiliary motor **7***b* will be described with reference to the drawings. FIG. **7** is a schematic view of the auxiliary propeller **6***b* and the auxiliary motor **7***b*. The auxiliary motor **7***b* is an inner rotor type motor. The auxiliary motor **7***b* is fixed to the axial upper surface of the arm portion **122***b*. The auxiliary motor **7***b* includes an upper cover **701***b*, a base portion **702***b*, a stator **71***b*, a rotor **72***b*, the upper bearing **73**, and the lower bearing **74**.

[0085] The upper cover **701***b* has a lidded tubular shape. The upper cover **701***b* includes an upper lid portion **703***b*, an auxiliary motor tubular portion **704***b*, and an upper bearing holding portion **705***b*. The upper lid portion **703***b* has an annular shape expanding in a direction orthogonal to a central axis Ax**2** of the auxiliary shaft **5***b*, and has a through hole **700***b* at the center. The auxiliary motor tubular portion **704***b* extends axially downward from a radial outer edge portion of the upper lid portion **703***b*. The upper bearing holding portion **705***b* has a tubular shape extending axially upward from the side edge portion of the through hole **700***b* of the upper lid portion **703***b*. The center of the upper bearing holding portion **705***b* coincides with the central axis Ax**2** of the auxiliary shaft **5***b*.

[0086] The base portion **702***b* has an annular shape expanding in a direction orthogonal to the central axis Ax**2** of the auxiliary shaft **5***b*. The base portion **702***b* includes a lower bearing holding portion **706***b*. The lower bearing holding portion **706***b* has a cylindrical shape, and is disposed at the radial center portion of the base portion **702***b*. The center of the lower bearing holding portion **706***b* overlaps the central axis Ax**2** of the auxiliary shaft **5***b*.

[0087] The outer ring of the upper bearing **73** is fixed to a radial inner surface of the upper bearing holding portion **705***b*. Due to this, the center of the inner ring of the upper bearing **73** overlaps the central axis Ax**2** of the auxiliary shaft **5***b*. The outer ring of the lower bearing **74** is fixed to a radial inner surface of the lower bearing holding portion **706***b*. Due to this, the center of the inner ring of the lower bearing **74** overlaps the central axis Ax**2** of the auxiliary shaft **5***b*. The auxiliary shaft **5***b* is fixed to the inner rings of the upper bearing **73** and the lower bearing **74** by press-fitting. This causes the auxiliary shaft **5***b* to be rotatably supported by the upper cover **701***b* and the base portion **702***b*. The auxiliary shaft **5***b* protrudes outward axially upward from the through hole at the radial center of the upper lid portion **703***b* of the upper cover **701***b*. The auxiliary shaft **5***b* extends axially upward from the arm portion **122***b*, that is, the body portion **1***b*, via the auxiliary motor **7***b*.

[0088] The stator **71***b* includes a stator core **711***b* and a coil **712***b*. The stator core **711***b* includes an annular core back **713***b* and a plurality of teeth **714***b*. The annular core back **713***b* is fixed to a radial inner surface of the auxiliary motor tubular portion **704***b*. The plurality of teeth **714***b* extend radially inward from the annular core back **713***b*. The coil **712***b* is configured by winding a wire around each of the teeth **714***b*.

[0089] The rotor **72***b* includes a rotor magnet **721***b*. The rotor magnet **721***b* is cylindrical and fixed to a radial outer surface of the auxiliary shaft **5***b*. The rotor magnet **721***b* radially faces the teeth **714***b*. The auxiliary shaft **5***b* is press-fitted into the inner rings of the upper bearing **73** and the lower bearing **74**, and the rotor **72***b* is rotatable with respect to the upper cover **701***b* and the base portion **702***b*. The auxiliary shaft **5***b* rotates around the central axis Ax**2** of the auxiliary shaft **5***b* by supplying a current to the coil **712***b*.

[0090] The auxiliary propeller **6***b* is fixed to the upper end portion of the auxiliary shaft **5***b*. The auxiliary propeller **6***b* includes an auxiliary propeller body portion **61***b* and an auxiliary blade portion **62***b*. The auxiliary propeller body portion **61***b* is columnar, and the center of the auxiliary propeller body portion **61***b* overlaps the central axis Ax**2** of the auxiliary shaft **5***b*. The auxiliary blade portion **62***b* extends radially outward from the radial outer surface of the auxiliary propeller body portion **61***b*. As the auxiliary motor **7***b* rotates, the auxiliary shaft **5***b* rotates. Due to this, the auxiliary propeller **6***b* fixed to the auxiliary shaft **5***b* rotates. Thus, it is also possible to adopt an inner rotor motor type motor as the auxiliary motor **7***b*. In the inner rotor motor, since the auxiliary shaft **5***b* axially protrudes from the auxiliary motor **7***b* and the auxiliary propeller **6***b* is fixed to the tip thereof, the auxiliary motor **7***b* can be fixed directly to the arm portion **122***b*. This allows the shape of the arm portion **122***b* to be simplified.

[0091] Other than this, there are features common to the first example embodiment.

