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(54) **BALL WHEEL FOR AN AIRCRAFT**

(76) Inventor: **Henry L. Blevio**, New Milford, CT (US)

Correspondence Address:
JOHN H CROZIER
1934 HUNTINGTON TURNPIKE
TRUMBULL, CT 06611

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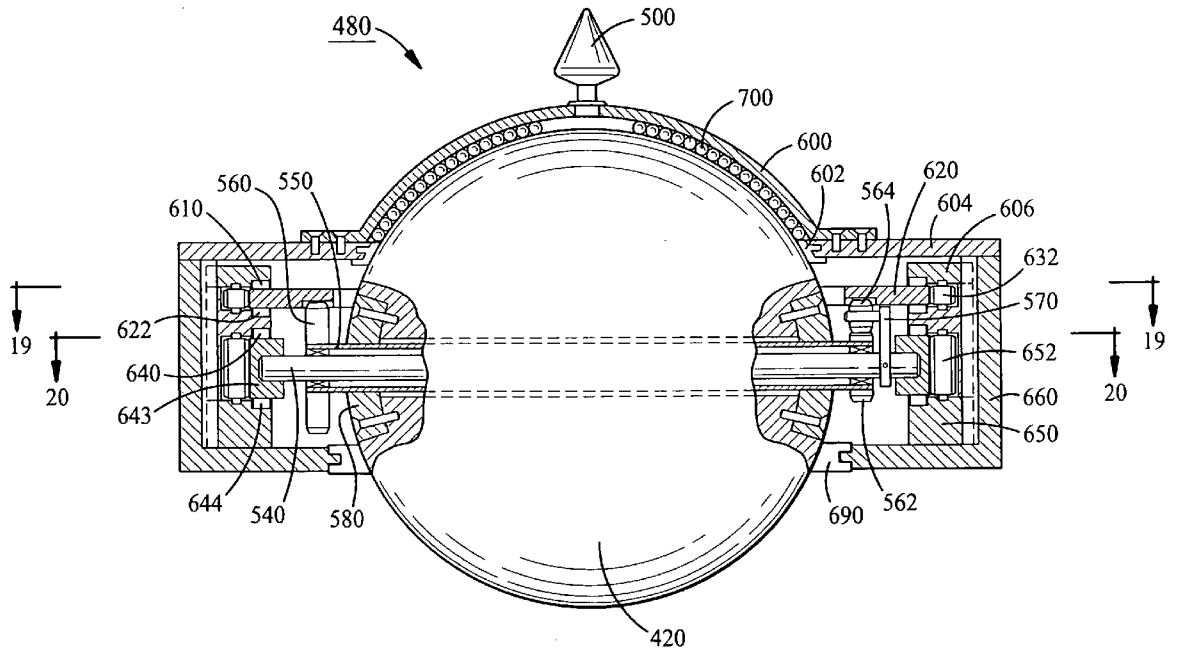
Publication Classification

(51) **Int. Cl.**
B60B 19/14 (2006.01)

(52) **U.S. Cl.** **301/6.1**; 180/7.1

(57) **ABSTRACT**

In a preferred embodiment, an apparatus, including: a ball wheel; and apparatus to cause the ball wheel to rotate in a selected direction.



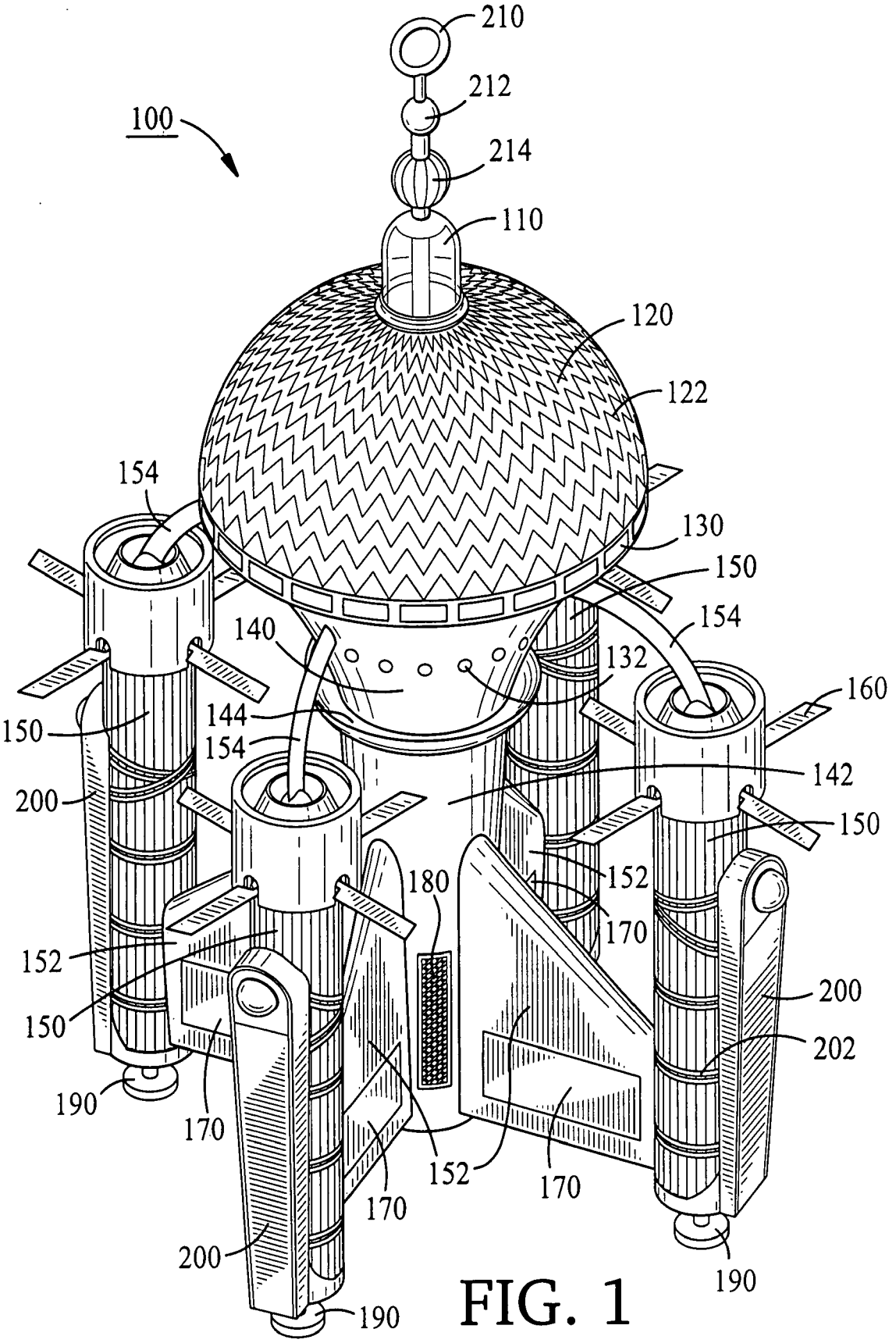

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FIG. 1

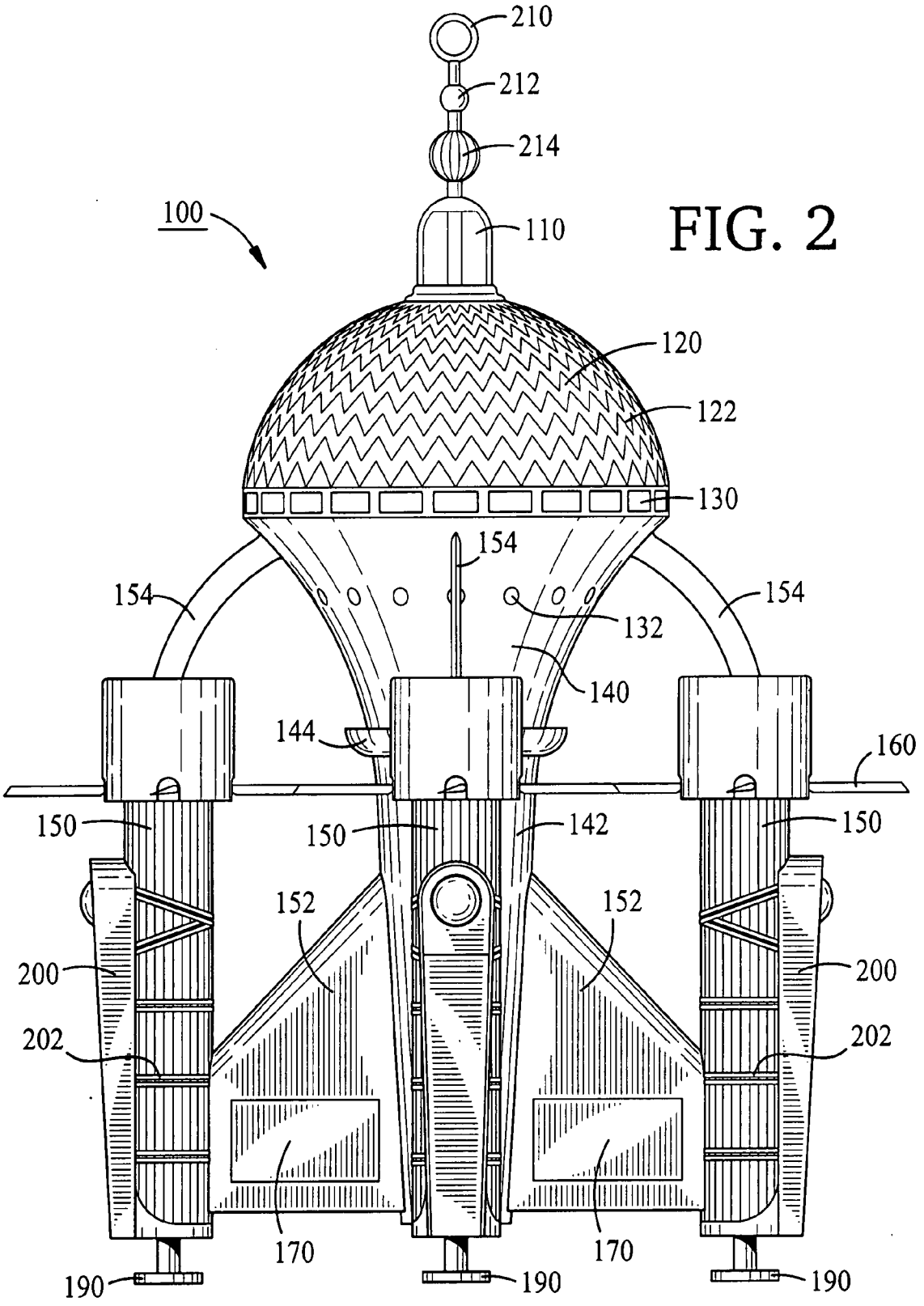
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FIG. 2