[0092] Yet another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **8** is a schematic side view of yet another example of the unmanned aerial vehicle according to the present disclosure. An unmanned aerial vehicle Dr**3** shown in FIG. **8** has the same configuration as that of the unmanned aerial vehicle Dr**1** of the first example embodiment except that an auxiliary shaft **5***c* is different. For this reason, in the configuration of the unmanned aerial vehicle Dr**3**, the same components as those of the unmanned aerial vehicle Dr**1** are given the same reference numerals and detailed descriptions thereof will be omitted.

[0093] As shown in FIG. **8**, in the unmanned aerial vehicle Dr**3**, a central axis Ax**3** of the auxiliary shaft **5***c* is inclined with respect to the central axis Ax of the unmanned aerial vehicle Dr**3**, that is, the central axis Ax of the main shaft **2**. Specifically, the auxiliary shaft **5***c* approaches the central axis Ax as going axially downward. Extension lines in which the central axes Ax**3** of the three auxiliary shafts **5***c* extend axially downward intersect with the central axis Ax at a point P**1**. In other words, the central axes Ax**3** of the three auxiliary shafts **5***c* each approach the central axis Ax as going axially downward. All the angles of the central axes Ax**3** of the three auxiliary shafts **5***c* formed with central axis Ax are equal.

[0094] That is, the lines in which the central axes Ax**3** of the plurality of auxiliary shafts **5***c* extend intersect with the line in which the central axis Ax of the main shaft **2** extends at one point (point P**1**). Thus, the plurality of auxiliary propellers **6** can exert a radial force on the body portion **1** while maintaining the balance of forces acting on the body portion **1**. This increases the operability of the unmanned aerial vehicle Dr**3**.

[0095] The operation of the unmanned aerial vehicle Dr**3** will be described. The central axis Ax**3** of the auxiliary shaft **5***c* is inclined with respect to the central axis Ax. The force acting on the body portion **1** by the rotation of the auxiliary propeller **6** connected to the auxiliary shaft **5***c* is in a direction along the central axis Ax**3** of the auxiliary shaft **5***c*. Therefore, the force acting on the body portion **1** by the rotation of the auxiliary propeller **6** includes an axially downward force component and a radially outward force component. When the three auxiliary propellers **6** rotate at the same rotation speed, the radially outward force components from the respective auxiliary propellers **6** to the body portion **1** are equal. The force acting on the body portion **1** from the auxiliary propeller **6** is acting via the auxiliary shaft **5***c*. The three auxiliary shafts **5***c* are disposed at equal intervals in the circumferential direction, and any of the central axes Ax**3** is inclined at the same angle with respect to the central axis Ax. Therefore, the radially outward force components of the forces acting on the body portion **1** from the three auxiliary propellers **6** cancel one another. That is, by rotating the three auxiliary propellers **6** at the same rotation speed, the unmanned aerial vehicle Dr**3** can be brought into the hovering state.

[0096] On the other hand, since the three auxiliary shafts **5***c* are inclined, the attitude or the position of the unmanned aerial vehicle Dr**3** can be greatly changed even if the change in the rotation speed of the auxiliary propeller **6** is small. For example, in a state where the unmanned aerial vehicle Dr**3** is hovering, each of the auxiliary propellers **6** is rotated at a rotation speed at which the balance of the radial force components changes while balancing the axial force components, and hence a radial, i.e., horizontal movement is facilitated with the horizontal attitude being kept. Due to this, the control of the unmanned aerial vehicle Dr**3** is easy, and the convenience of the unmanned aerial vehicle Dr**3** is high. In the unmanned aerial vehicle Dr**3** of the present example embodiment, the central axis Ax**3** of the auxiliary shaft **5***c* approaches the central axis Ax as going axially downward, but, conversely, it may approach the central axis as going axially upward. In any case, the lines in which the central axes Ax**3** of the three auxiliary shafts **5***c* extend may intersect with the line in which the central axis Ax of the main shaft **2** extends at one point (point P**1**).

[0097] Other than this, there are features common to the first example embodiment.

[0098] Yet another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **9** is a schematic plan view of yet another example of the unmanned aerial vehicle according to the present disclosure. FIG. **10** is a schematic side view of the unmanned aerial vehicle shown in FIG. **9**. An unmanned aerial vehicle Dr**4** shown in FIGS. **9** and **10** has the same configuration as that of the unmanned aerial vehicle Dr**1** of the first example embodiment except that a body portion **1***d*, a main shaft **2***d*, a main propeller **3***d*, and a main motor **4***d* are different. For this reason, in the configuration of the unmanned aerial vehicle Dr**4**, the same components as those of the unmanned aerial vehicle Dr**1** are given the same reference numerals and detailed descriptions thereof will be omitted.

[0099] As shown in FIG. **10**, the unmanned aerial vehicle Dr**4** includes the body portion **1***d*, the main shaft **2***d*, the main propeller **3***d*, the main motor **4***d*, the auxiliary shaft **5**, the auxiliary propeller **6**, the auxiliary motor **7**, the battery **81**, the camera **82**, and the circuit board **83**. Although the lead wire is omitted in the unmanned aerial vehicle Dr**4**, the lead wire connects between the battery **81** and the circuit board **83** and between the circuit board **83** and the main motor **4***d* and the auxiliary motor **7**.

[0100] The body portion **1***d* includes the main body portion **11** and the frame portion **12**. In the body portion **1***d*, the axial upper surface of the main body portion **11** is in contact with the axial lower surface of the frame portion **12**. The main body portion **11** and the frame portion **12** are integrally formed. Note that being integrally formed here includes being an integral molded body of a resin or the like and being integrally fixed with adhesion or the like. That is, the body portion **1***d* includes the main body portion **11** and the frame portion **12** that expands in a direction orthogonal to the central axis Ax of the main shaft **2***d*.

[0101] As shown in FIG. **10**, the main shaft **2***d* has a cylindrical shape extending axially upward from the top surface of the frame body portion **121** of the frame portion **12**. A lead wire that connects the circuit board **83** and the main motor **4***d* is wired in an internal space of the main shaft **2***d*. The central axis of the main shaft **2***d* coincides with the central axis Ax of the unmanned aerial vehicle Dr**4**. Therefore, the central axis of the main shaft **2***d* is described as the central axis Ax of the main shaft **2***d*.

[0102] The main shaft **2***d* extends more axially upward than the axial upper end of the auxiliary propeller **6**. The main motor **4***d* is attached to the axial upper end of the main shaft **2***d*, and the main propeller **3***d* is connected to the main shaft **2***d* via the main motor **4***d*.

[0103] The main propeller **3***d* and the main motor **4***d* will be described with reference to the drawings. FIG. **11** is an enlarged sectional view of the main propeller **3***d* and the main motor **4***d*.

[0104] As shown in FIG. **9**, the main propeller **3***d* includes a main propeller body portion **31***d* and three main blade portions **32***d*. As shown in FIG. **11**, the main propeller body portion **31***d* includes an upper cover **311***d* and a lower cover **312***d*. The upper cover **311***d* has a lidded tubular shape. The upper cover **311***d* includes an annular upper lid portion **313***d* expanding in a direction orthogonal to the central axis Ax, and a cylindrical main propeller tubular portion **314***d* extending axially downward from a radial outer edge of the upper lid portion **313***d*. The axial upper surface of the rotor shaft **422***d* is fixed to the axial lower surface of the upper lid portion **313***d*. That is, the rotor shaft **422***d* extends axially downward from the radial center portion of the axial lower surface of the upper lid portion **313***d*. The upper lid portion **313***d* may be provided with an axially penetrating hole portion, and the upper end portion of the rotor shaft **422***d* may be fixed to the hole portion. The upper lid portion **313***d* and the rotor shaft **422***d* may be produced by integrally molding.

[0105] The lower cover **312***d* is in a disc form expanding in a direction orthogonal to the central axis Ax. A tubular bearing holding portion **315***d* extending axially upward is included in a radial center portion of the lower cover **312***d*. An upper bearing **43***d* and a lower bearing **44***d* of the main motor **4***d* are held by the bearing holding portion **315***d*. The axial lower surface of the main propeller tubular portion **314***d* axially faces the radial outer edge portion of the lower cover **312***d*.

[0106] An inner ring of the upper bearing **43***d* and an inner ring of the lower bearing **44***d* are fixed to the rotor shaft **422***d* at positions separated vertically in the axial direction.

[0107] The three main blade portions **32***d* extend radially outward from the radial outer surface of the main propeller tubular portion **314***d*. The three main blade portions **32***d* are fixed to the main propeller tubular portion **314***d*. That is, the main propeller **3***d* includes the propeller body portion **31***d* and the plurality of main blade portions **32***d*, which extend radially outward from the propeller body portion **31***d* and are circumferentially disposed. The main propeller tubular portion **314***d* and the three main blade portions **32***d* may be formed by integral molding. The three main blade portions **32***d* are disposed at equal intervals in the circumferential direction.

[0108] Next, the main motor **4***d* will be described. The main motor **4***d* is disposed in an axial upper end portion of the main shaft **2***d*. The main motor **4***d* is disposed inside the main propeller body portion **31***d* of the main propeller **3***d*. That is, the main propeller **3***d* radially faces a driver **4***d*. The driver **4***d* is housed inside the propeller body portion **31***d*. This configuration allows the axial length of the rotor shaft **422***d* to be shortened, and the transmission efficiency of the driving force to be enhanced.

[0109] The main motor **4***d* is an outer rotor type motor. The main motor **4***d* includes a stator **41***d* and a rotor **42***d*. The stator **41***d* includes a stator core **411***d* and a coil **412***d*. The stator core **411***d* is a laminate in which, for example, electromagnetic steel sheets are axially laminated. Note that the stator core **411***d* is not limited to a laminate in which electromagnetic steel sheets are laminated, and may be a single member such as a fired body of powder or a casting.

[0110] The stator core **411***d* includes an annular core back **413***d* and a plurality of teeth **414***d*. The bearing holding portion **315***d* is press-fitted into the central penetration portion of the annular core back **413***d*. Due to this, the stator core **411***d* is fixed to the bearing holding portion **315***d*. That is, the stator **41***d* is fixed to the lower cover **312***d* via the bearing holding portion **315***d*. The plurality of teeth **414***d* extend radially outward from the radial outer surface of the core back **413***d*, and are formed radially. The coil **412***d* is configured by winding a wire around each of the teeth **414***d*.

[0111] The rotor **42***d* includes a cylindrical rotor magnet **421***d* and a rotor shaft **422***d*. The rotor magnet **421***d* radially faces the teeth **414***d*. The rotor magnet **421***d* is fixed to a radial inner surface of the main propeller tubular portion **314***d*. In the rotor magnet **421***d*, N poles and S poles are alternately disposed in the circumferential direction. That is, the main motor **4***d* uses the main propeller tubular portion **314***d* as a rotor housing.