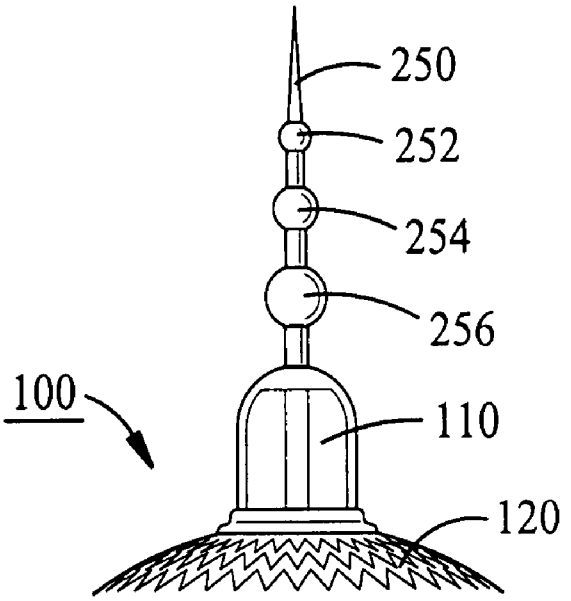

FIG. 3

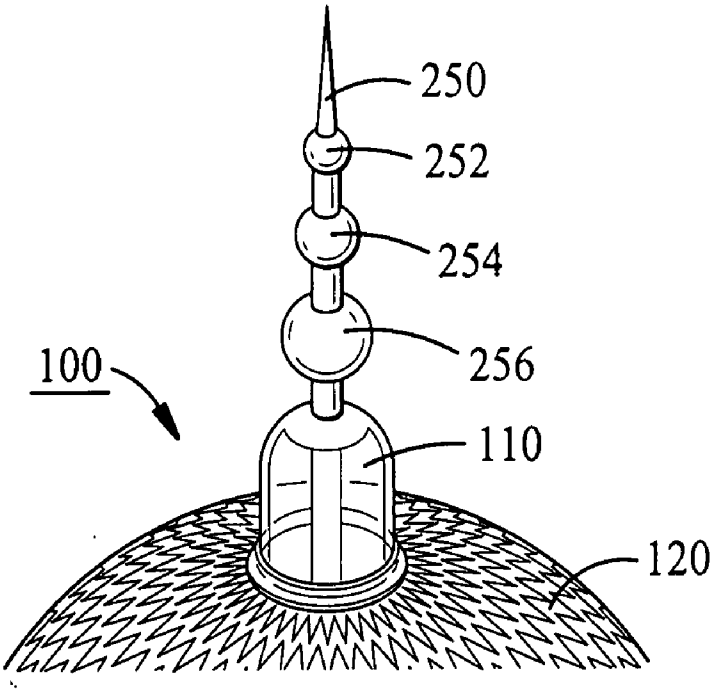

FIG. 4

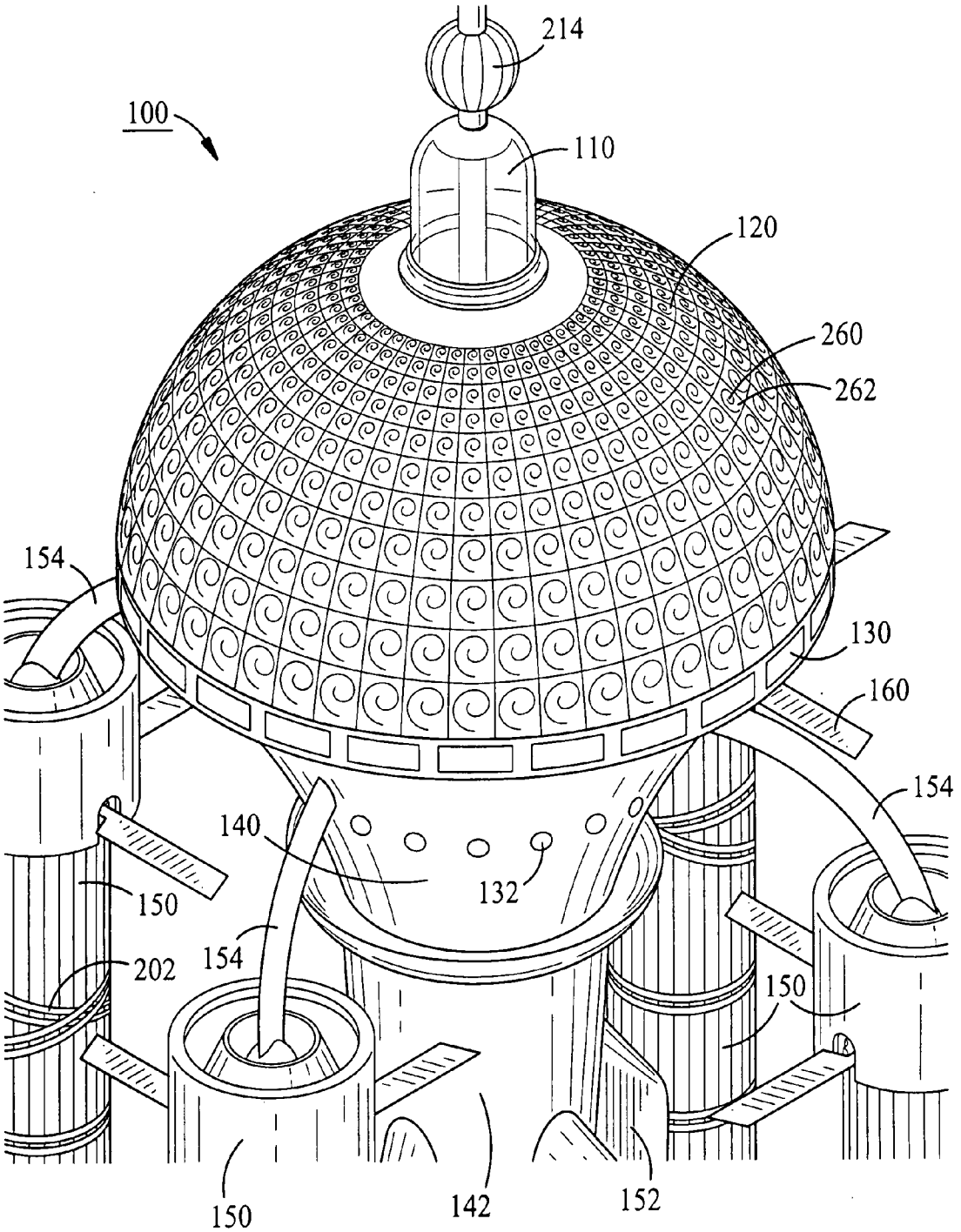
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FIG. 5

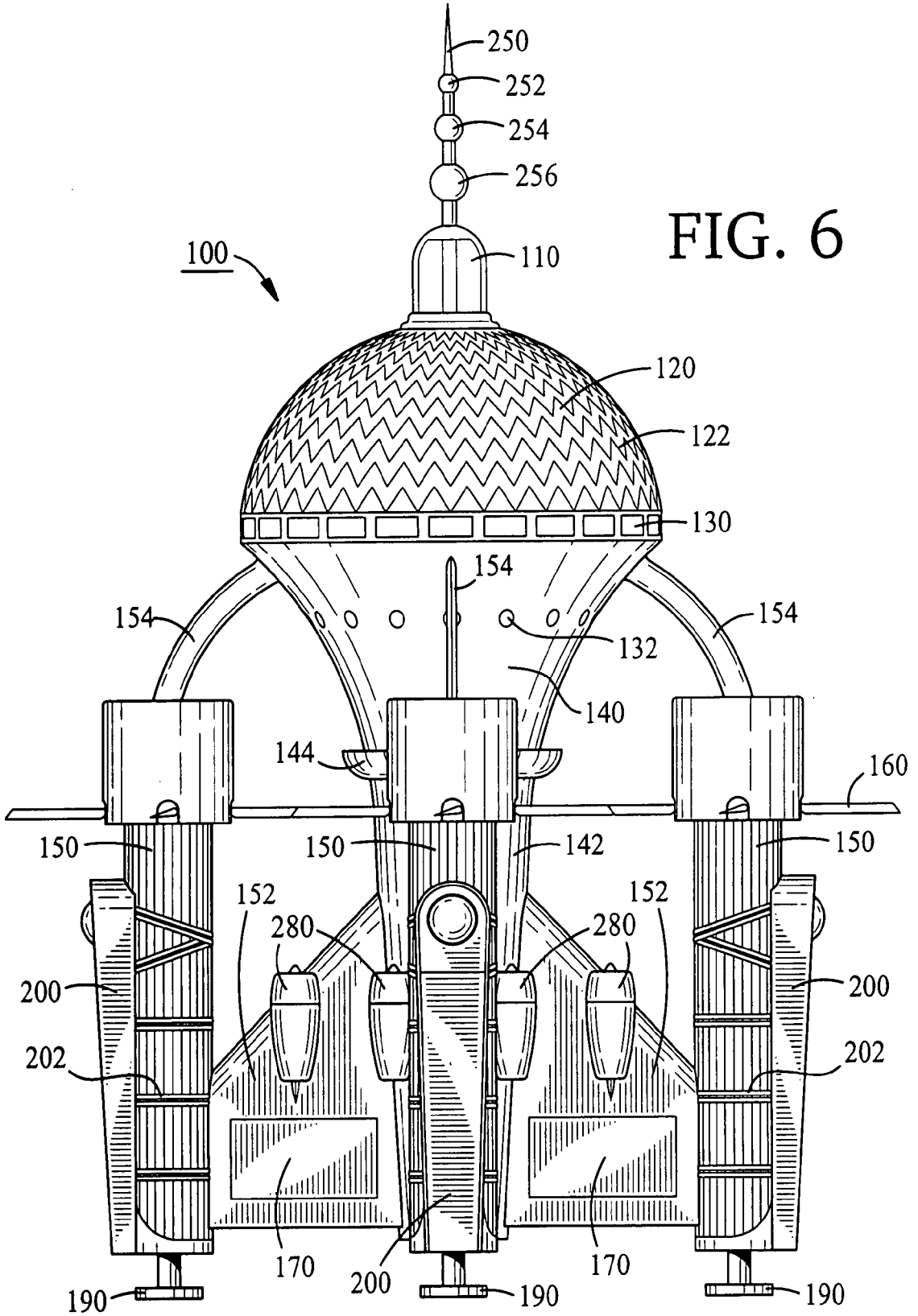
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FIG. 6

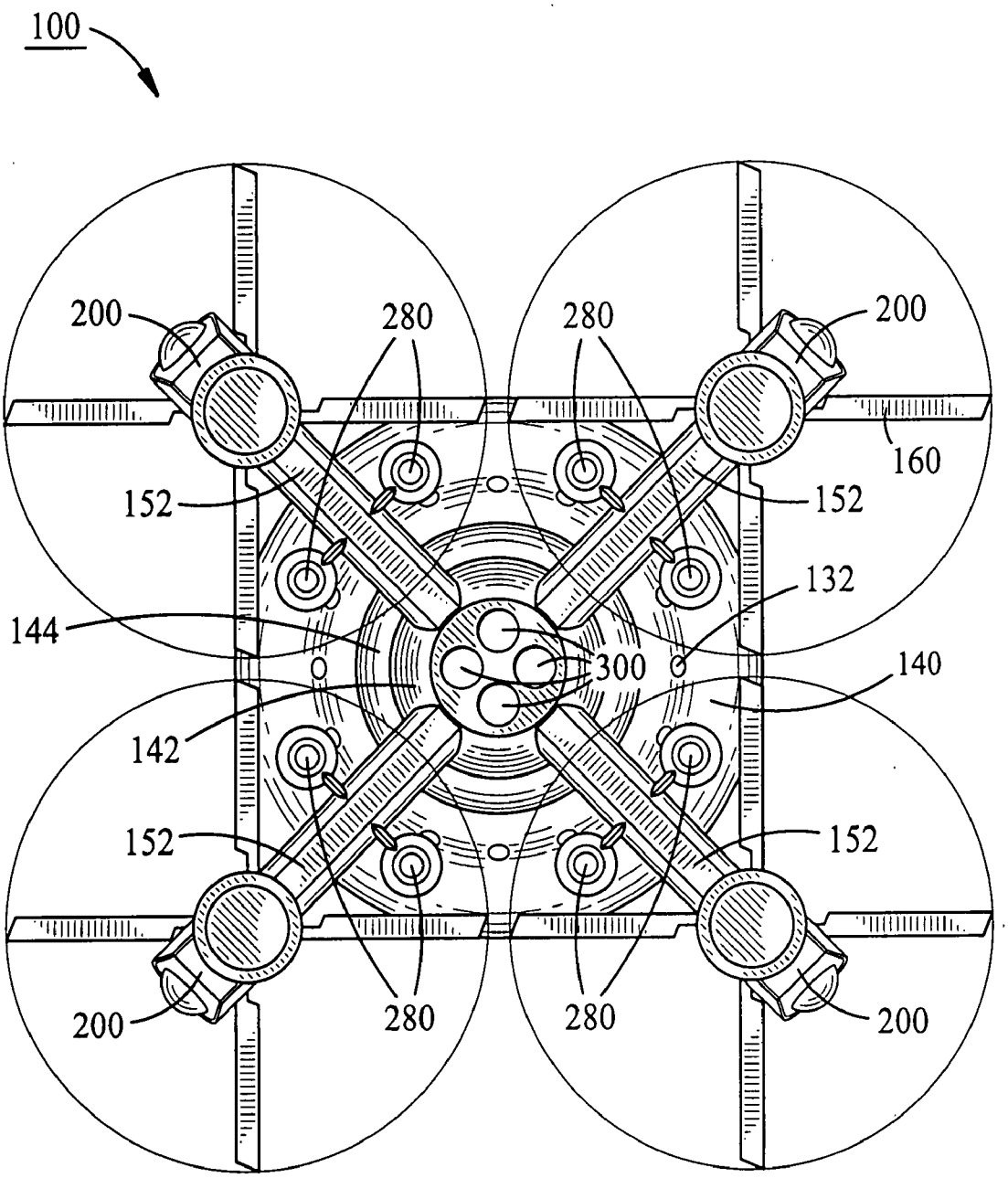
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FIG. 7