[0112] The upper bearing **43***d* and the lower bearing **44***d* are ball bearings. The upper bearing **43***d* and the lower bearing **44***d* include an outer ring, the inner ring, and a plurality of balls disposed between the outer ring and the inner ring. In the upper bearing **43***d* and the lower bearing **44***d*, the inner ring and the outer ring relatively rotate as the balls rotate. The outer ring of the upper bearing **43***d* is fixed to the bearing holding portion **315***d*. The outer ring of the lower bearing **44***d* is also fixed to the bearing holding portion **315***d*. Although fixation of the outer rings of the upper bearing **43***d* and the lower bearing **44***d* and the bearing holding portion **315***d* may include press-fit, it is not limited to this. The inner rings of the upper bearing **43***d* and the lower bearing **44***d* are fixed to axially separated portions of the rotor shaft **422***d*.

[0113] Although fixation of the outer rings of the upper bearing **43***d* and the lower bearing **44***d* and the rotor shaft **422***d* may include press-fit, it is not limited to this.

[0114] This causes the rotor shaft **422***d* to be rotatably supported by the bearing holding portion **315***d* via the upper bearing **43***d* and the lower bearing **44***d*. More specifically, the rotor shaft **422***d* and the upper cover **311***d* fixed to the rotor shaft **422***d* are rotatably supported relative to the lower cover **312***d*.

[0115] As shown in FIGS. **9** and **10**, in the unmanned aerial vehicle Dr**4**, the main body portion **11** and the frame portion **12** are directly connected. Therefore, no member is interposed between the main body portion **11** and the frame portion **12**, and hence a transmitted force is less likely to be attenuated. For example, when controlling the rotation speed of the auxiliary propeller **6**, the responsiveness of change of the attitude of the unmanned aerial vehicle Dr**4** and change of the movement direction of the unmanned aerial vehicle Dr**4** is high. Therefore, the operability of the unmanned aerial vehicle Dr**4** is increased. The main propeller **3***d*, the main motor **4***d*, the auxiliary propeller **6**, and the auxiliary motor **7** are all positioned axially above the frame portion **12**. That is, the frame portion **12** is disposed axially between the main body portion **11** and the main propeller **3***d* and the plurality of auxiliary propellers **6**. Thus, the main propeller **3***d* and the auxiliary propeller **6** are on the same side (axially upper side) with respect to the body portion **1**. Therefore, at the time of maintenance such as adjustment and repair, it is sufficient to only work on the unmanned aerial vehicle Dr**4** from axially above, and the workability is high.

[0116] Other than this, there are features common to the first example embodiment.

[0117] An actual example of the unmanned aerial vehicle Dr**4** of the present example embodiment will be described. An example of the unmanned aerial vehicle Dr**4** of the present example embodiment is taken as Example 3. The unmanned aerial vehicle Dr**4** of Example 3 is capable of generating a lift of 50 g. The unmanned aerial vehicle Dr**4** of Example 3 uses the main propeller **3***d* having an outermost diameter, that is, the outer diameter of the locus St**1** of the radially outer end of the main blade portion **32***d* of 120 mm. The unmanned aerial vehicle Dr**4** of Example 3 also uses the three auxiliary propellers **6** each having an outermost diameter, that is, the outer diameter of the locus St**2** of the radially outer end of the auxiliary blade portion **62** of 50 mm. The main motor **4***d* and the auxiliary motor **7** are outer rotor motors.

[0118] The weight of the body portion **1***d* and the like are 20 g. The weight of the main propeller **3***d* is 3 g and the weight of the main motor **4***d* is 4 g, thus the total of 7 g. The weight of the auxiliary propeller **6** is 1 g and the weight of the auxiliary motor **7** is 1.5 g, and the total of the three auxiliary propellers **6** and auxiliary motor **7** is 7.5 g. The weight of the battery **81** is 8 g, the weight of the camera **82** is 3 g, and the weight of the circuit board **83** is 1 g. Therefore, the total weight of Example 3 is 46.5 g. With this configuration, the unmanned aerial vehicle Dr**4** of Example 3 can fly.

[0119] Yet another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **12** is a schematic side view of yet another example of the unmanned aerial vehicle according to the present disclosure. FIG. **13** is an enlarged sectional view of the main propeller and the main motor of the unmanned aerial vehicle shown in FIG. **12**. An unmanned aerial vehicle Dr**5** shown in FIG. **12** has the same configuration as that of the unmanned aerial vehicle Dr**2** of the second example embodiment except that a body portion le, a main shaft **2***e*, a main propeller **3***e*, and a main motor **4***e* are different from the body portion **1***b*, the main shaft **2**, the main propeller **3**, and the main motor **4**. For this reason, in the configuration of the unmanned aerial vehicle Dr**5**, the same components as those of the unmanned aerial vehicle Dr**2** are given the same reference numerals and detailed descriptions thereof will be omitted.