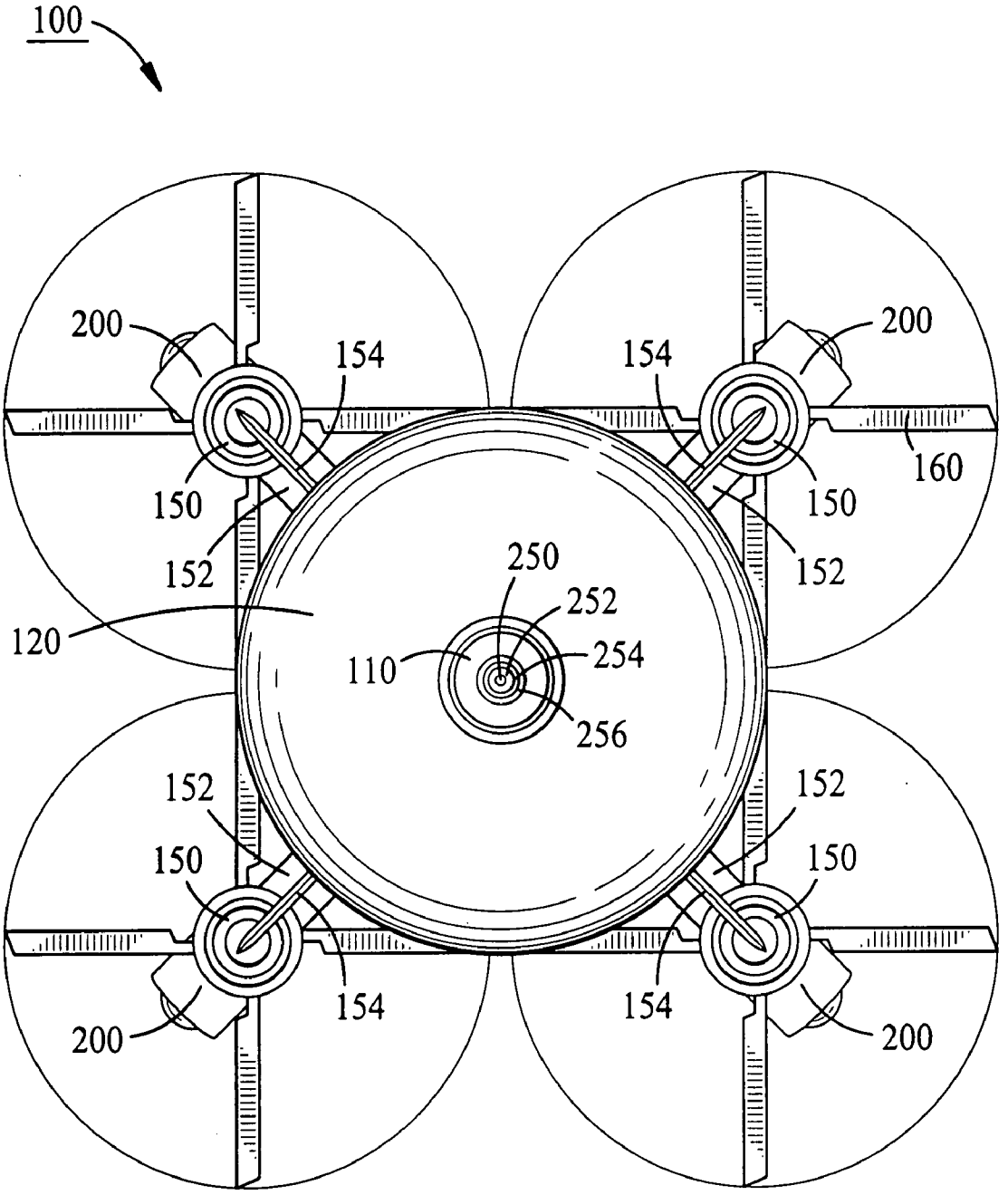
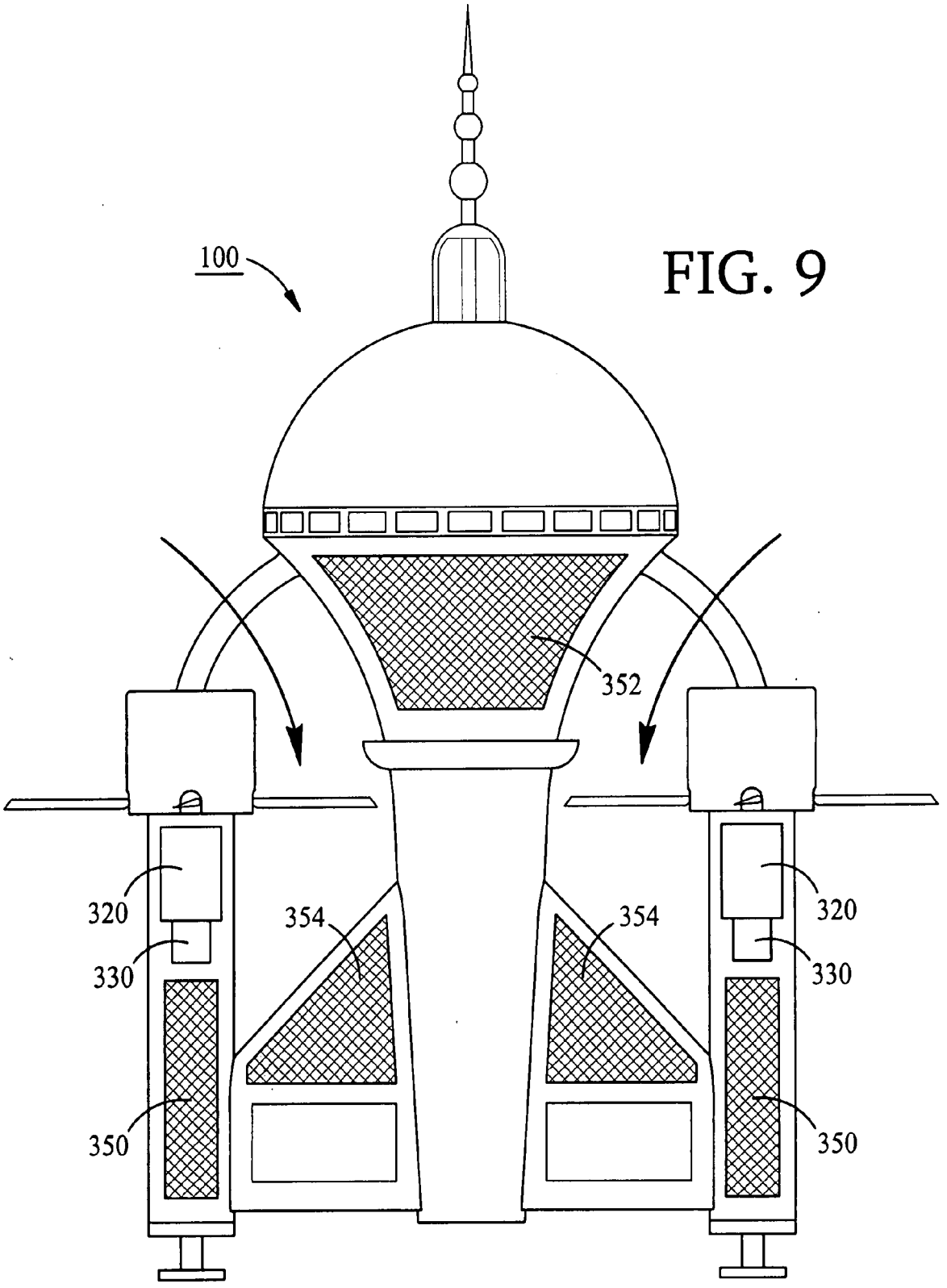


FIG. 8

FIG. 9



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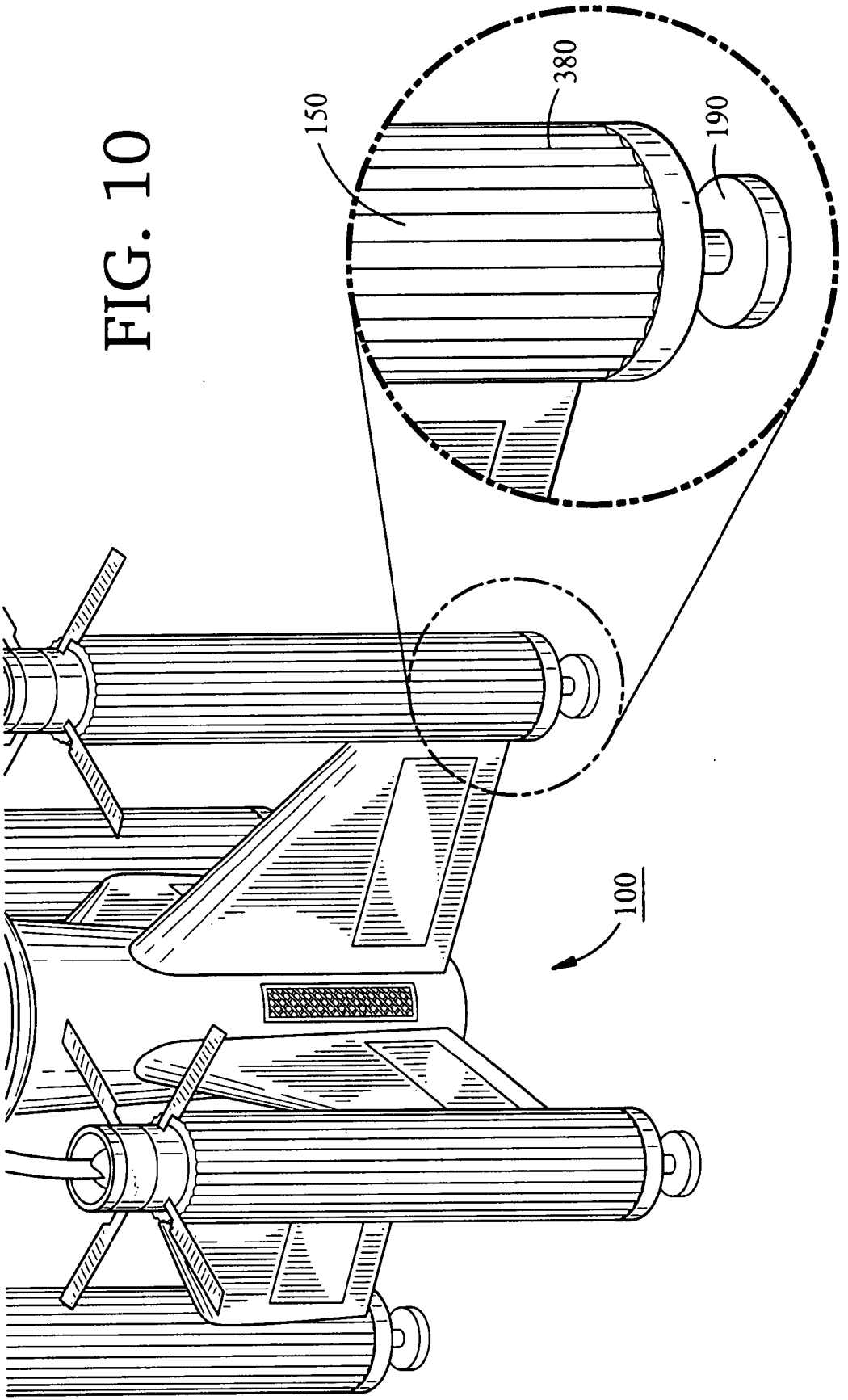

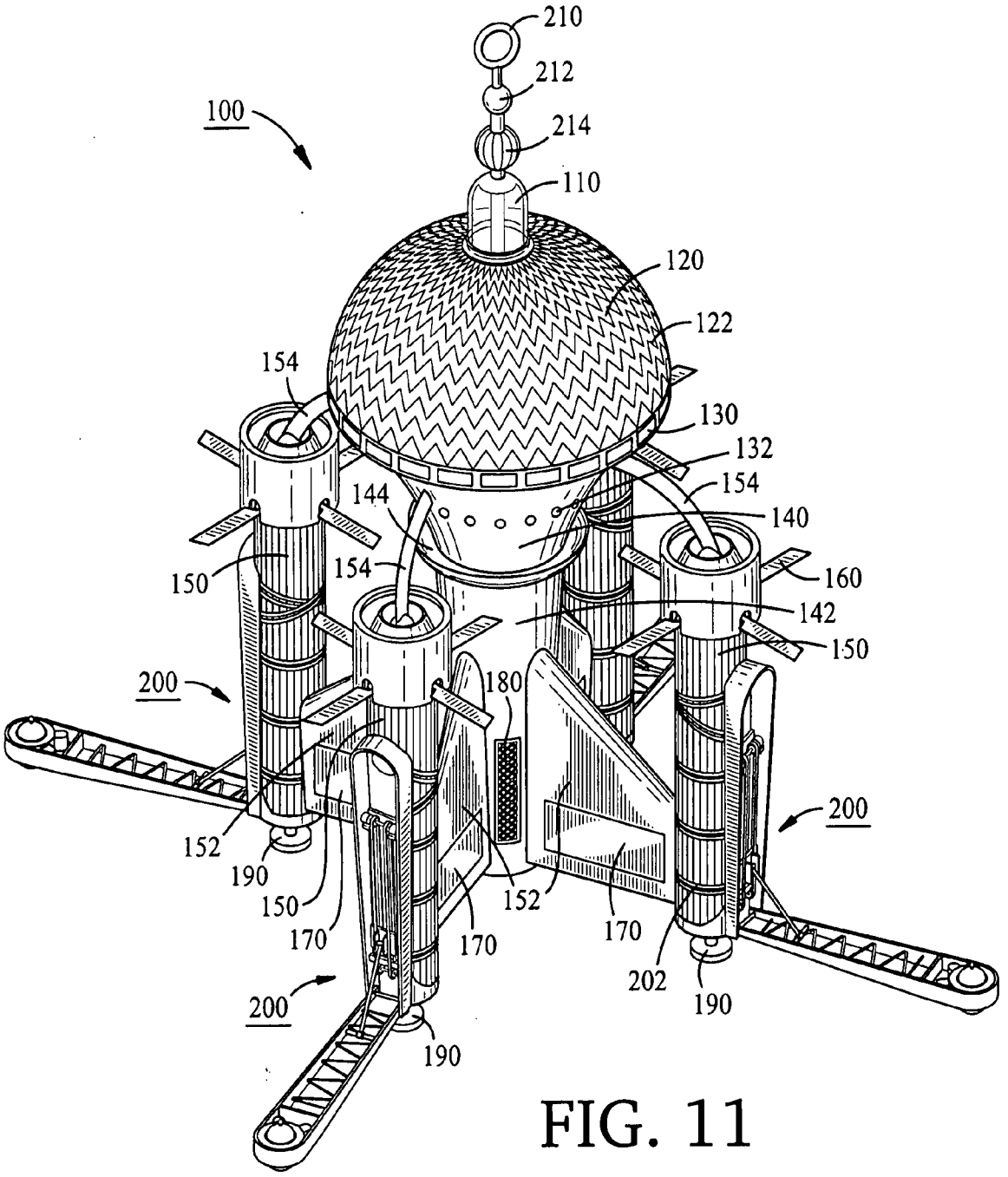
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FIG. 11