[0120] As shown in FIG. **13**, an axial lower surface of the frame portion **12***b* of the body portion le of the unmanned aerial vehicle Dr**5** is in contact with an axial upper surface of the main body portion **11**. That is, the frame portion **12***b* and the main body portion **11** are directly connected. The main body portion **11** and the frame portion **12***b* may be integrally formed or may be separable. In a case of being separable, it may be configured such that, when the main body portion **11** and the frame portion **12***b* are separated, the battery **81** disposed inside the main body portion **11** and the circuit board **83** disposed in the frame portion **12***b* are exposed to the outside. As a fixing method for the main body portion **11** and the frame portion **12***b*, it is possible to adopt a method in which, for example, an internal thread is formed on one side and an external thread is formed on the other side and the external thread is screwed on the female thread. Also, other methods may be adopted.

[0121] The main motor **4***e* is an inner rotor type motor. The main motor **4***e* is fixed to an axial upper surface of the frame body portion **121***b*. The main motor **4***b* includes an upper cover **401***e*, a base portion **402***e*, a stator **41***e*, a rotor **42***e*, an upper bearing **43***e*, and a lower bearing **44***e*.

[0122] The upper cover **401***e* has a lidded tubular shape. The upper cover **401***e* includes an upper lid portion **403***e*, a main motor tubular portion **404***e*, and an upper bearing holding portion **405***e*. The upper lid portion **403***e* has an annular shape expanding in a direction orthogonal to the central axis Ax, and has a through hole **400***e* at the center. The main motor tubular portion **404***e* extends axially downward from a radial outer edge portion of the upper lid portion **403***e*. The upper bearing holding portion **405***e* has a tubular shape extending axially upward from the side edge portion of the through hole **400***e* of the upper lid portion **403***e*. The center of the upper bearing holding portion **405***e* coincides with the central axis Ax.

[0123] The base portion **402***e* has an annular shape expanding in a direction orthogonal to the central axis Ax. The base portion **402***e* includes a lower bearing holding portion **406***e*. The lower bearing holding portion **406***e* has a cylindrical shape, and is disposed at the radial center portion of the base portion **402***e*. The center of the lower bearing holding portion **406***e* overlaps the central axis Ax.

[0124] The outer ring of the upper bearing **43***e* is fixed to a radial inner surface of the upper bearing holding portion **405***e*. Thus, the center of the inner ring of the upper bearing **43***e* overlaps the central axis Ax. The outer ring of the lower bearing **44***e* is fixed to a radial inner surface of the lower bearing holding portion **406***e*. Thus, the center of the inner ring of the lower bearing **44***e* overlaps the central axis Ax. The main shaft **2***e* is fixed to the inner rings of the upper bearing **43***e* and the lower bearing **44***e* by press-fitting. This causes the main shaft **2***e* to be rotatably supported by the upper cover **401***e* and the base portion **402***e*. The main shaft **2***e* protrudes outward axially upward from the through hole at the radial center of the upper lid portion **403***e* of the upper cover **401***e*. The main shaft **2***e* extends axially upward from the arm portion **122***b*, that is, the body portion le, via the main motor **4***e*.

[0125] The stator **41***e* includes a stator core **411***e* and a coil **412***e*. The stator core **411***e* includes an annular core back **413***e* and a plurality of teeth **414***e*. The annular core back **413***e* is fixed to a radial inner surface of the main motor tubular portion **404***e*. The plurality of teeth **414***e* extend radially inward from the annular core back **413***e*. The coil **412***e* is configured by winding a wire around each of the teeth **414***e*.

[0126] The rotor **42***e* includes a rotor magnet **421***e*. The rotor magnet **421***e* is cylindrical and fixed to a radial outer surface of the main shaft **2***e*. The rotor magnet **421***e* radially faces the teeth **414***e*. The main shaft **2***e* is press-fitted into the upper bearing **43***e* and the lower bearing **44***e*, and the rotor **42***e* is rotatable with respect to the upper cover **401***e* and the base portion **402***e*. The main shaft **2***e* rotates around the central axis Ax by supplying a current to the coil **412***e*.

[0127] The main propeller **3***e* is fixed to an upper end portion of the main shaft **2***e*. The main propeller **3***e* includes a main propeller body portion **31***e* and a main blade portion **32***e*. The main propeller body portion **31***e* is columnar, and the center of the main propeller body portion **31***e* overlap the central axis Ax. The main blade portion **32***e* extends radially outward from the radial outer surface of the main propeller body portion **31***e*. As the main motor **4***e* rotates, the main shaft **2***e* rotates. Due to this, the main propeller **3***e* fixed to the main shaft **2***e* rotates. Thus, it is also possible to adopt an inner rotor motor type motor as the main motor **4***e*. In the inner rotor motor, since the main shaft **2***e* axially protrudes from the main motor **4***e* and the main propeller **3***e* is fixed to the tip thereof, the main motor **4***e* can be fixed directly to the frame body portion **121***b*. In addition, it is easy to use a general-purpose product as the main motor **4***e*, the degree of freedom in design is increased, and the maintainability is high.

[0128] In the unmanned aerial vehicle Dr**5** of the present example embodiment, the main motor **4***e* and the three auxiliary motors **7***b* are fixed to the frame portion **12**. That is, the main motor **4***e* that drives the main propeller **3***e* and the auxiliary driver **7***b* that drives the auxiliary propeller **6***b* are disposed in the frame portion **12**. Since the motor is fixed directly to the frame portion **12**, fixing of the motor is easy. Moreover, the part to which the motor of the flame portion **12** is attached may be a plane, and the workability is high. In addition, it is possible to position the center of gravity of the unmanned aerial vehicle Dr**5** near the body portion, and it is possible to stably fly the unmanned aerial vehicle Dr**5**.