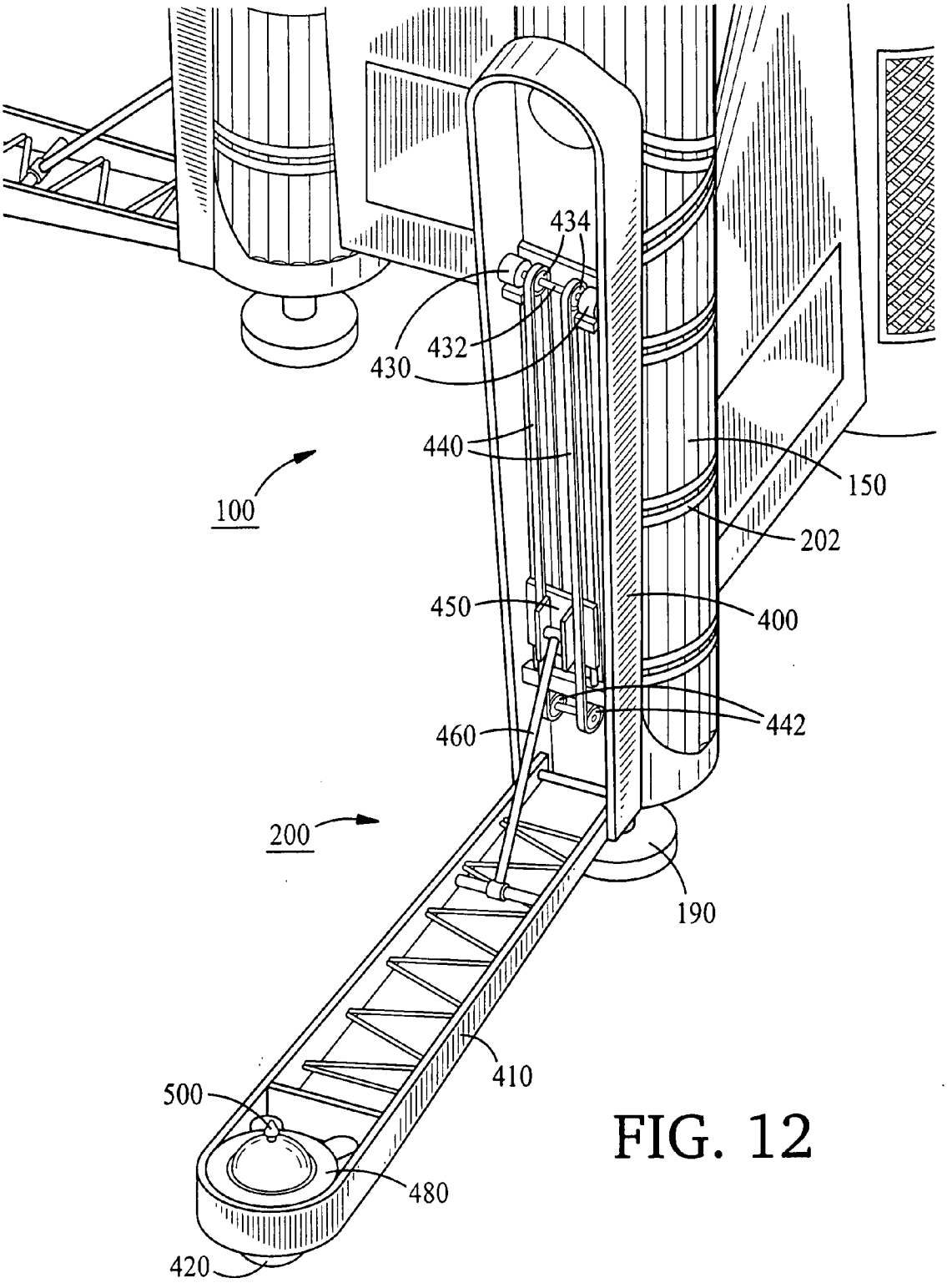
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FIG. 12

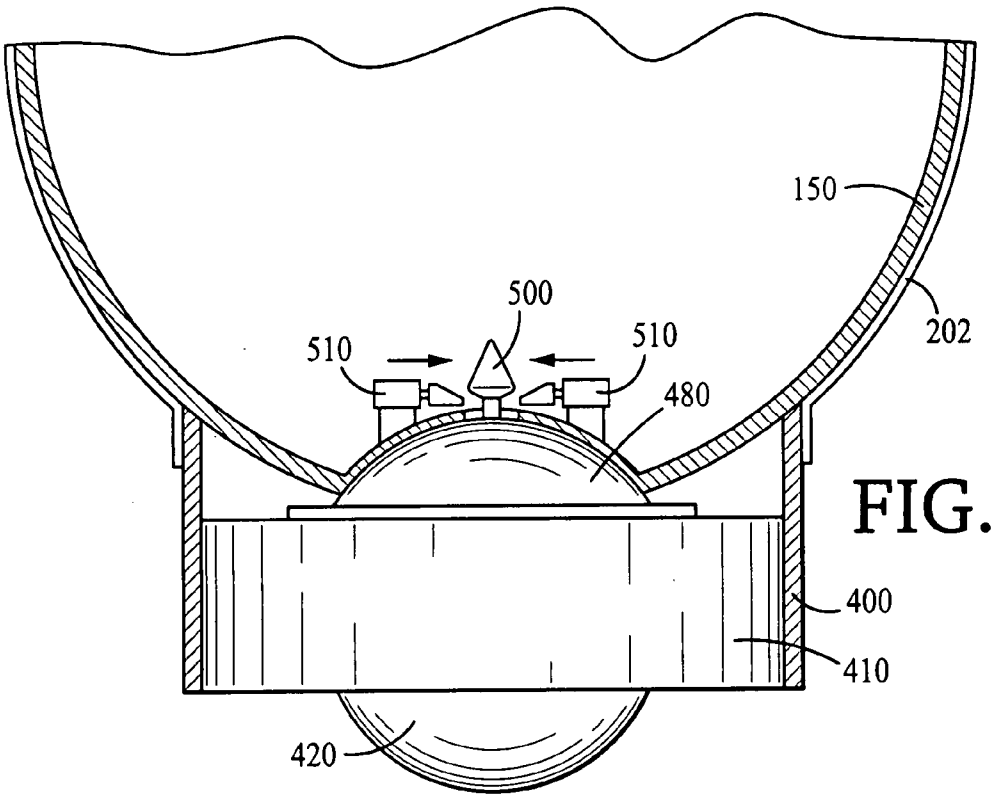
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FIG. 13

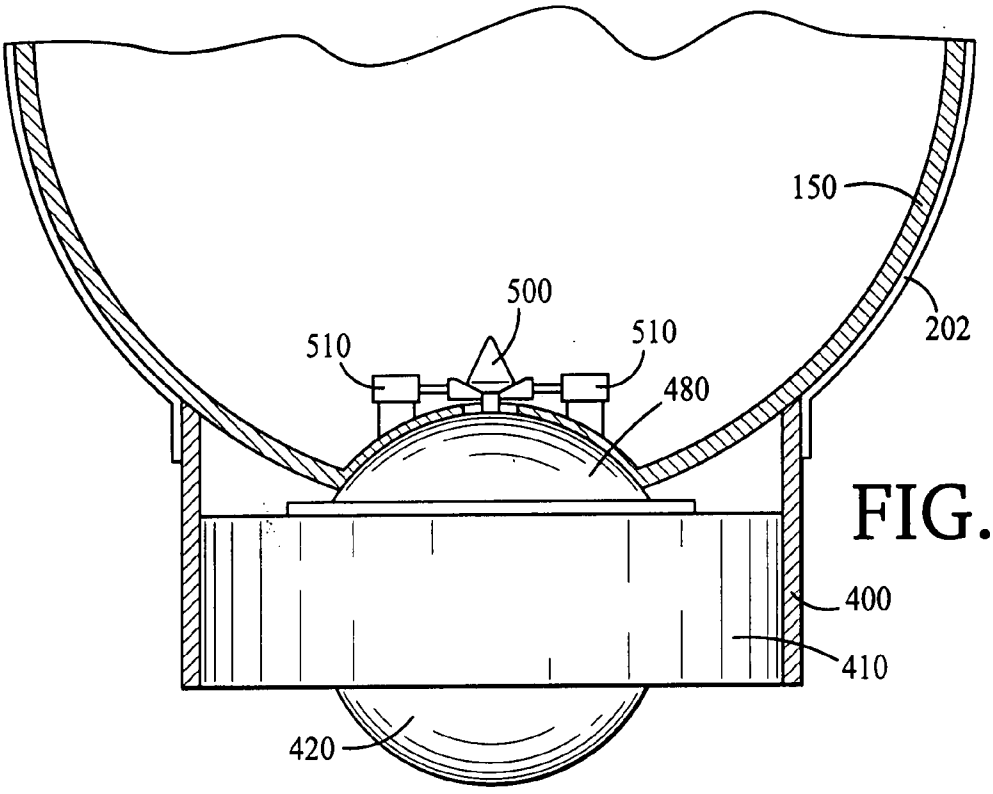
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FIG. 14

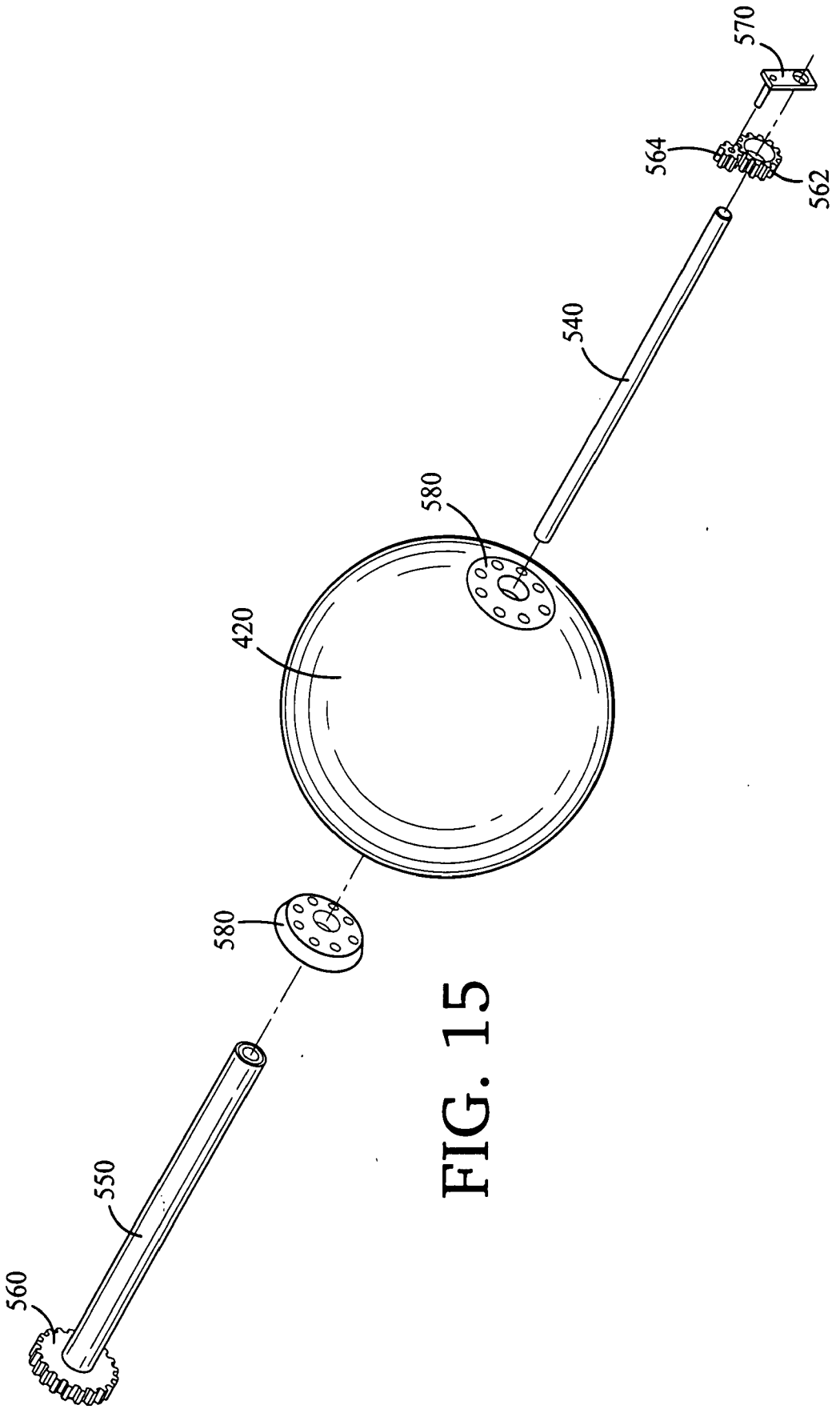
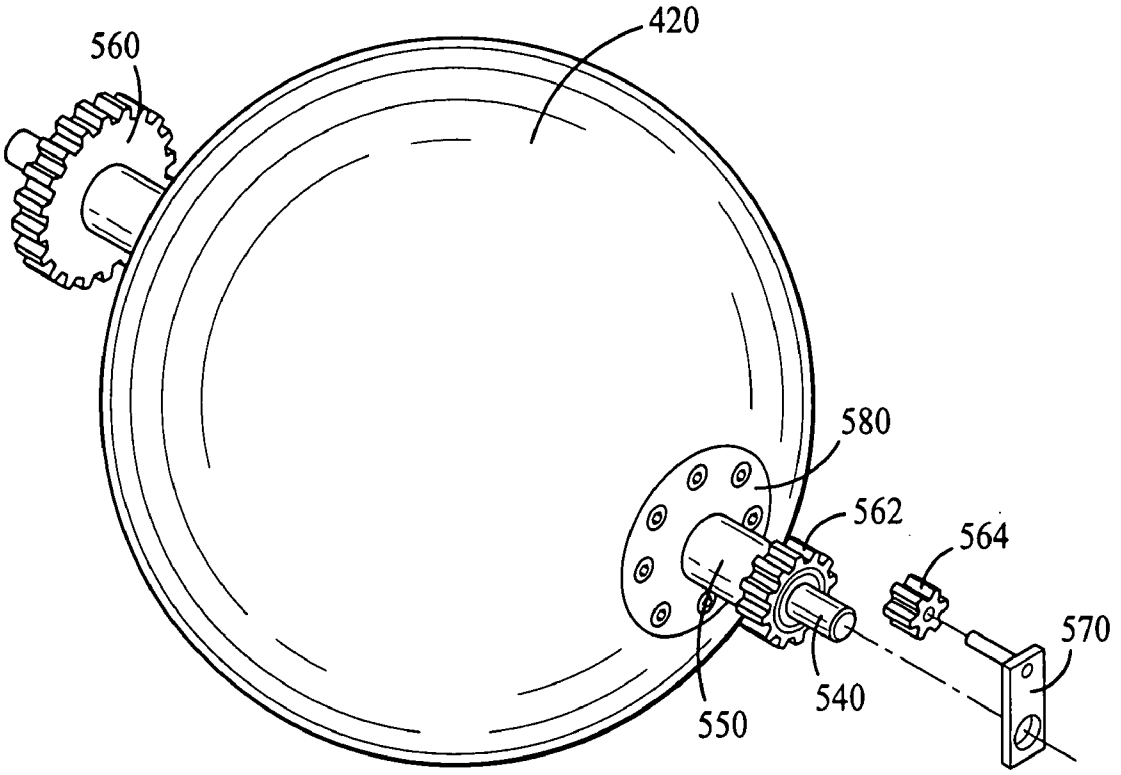


FIG. 15



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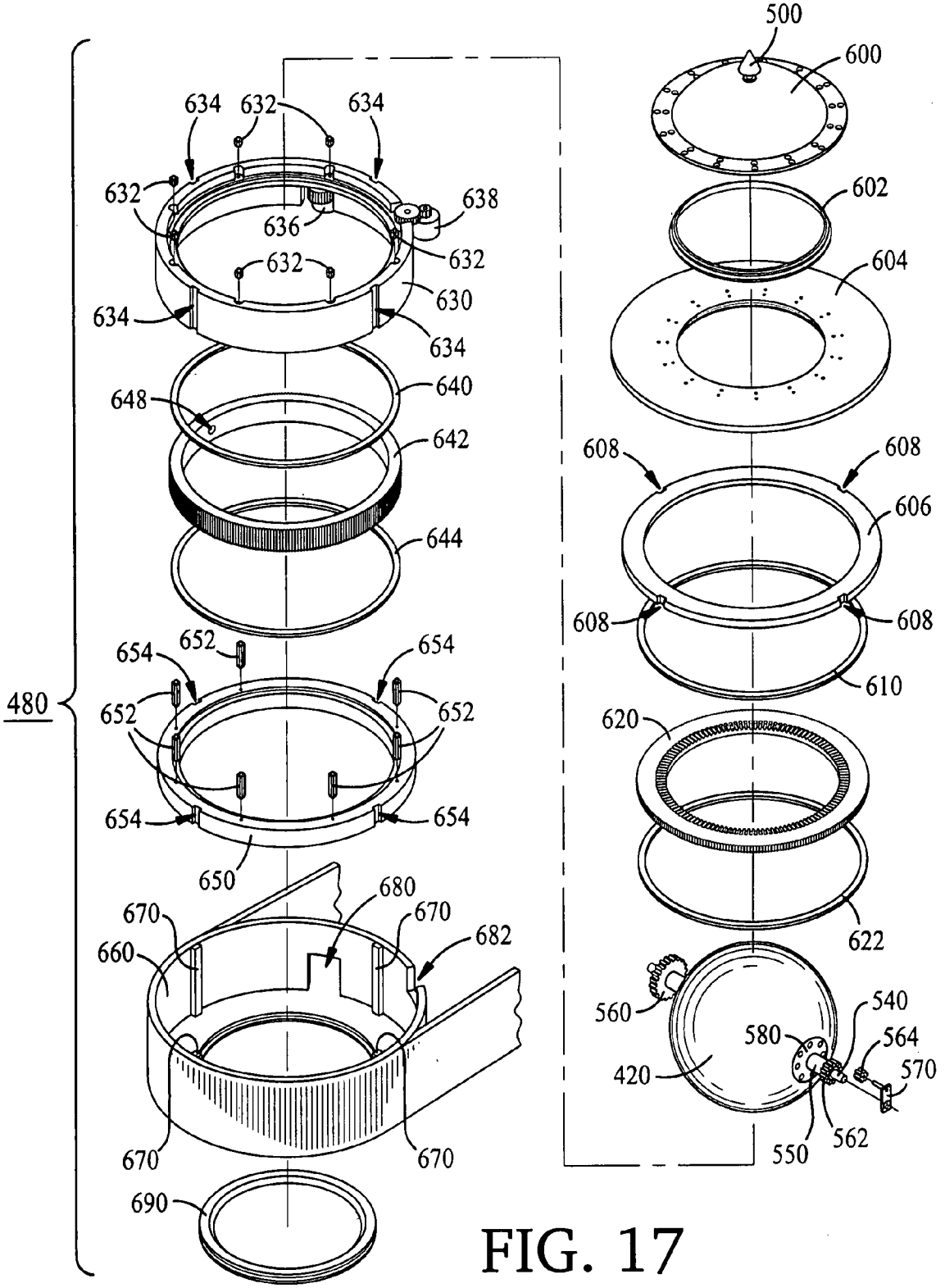
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FIG. 17

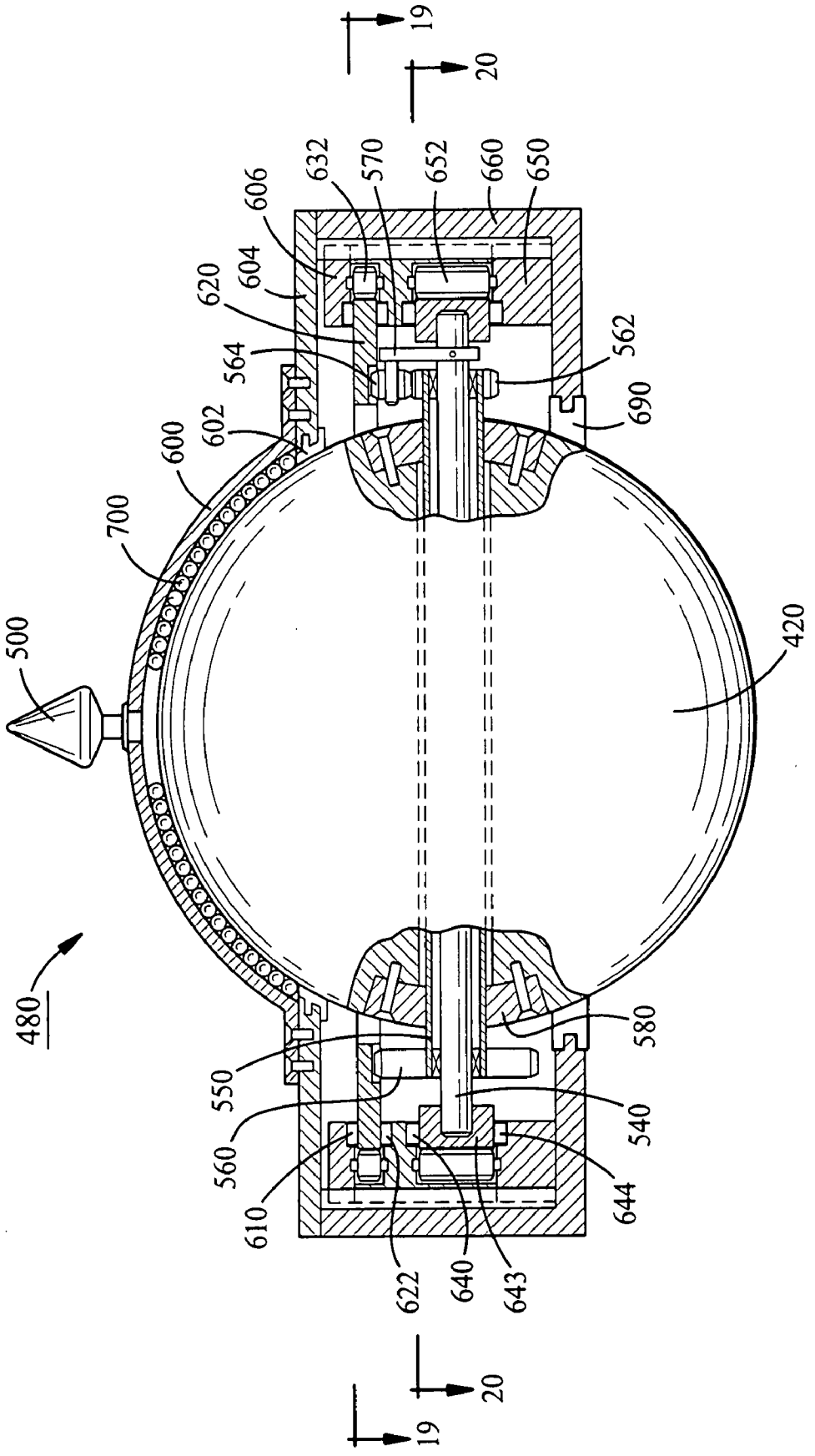
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FIG. 18

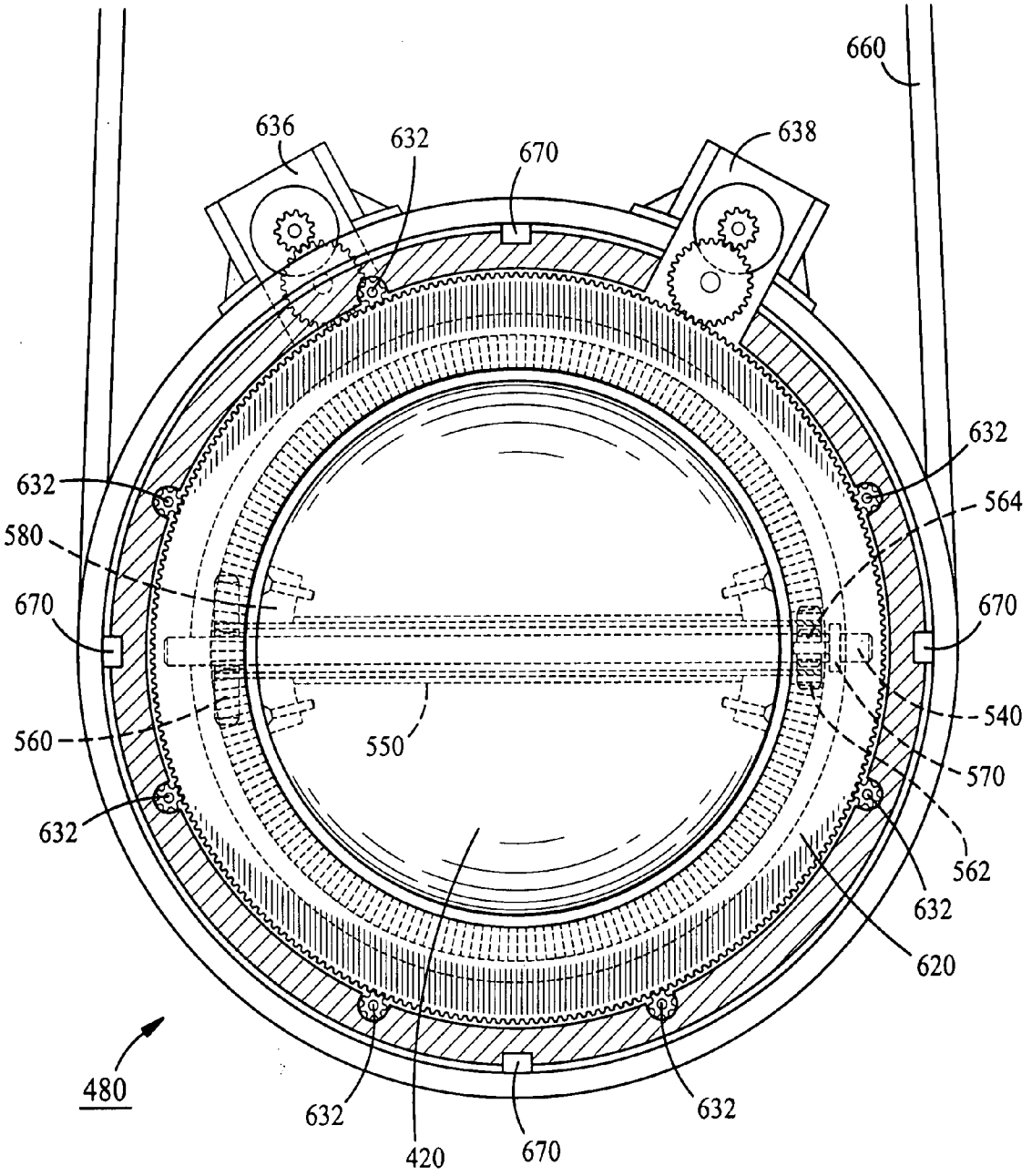
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FIG. 19

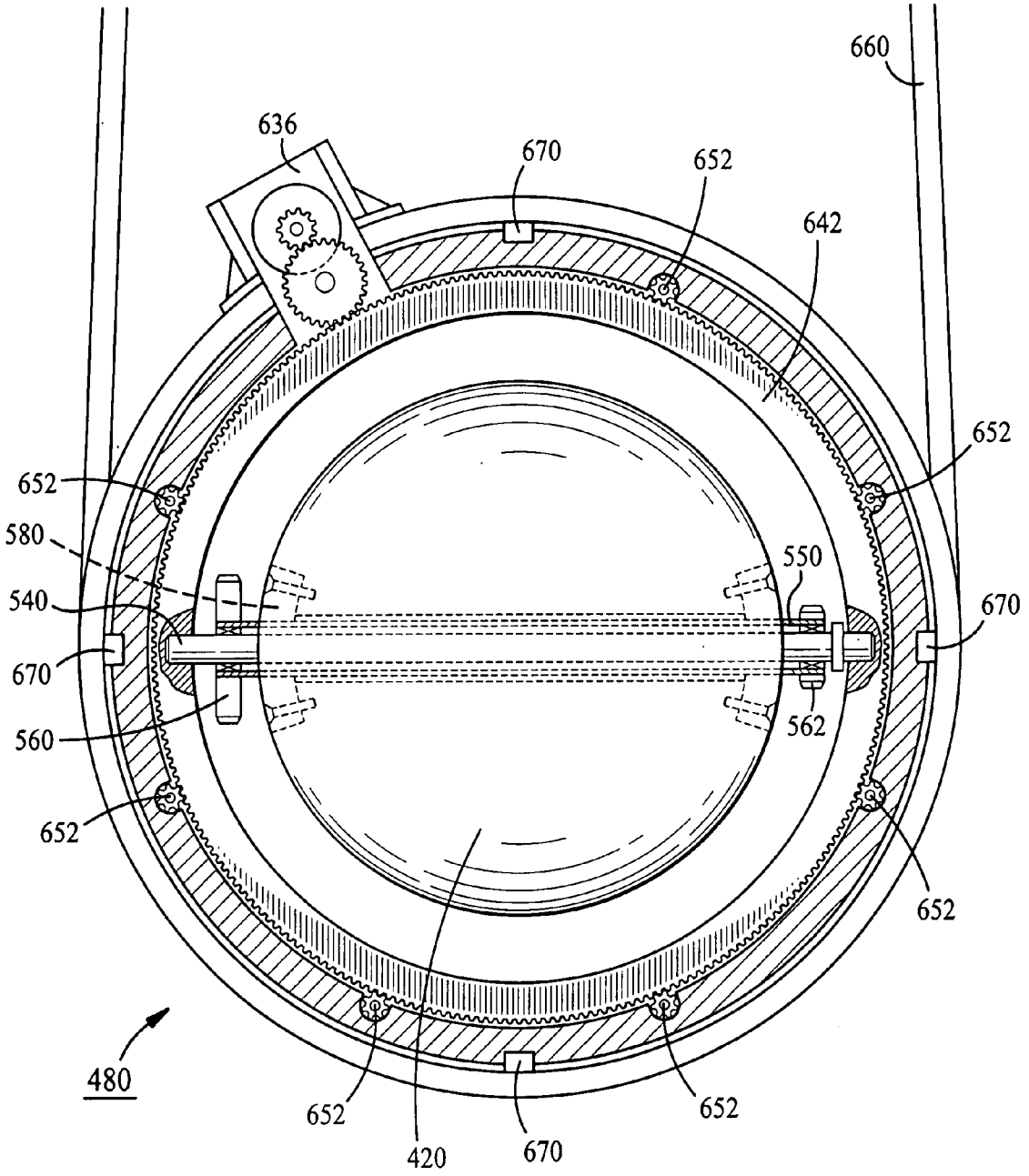
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FIG. 20