[0129] Other than this, there are features common to the second example embodiment.

[0130] Yet another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **14** is a plan view of yet another example of the unmanned aerial vehicle according to the present disclosure. FIG. **15** is a schematic side view of the unmanned aerial vehicle shown in FIG. **14**. An unmanned aerial vehicle Dr**6** shown in FIGS. **14** and **15** differs from the unmanned aerial vehicle Dr**4** of the fourth example embodiment in that an auxiliary shaft **5***f* extends axially downward. Along with this, the configurations of a body portion if and a main shaft **2***f* are slightly different, but the configurations of the others are the same as those of the unmanned aerial vehicle Dr**4**. For this reason, substantially the same parts will be given the same reference numerals and detailed descriptions of the same parts will be omitted.

[0131] As shown in FIG. **15**, the unmanned aerial vehicle Dr**6** includes the body portion **1***f*, the main shaft **2***f*, the main propeller **3***d*, the main motor **4***d*, the auxiliary shaft **5***f*, the auxiliary propeller **6**, the auxiliary motor **7**, the battery **81**, the camera **82**, and the circuit board **83**. Although the lead wire is omitted in the unmanned aerial vehicle Dr**4**, the lead wire connects between the battery **81** and the circuit board **83** and between the circuit board **83** and the main motor **4***d* and the auxiliary motor **7**.

[0132] The body portion if includes the main body portion **11** and the frame portion **12**. The main body portion **11** and the frame portion **12** are the same as the main body portion **11** and the frame portion **12** of the unmanned aerial vehicle Dr**1** of the first example embodiment, and detailed description will be omitted. In the body portion **1***f*, the main body portion **11** and the frame portion **12** are connected via a tubular portion **13**. The center of the tubular portion **13** overlaps the central axis Ax. Inside the tubular portion **13**, a lead wire connecting the battery **81** and the circuit board **83**

is housed. In the body portion **1***f*, since the main body portion **11** and the frame portion **12** interfere with the auxiliary propeller **6**, the main body portion **11** and the frame portion **12** are axially separated from each other and coupled via the tubular portion **13**. However, if not interfering with the auxiliary propeller **6**, the main body portion **11** and the frame portion **12** may be directly fixed, as in the body portion **1***d* or the like.

[0133] The main shaft **2***f* is a cylindrical body extending axially upward from an axial upper surface of the frame body portion **121** of the frame portion **12**. The center of the main shaft **2***f* coincides with the central axis Ax. The main motor **4***d* is connected to and the main propeller **3***d* connected via the main motor **4***d* to an axial upper end of the main shaft **2***f*.

[0134] In the unmanned aerial vehicle Dr**6**, the auxiliary shaft **5***f* extends axially downward from the arm portion **122** of the frame portion **12**. And the auxiliary motor **7** is attached to the axial lower end of auxiliary shafts **5***f*. The auxiliary propeller **6** is connected to the axial lower end of the auxiliary shaft **5** via the auxiliary motor **7**.

[0135] That is, in the unmanned aerial vehicle Dr**6**, the main propeller **3***b* is disposed axially above the frame portion **12** and the auxiliary propeller **6** is disposed axially below the frame portion **12**. With such configuration, the axial directions of the main motor **4***b* and the auxiliary motor **7** are opposite to each other. Therefore, even if the main motor **4***b* and the auxiliary motor **7** are rotated in the same direction as viewed from the axial upper cover side, the torque acting on the unmanned aerial vehicle Dr**6** can be opposite to each other. This allows the control of the main motor **4***b* and the three auxiliary motors **7** to be simplified.

[0136] In addition, since the rotor shaft of each of the main motor **4***b* and the auxiliary motor **7** can be shortened, the rotation accuracy can be enhanced. This can increase the operability of the unmanned aerial vehicle Dr**6**.

[0137] In the unmanned aerial vehicle Dr**6**, the plurality of auxiliary propellers **6** are disposed axially between the main body portion **11** and the frame portion **12**. The main driver **4***d* that drives the main propeller **3***d* is disposed on the main propeller **3***d* side, which is one side of the frame portion **12**. The plurality of auxiliary drivers **7** are disposed on the plurality of auxiliary propellers **6** side, which is the other side of the frame portion **12**. The body portion if includes the tubular portion **13** extending axially at the center of a pitch circle of the plurality of auxiliary drivers **7**. The tubular portion **13** supports the frame portion **12**. This can shorten the length of the rotor shaft. This can increase the rotation accuracy of the main propeller **3***d* and the auxiliary propeller **7**, and can reduce the noise of the rotation of the main propeller **3***d* and the auxiliary propeller **7**.

[0138] Other than this, there are features common to the fourth example embodiment.

[0139] An actual example of the unmanned aerial vehicle Dr**6** of the present example embodiment will be described. An example of the unmanned aerial vehicle Dr**6** of the present example embodiment is taken as Example 4. The unmanned aerial vehicle Dr**6** of Example 4 is capable of generating a lift of 50 g. The unmanned aerial vehicle Dr**6** of Example 4 uses the main propeller **3***d* having an outermost diameter, that is, the outer diameter of the locus St**1** of the radially outer end of the main blade portion **32***d* of 120 mm. The unmanned aerial vehicle Dr**6** of Example 4 also uses the three auxiliary propellers **6** each having an outermost diameter, that is, the outer diameter of the locus St**2** of the radially outer end of the auxiliary blade portion **62** of 50 mm. The main motor **4** and the auxiliary motor **7** are outer rotor motors.

[0140] The weight of the body portion if and the like are 20 g. The weight of the main propeller **3***d* is 3 g and the weight of the main motor **4***d* is 4 g, thus the total of 7 g. The weight of the auxiliary propeller **6** is 1 g and the weight of the auxiliary motor **7** is 1.5 g, and the total of the three auxiliary propellers **6** and auxiliary motor **7** is 7.5 g. The weight of the battery **81** is 8 g, the weight of the camera **82** is 3 g, and the weight of the circuit board **83** is 1 g. Therefore, the total weight of Example 4 is 46.5 g. With this configuration, the unmanned aerial vehicle Dr**6** of Example 4 can fly.

[0141] Yet another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **16** is a schematic side view of yet another example of the unmanned aerial vehicle according to the present disclosure. An unmanned aerial vehicle Dr**7** shown in FIG. **16** has the same configuration as that of the unmanned aerial vehicle Dr**6** shown in FIG. **6** except the use of a body portion **1***g*, the main propeller **3***e*, the main motor **4***e*, the auxiliary propeller **6***b*, and the auxiliary motor **7***b*. For this reason, in the unmanned aerial vehicle Dr**7** shown in FIG. **16**, substantially the same parts as those of the unmanned aerial vehicle Dr**6** will be given the same reference numerals and detailed descriptions of the same parts will be omitted.

[0142] As shown in FIG. **16**, the unmanned aerial vehicle Dr**7** includes the body portion **11** and the frame portion **12***b*. The axial upper surface of the body portion **11** and the axial lower surface of the frame portion **12***b* are coupled via the tubular portion **13**. The tubular portion **13** is an axially extending cylindrical body that includes an internal space. In the internal space, a lead wire (not illustrated) connecting the battery **81** and the circuit board **83** is disposed.

[0143] As shown in FIG. **16**, in the unmanned aerial vehicle Dr**7**, the main motor **4***e*, which is an inner rotor type motor, can be used by using the frame portion **12***b*. It is also possible to directly fix the auxiliary motor **7***b*, which is an inner rotor type motor, to the axial lower surface of the arm portion **122***b*. Since the inner rotor type motor has a motor and a propeller that are separate from each other, it is possible to use a general-purpose motor. Moreover, since it is less prone to a shape or other restrictions, the degree of freedom in design can be increased.

[0144] Other than this, there are features common to the sixth example embodiment.

[0145] Yet another example of the unmanned aerial vehicle according to the present disclosure will be described with reference to the drawings. FIG. **17** is a schematic side view of yet another example of the unmanned aerial vehicle according to the present disclosure. An unmanned aerial vehicle Dr**8** shown in FIG. **17** has the same configuration as that of the unmanned aerial vehicle Dr**6** of the sixth example embodiment except that an auxiliary shaft **5***h* is different. For this reason, in the configuration of the unmanned aerial vehicle Dr**8**, the same components as those of the unmanned aerial vehicle Dr**6** are given the same reference numerals and detailed descriptions thereof will be omitted.

[0146] As shown in FIG. **17**, in the unmanned aerial vehicle Dr**8**, an central axis Ax**4** of the auxiliary shaft **5***h* is inclined with respect to the central axis Ax of the unmanned aerial vehicle Dr**8**, that is, the central axis Ax of the main shaft **2***f*. Specifically, the auxiliary shaft **5***h* approaches the central axis Ax as going axially upward. Extension lines in which the central axes Ax**4** of the three auxiliary shafts **5***h* extend axially upward intersect with the central axis Ax at a point P**2**. In other words, the central axes Ax**4** of the three auxiliary shafts **5***h* each approach the central axis Ax as going axially upward. All the angles of the central axes Ax**4** of the three auxiliary shafts **5***h* formed with central axis Ax are equal.

[0147] That is, the lines in which the central axes Ax4 of the plurality of auxiliary shafts **5***h* extend intersect with the line in which the central axis Ax of the main shaft **2***f* extends at one point. Thus, the plurality of auxiliary propellers **6** can exert a radial force on the body portion **1** while maintaining the balance of forces acting on the body portion **1**. This increases the operability of the unmanned aerial vehicle Dr**8**.

[0148] Thus, by the auxiliary shaft **5***h* being inclined, the air flow generated by the rotation of the auxiliary propeller **6** is directed axially downward and radially outward. Therefore, the air flow generated by the auxiliary propeller **6** is less likely to be disturbed, and as a result, the drive efficiency of the unmanned aerial vehicle Dr**8** is increased. Furthermore, since the air flow is unlikely to be disturbed, it is possible to perform a responsive attitude change and movement when the rotation speed of the auxiliary propeller **6** is changed. This can increase the operability. In the unmanned aerial vehicle Dr**8** of the present example embodiment, the central axis Ax**4** of the auxiliary shaft **5***h* approaches the central axis Ax as going axially upward, but, conversely, it may approach the central axis Ax as going axially downward. In any case, the lines in which the central axes Ax**4** of the three auxiliary shafts **5***h* extend may intersect with the line in which the central axis Ax of the main shaft **2***f* extends at one point (point P**2**).