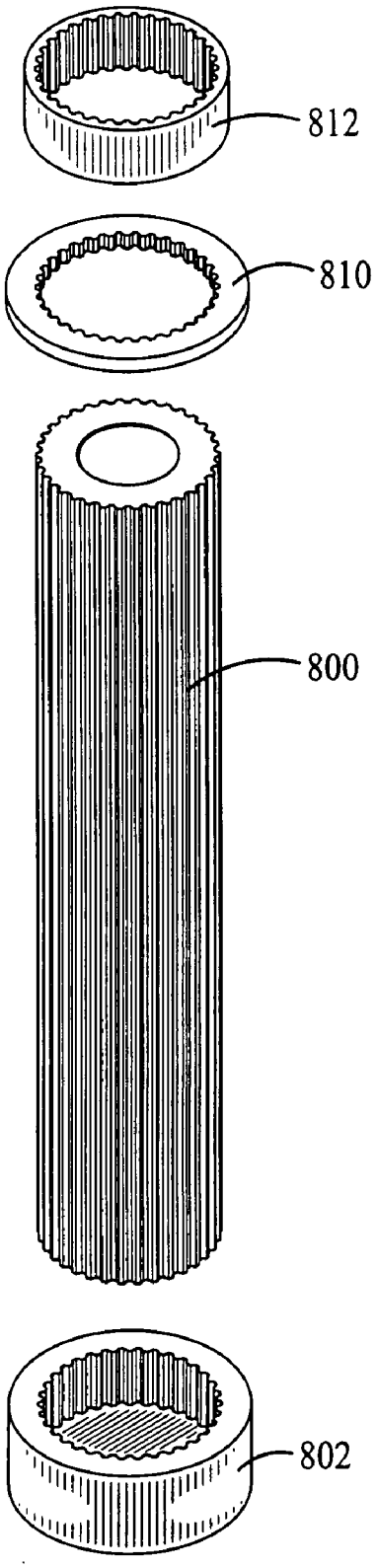

FIG. 21

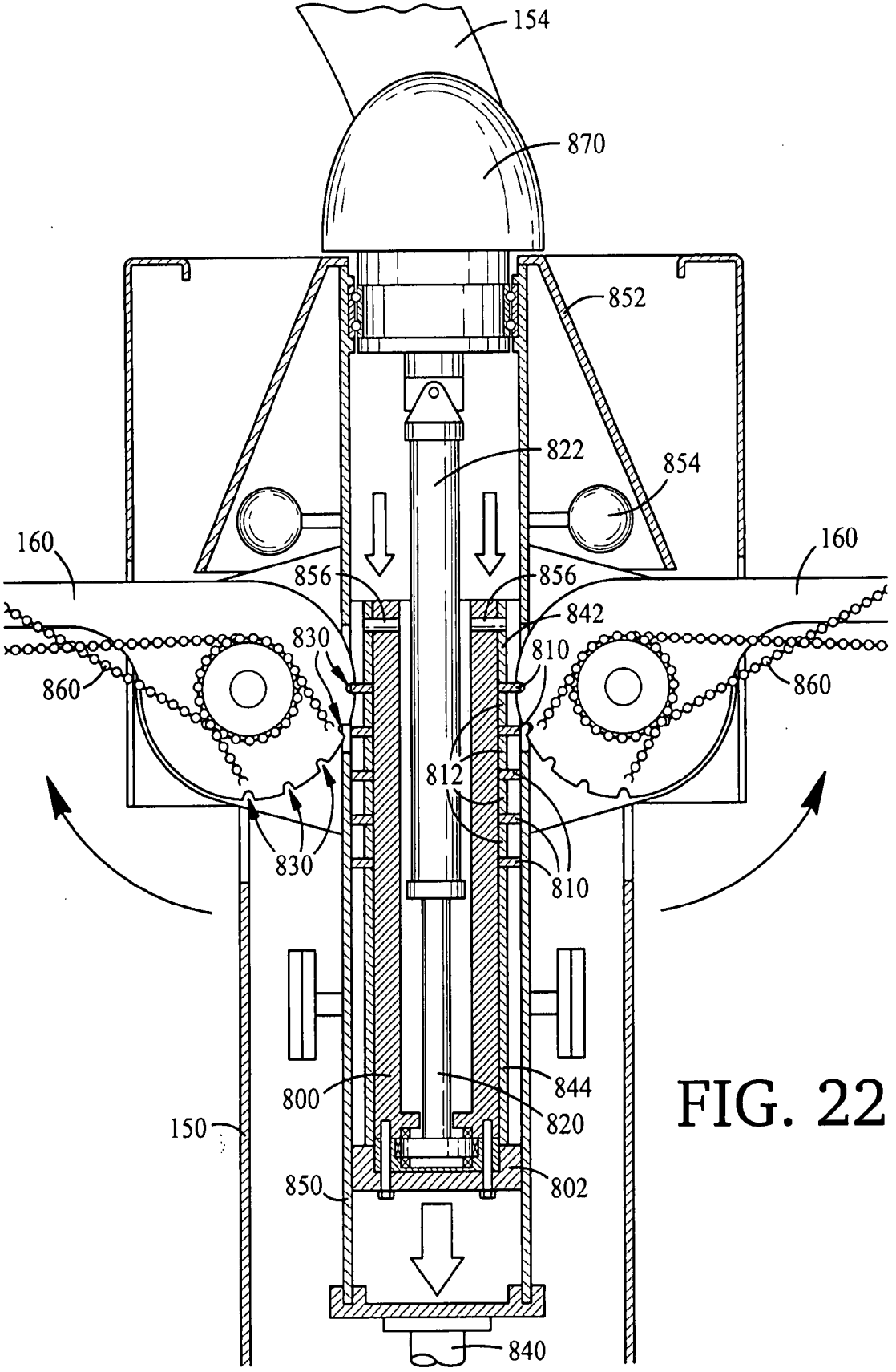
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FIG. 22

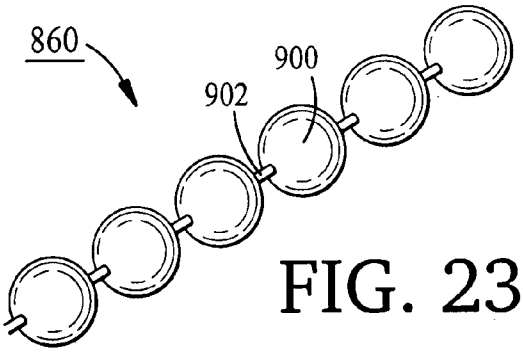

FIG. 23

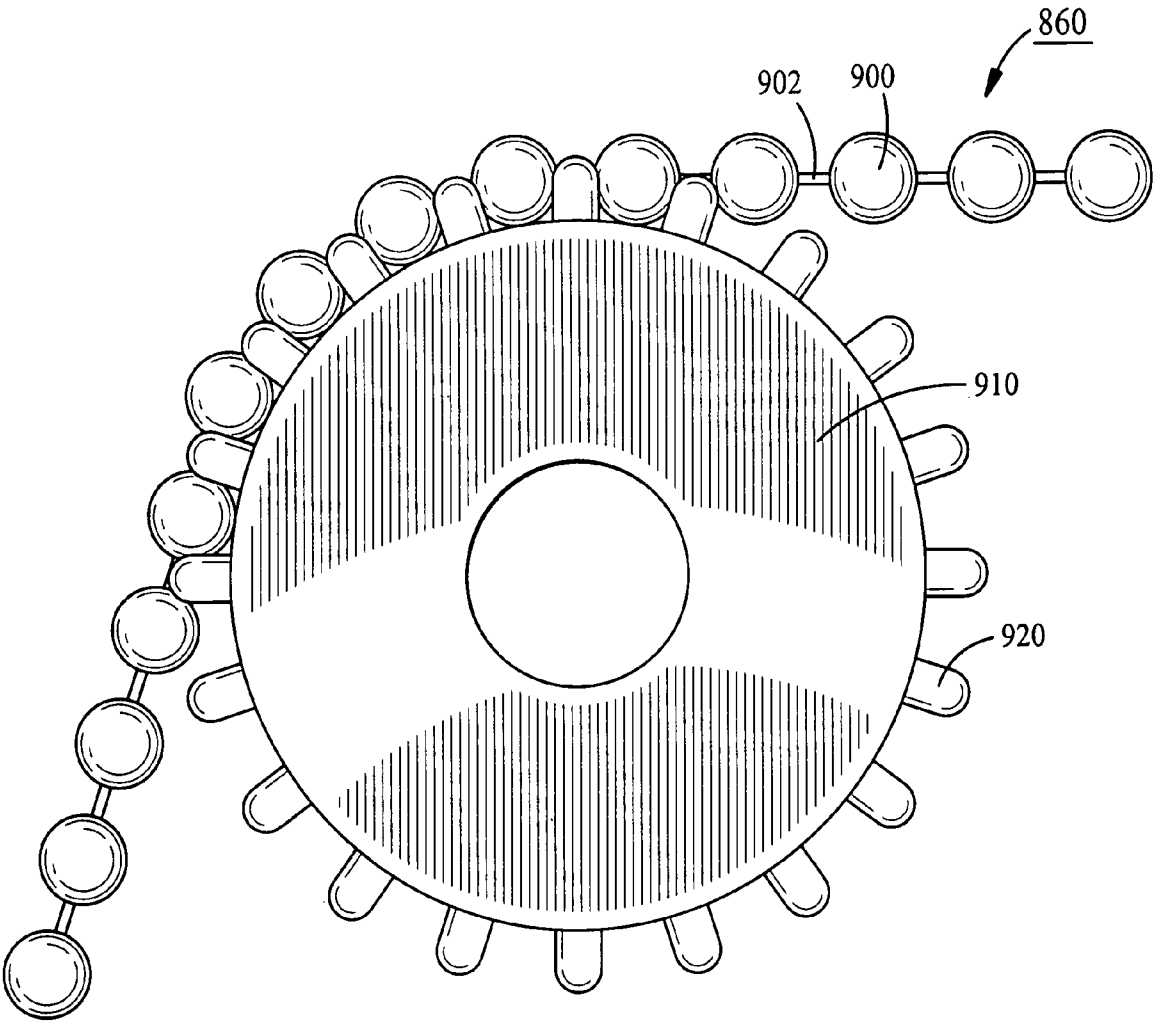

FIG. 24

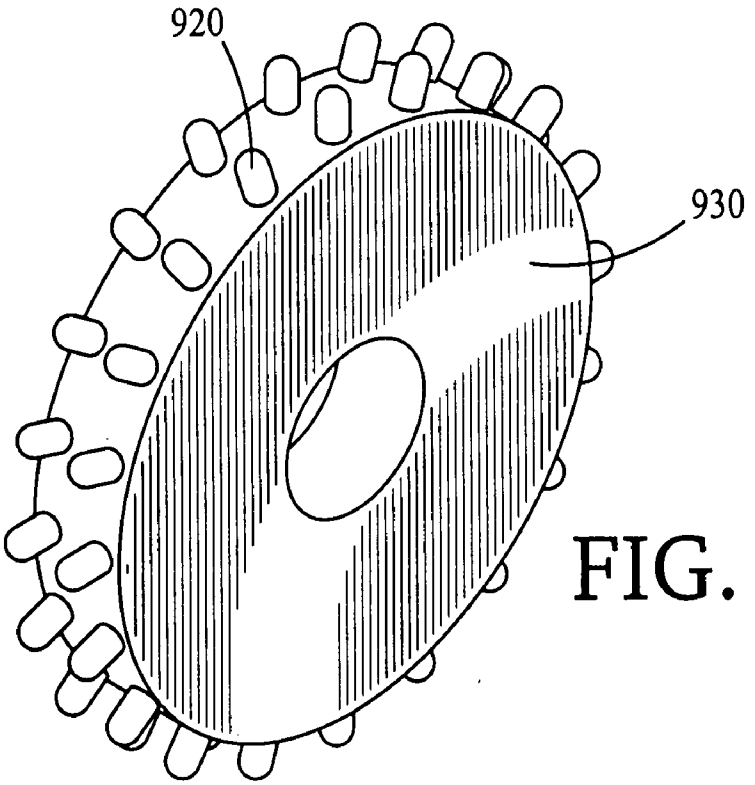

FIG. 25

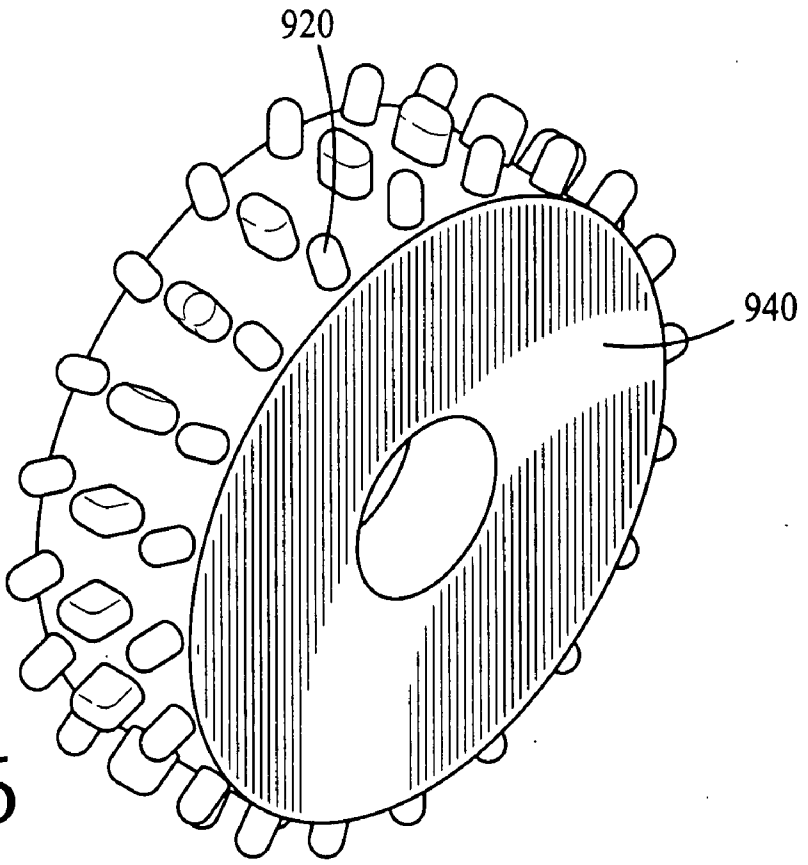

FIG. 26

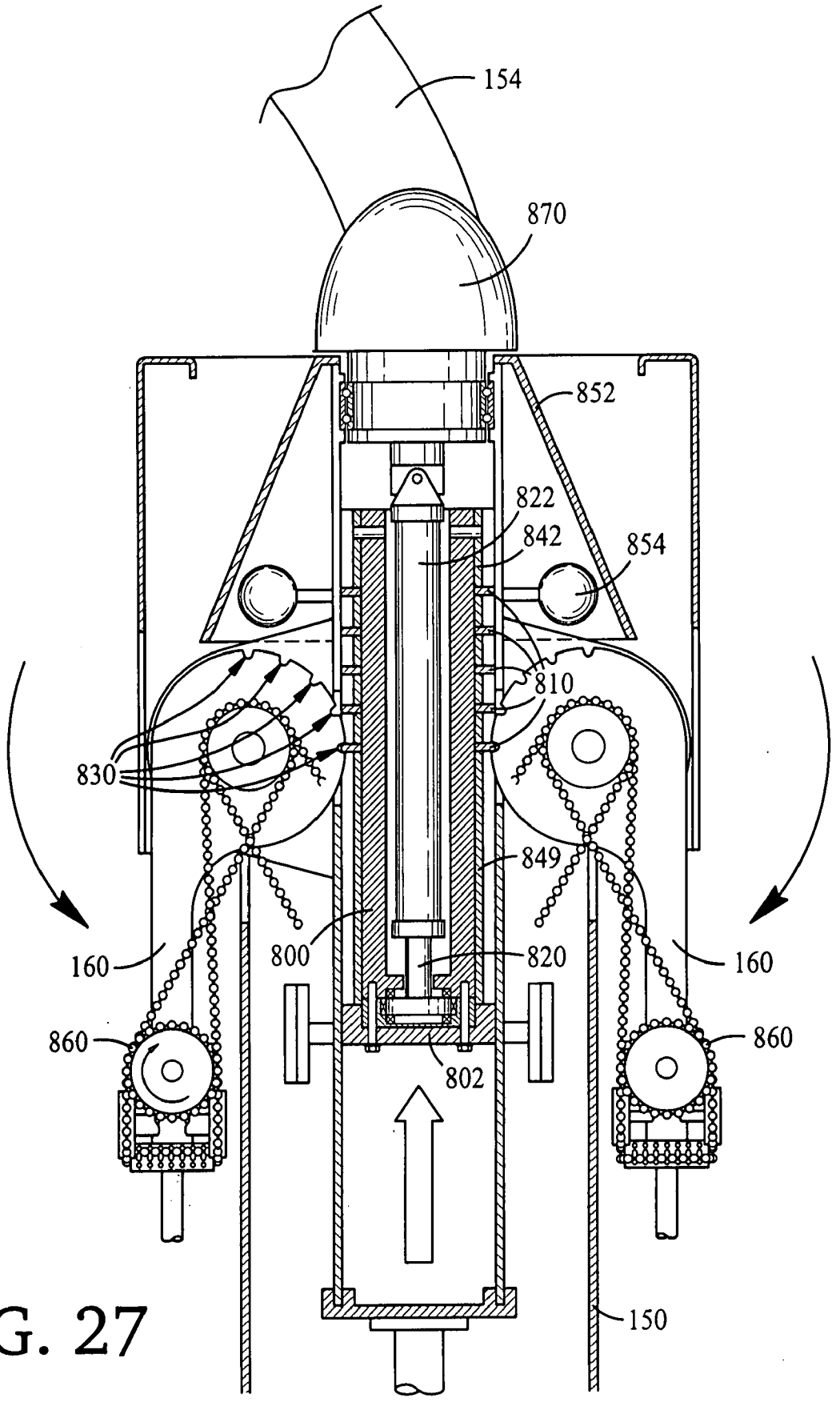
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FIG. 27