[0149] While the example embodiments of the present disclosure have been described above, the example embodiments can be modified and combined in various ways within the scope of the present disclosure.

[0150] The present disclosure can be used for unmanned aerial vehicles used for sound recording, photographing, and the like.

[0151] While example embodiments of the present disclosure have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present disclosure. The scope of the present disclosure, therefore, is to be determined solely by the following claims.

1-16. (canceled)

17. An unmanned aerial vehicle, comprising:

a body;

a main shaft extending axially from the body;

a main propeller connected to the main shaft;

a plurality of auxiliary shafts extending axially from the body;

a plurality of auxiliary propellers connected to the plurality of auxiliary shafts respectively; and

a plurality of drivers that drive the main propeller and the plurality of auxiliary propellers; wherein

a circle drawn by a tip of the main propeller and a circle drawn by tips of each of the plurality of auxiliary propellers axially overlap at least partially;

a rotational direction of the plurality of auxiliary propellers is opposite to a rotational direction of the main propeller, when viewed from one axial side of the main shaft; and

a torque acting on the body from the main propeller when the body is hovering in an air is equal or substantially equal to a sum of torque acting on the body from the plurality of auxiliary propellers.

18. The unmanned aerial vehicle according to claim **17**, wherein at least one of the main propeller and the plurality of auxiliary propellers radially face the driver.

19. The unmanned aerial vehicle according to claim **18**, wherein

at least one of the main propeller and the plurality of auxiliary propellers each include:

a propeller body; and

a plurality of main blades, which extend radially outward from the propeller body and are circumferentially disposed; and

the driver is housed inside the propeller body.

20. The unmanned aerial vehicle according to claim **17**, wherein

each of the plurality of auxiliary propellers is drivable at a rotation speed different from that of other auxiliary propellers; and

a torque acting on the body from the main propeller when the body is moving in an air is different from a sum of torque acting on the body from the plurality of auxiliary propellers.

21. The unmanned aerial vehicle according to claim **17**, wherein central axes of the plurality of auxiliary shafts are parallel or substantially parallel to a central axis of the main shaft.

22. The unmanned aerial vehicle according to claim **17**, wherein lines in which central axes of the plurality of auxiliary shafts extend intersect with a line in which a central axis of the main shaft extends at one point.

23. The unmanned aerial vehicle according to claim **17**, wherein the body includes:

a main body; and

a frame expanding in a direction perpendicular or substantially perpendicular to a central axis of the main shaft;

the frame is disposed axially between the main body and any one of the main propeller and the plurality of auxiliary propellers; and

a plurality of auxiliary drivers that drive the plurality of auxiliary propellers are connected to the frame.

24. The unmanned aerial vehicle according to claim **23**, wherein a main driver that drives the main propeller and the plurality of auxiliary drivers are disposed in the frame.

25. The unmanned aerial vehicle according to claim **23**, wherein the frame includes:

a frame body; and

a plurality of arms extending radially from the frame body; and

the plurality of auxiliary drivers are connected to the respective arms.

26. The unmanned aerial vehicle according to claim **23**, wherein the main body includes a battery.

27. The unmanned aerial vehicle according to claim **23**, wherein the main body includes a camera.

28. The unmanned aerial vehicle according to claim **17**, wherein the body includes:

a main body; and

a frame expanding in a direction perpendicular or substantially perpendicular to a central axis of the main shaft;

the frame is disposed axially between the main propeller and the plurality of auxiliary propellers; and

a plurality of auxiliary drivers that drive the plurality of auxiliary propellers among the plurality of drivers are connected to the frame.

29. The unmanned aerial vehicle according to claim **28**, wherein

the main propeller is disposed axially between the main body and the frame;

the main driver that drives the main propeller is disposed axially between the main body and the frame;

the plurality of auxiliary drivers are disposed in the frame;

the main body and the frame are connected via a hollow shaft; and

a connection wire that electrically connects the main driver and at least one of the plurality of auxiliary drivers is disposed inside the hollow shaft.

30. The unmanned aerial vehicle according to claim **28**, wherein

the plurality of auxiliary propellers are disposed axially between the main body and the frame;

the main driver that drives the main propeller is disposed on the main propeller side, which is one side of the frame;

the plurality of auxiliary drivers are disposed on the plurality of auxiliary propellers side, which is another side of the frame;

the body further includes a tubular portion extending axially at a center of a pitch circle of the plurality of auxiliary drivers; and

the tubular portion supports the frame.

31. The unmanned aerial vehicle according to claim **28**, wherein the frame includes:

a frame body; and

a plurality of arms extending radially from the frame body; and

the plurality of auxiliary drivers are connected to the respective arms.

32. The unmanned aerial vehicle according to claim **28**, wherein the main body includes a battery.

33. The unmanned aerial vehicle according to claim **28**, wherein the main body includes a camera.

34. The unmanned aerial vehicle according to claim **17**, wherein the body includes a battery.

35. The unmanned aerial vehicle according to claim **17**, wherein the body includes a camera.

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