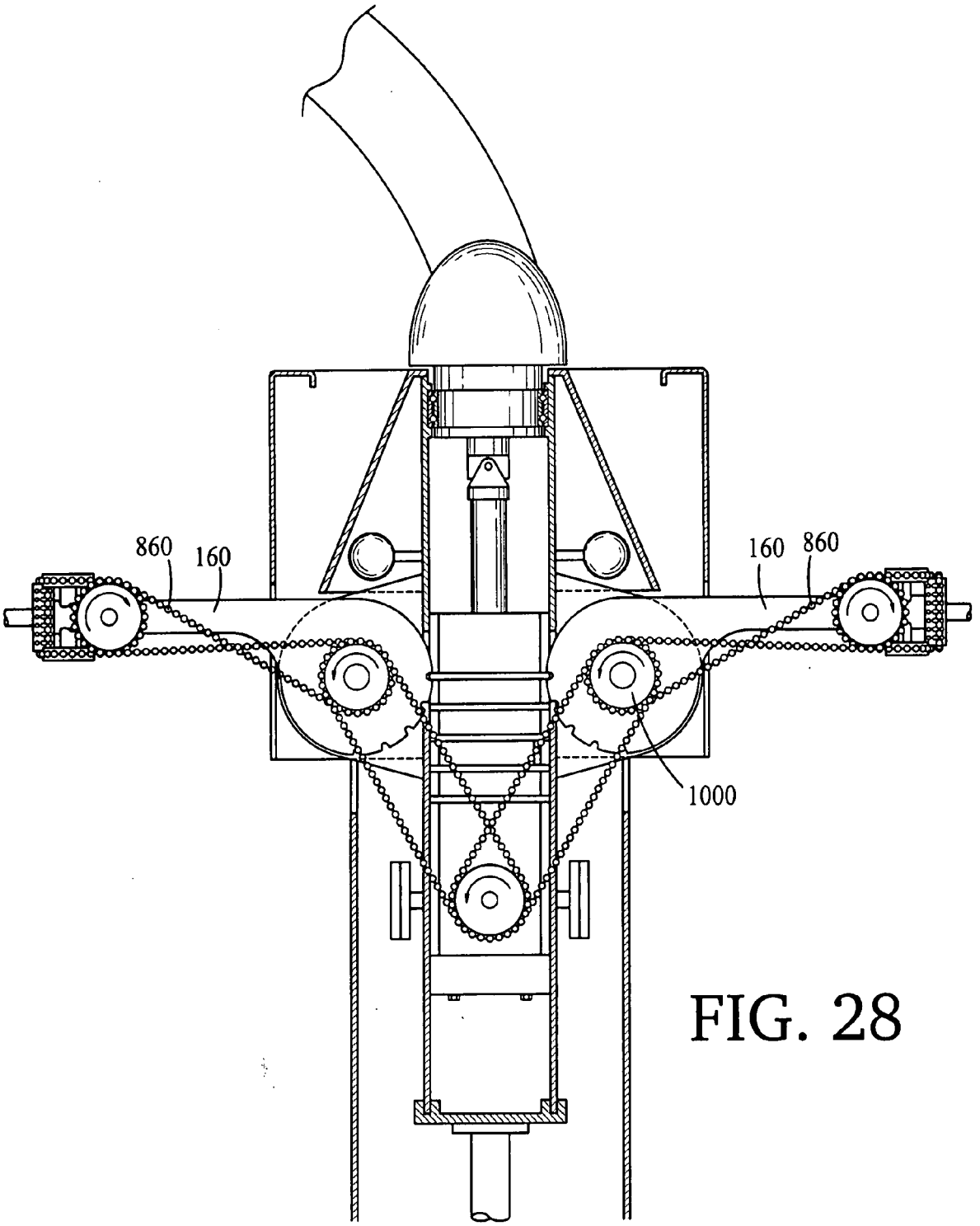

FIG. 28

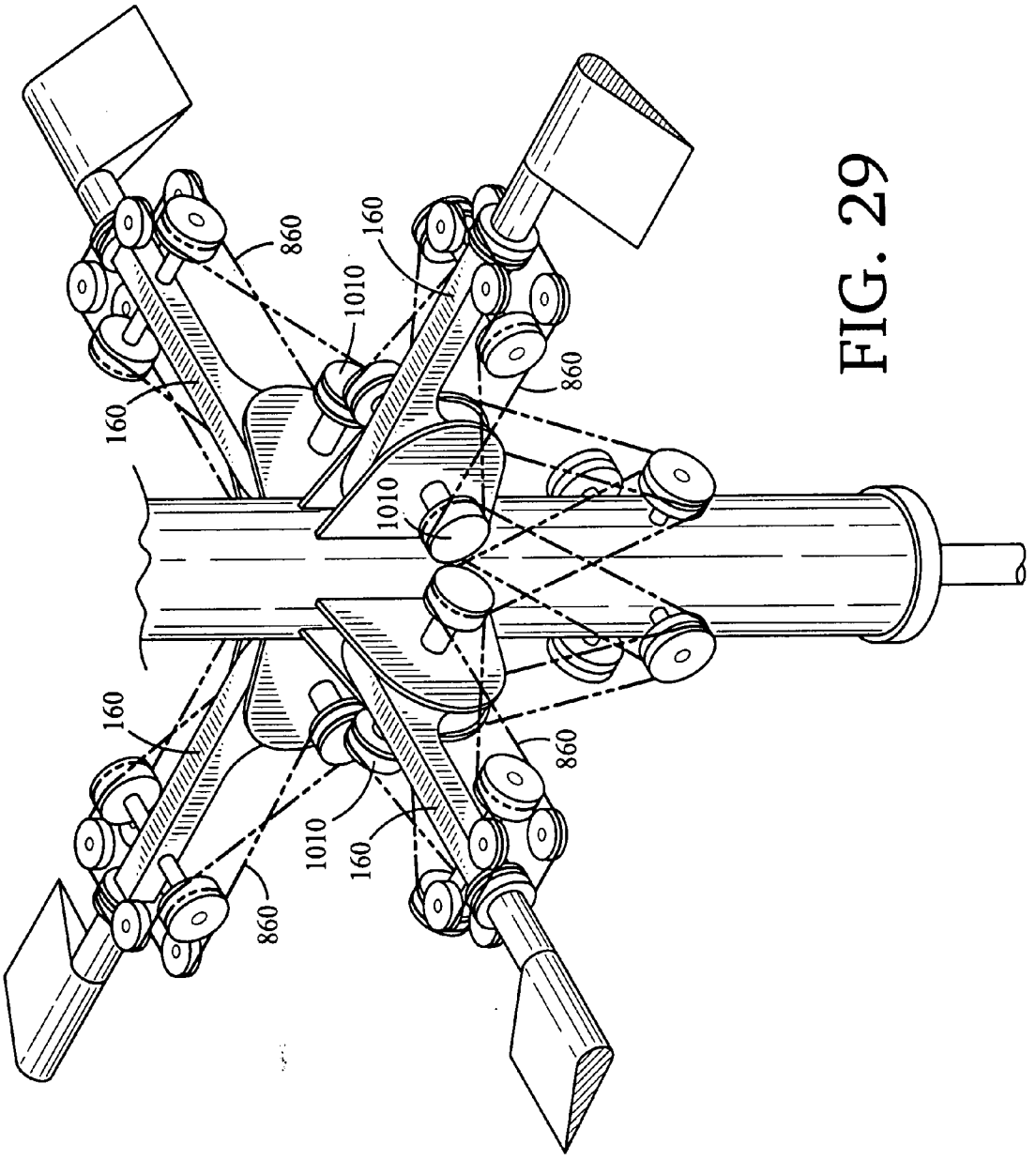

FIG. 29

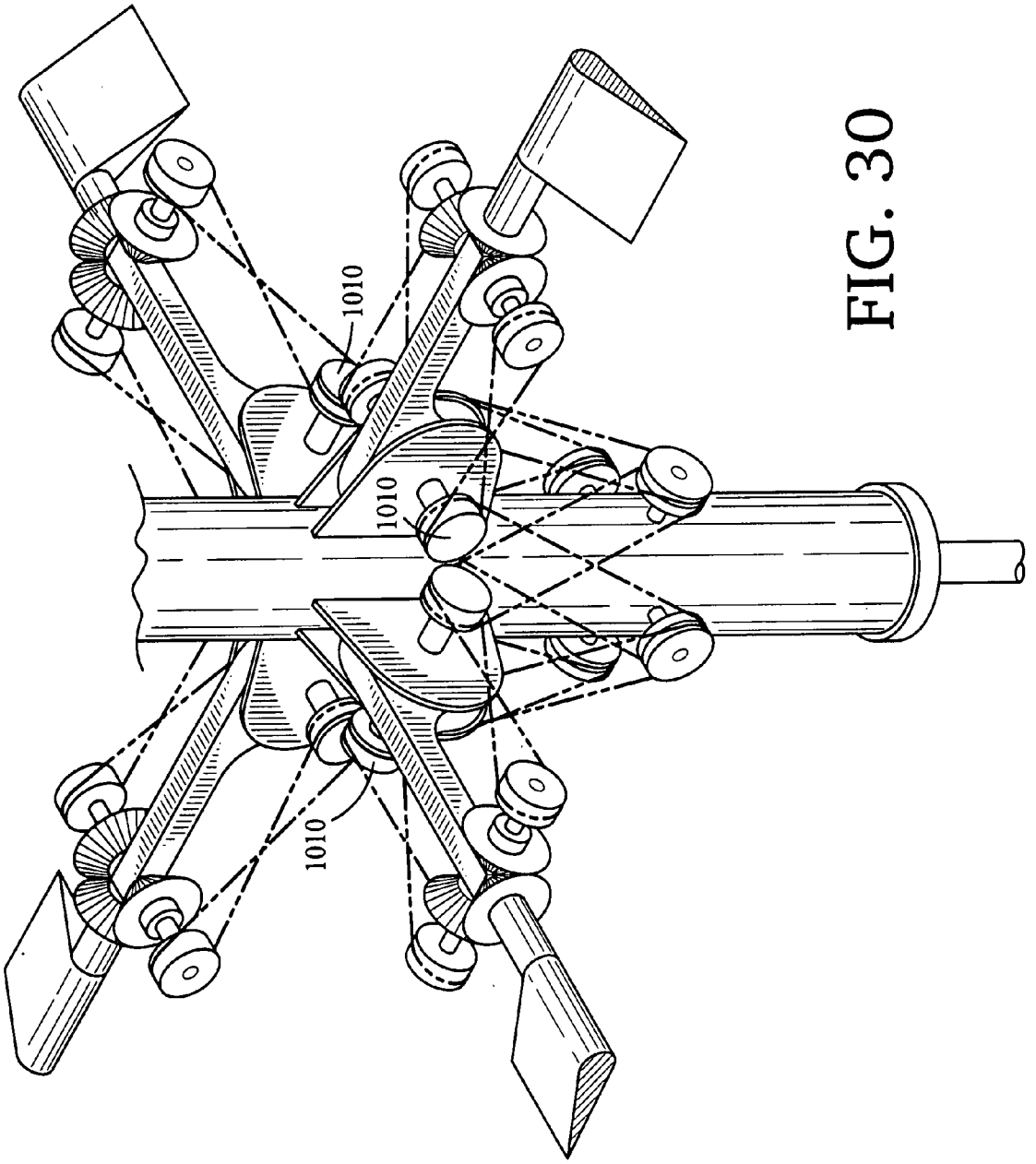

FIG. 30

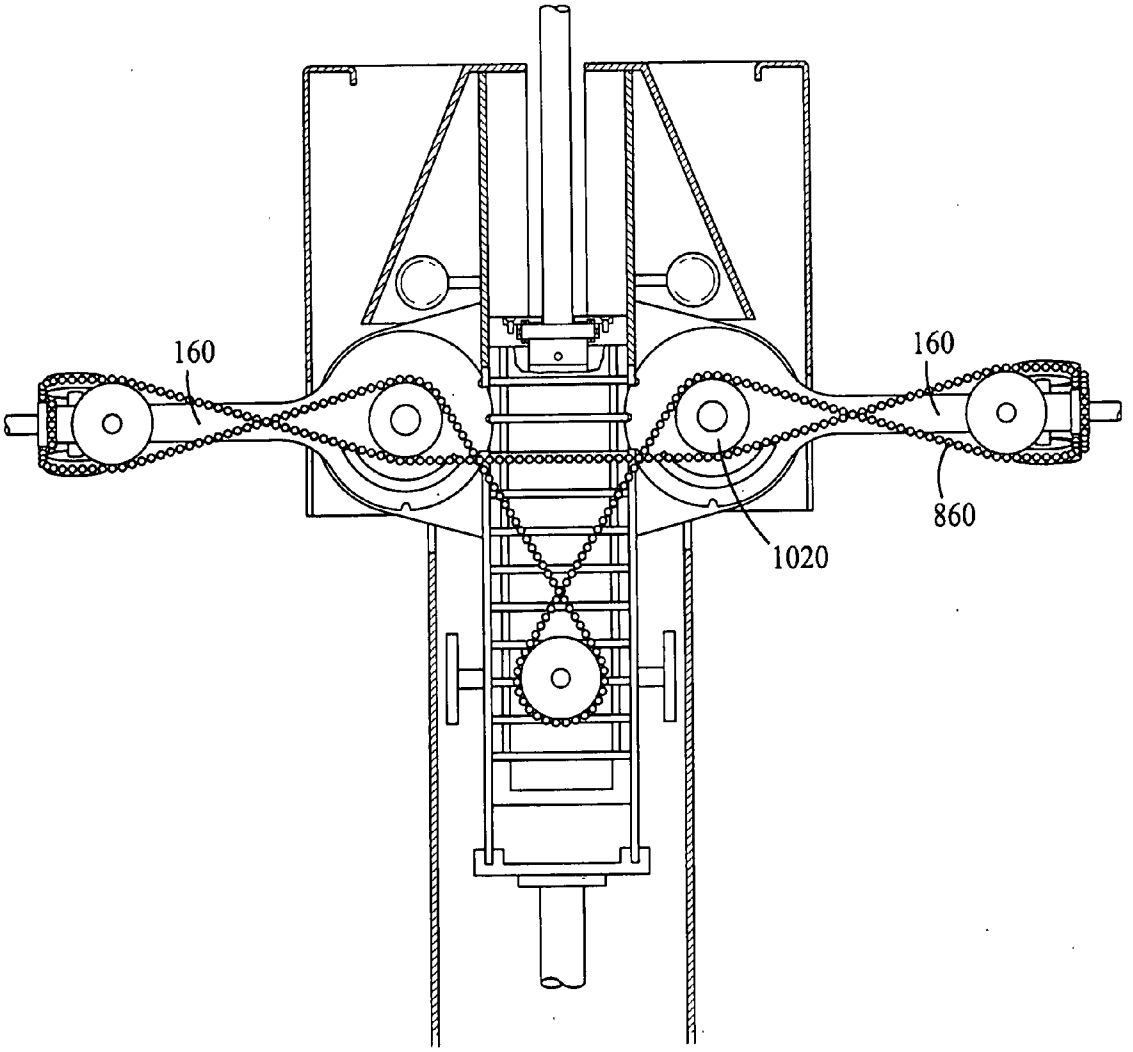

FIG. 31

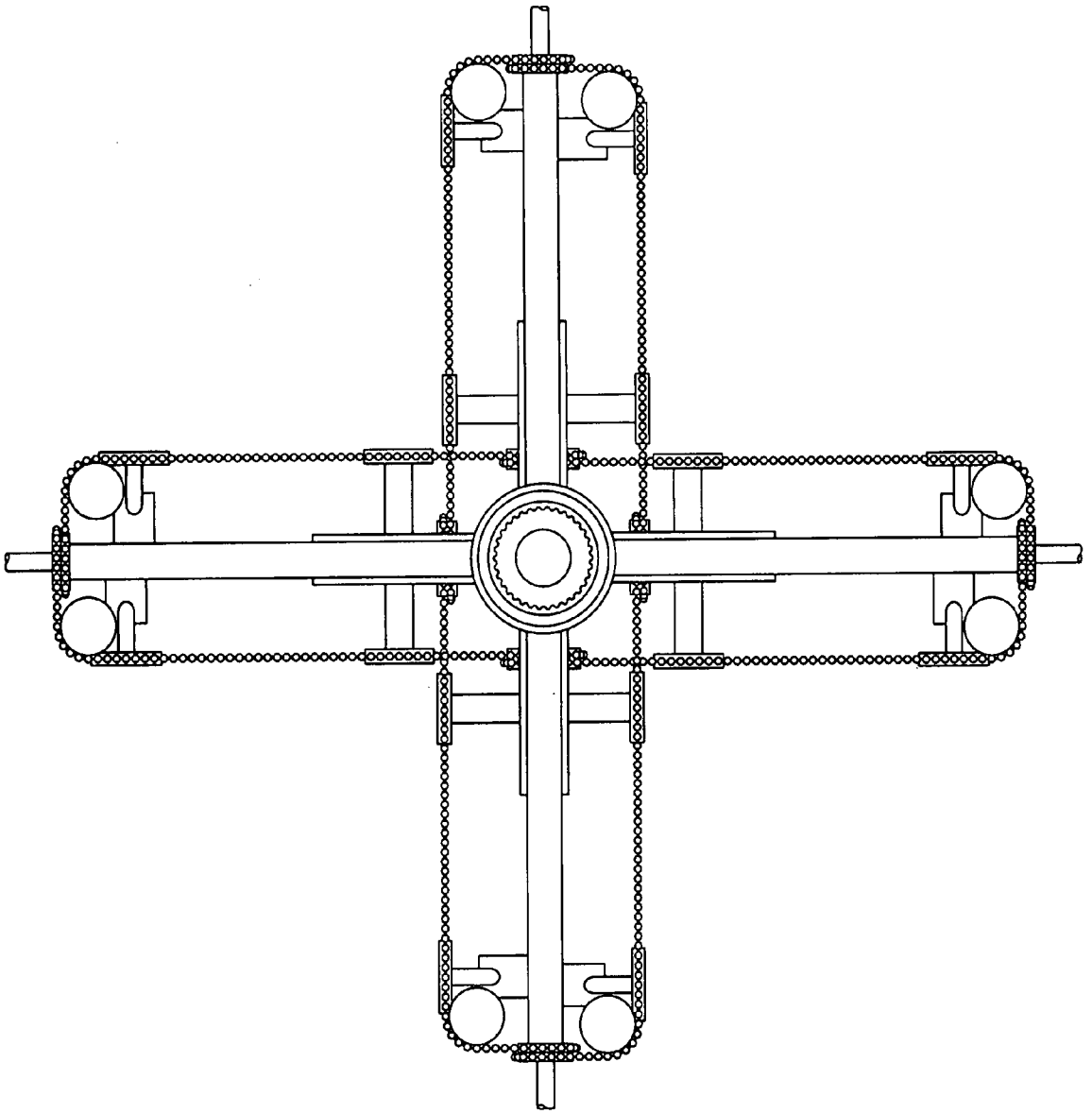

FIG. 32

BALL WHEEL FOR AN AIRCRAFT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a divisional of co-pending U.S. patent application Ser. No. 10/958,038, filed Oct. 4, 2004, and titled AERODYNAMICALLY STABLE, HIGH-LIFT, VERTICAL TAKEOFF AIRCRAFT. Benefit is claimed of the filing date of U.S. Provisional Application Ser. No. 60/507,530, filed Oct. 2, 2003, and titled FIVE-PIECE FUSELAGE, INCLUDING ENGINES AND WINGS, FOR AN AERODYNAMICALLY STABLE, HIGH-LIFT, VERTICAL TAKEOFF AIRCRAFT.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to vertical take-off aircraft generally and, more particularly, but not by way of limitation, to a ball wheel for such an aircraft.

[0004] 2. Background Art

[0005] Vertical take-off aircraft are useful in various situations in which horizontal space is limited. Aircraft are well known means of air transport. Among conventional aircraft are: common airplanes with fixed wings, helicopters with rotating wings, common airplanes with tilting rotors (Osprey), gyrocopters with freely rotating wings creating lift by spinning because vehicle is pushed with regular horizontal motor with propeller, fighter jets with adjustable thrust downwards for takeoff and horizontal thrust to fly (Joint Air Strike Fighter), rockets, and disc-shaped aircraft with internal engine exhaust blowing over airfoil to create lift.

[0006] A disadvantage of many of these conventional aircraft is that they require a relatively long horizontal distance to take off. Others, such as rockets, are unsuitable for general use.

[0007] The Osprey suffers from the disadvantage that it has only a lift force or a push force by propellers and during transitional flight, this force is divided. Because of the tilting of the propellers, the vehicle bearing low pressure disc (created by the propellers) gets much smaller and is divided into a vertical part and a horizontal part. But the vertical part needs enough bearing capacity to lift. This is resolved by providing oversized propellers—more than necessary—and this requires more than necessary engine power that is not efficient. Huge propellers are not efficient and are disturbing for straight level flight. During the tilting process, the propellers cut through the downwards directed air stream, reduce efficiency, and make the aircraft very shaky and unsecured. The tilting rotating masses create a gyroeffect and make it very hard to stabilize the aircraft, one movement creating another effect and so on. Sometimes the aircraft is impossible to control and it falls down.

[0008] Some attempts to provide such an aircraft include the following:

[0009] U.S. Pat. No. 2,859,003, issued Nov. 4, 1958, to Servanty, and titled AERODYNE, describes a vertical take-off aircraft that has three equally spaced engines spaced apart from the base of a fuselage by vertical wings. Three vertical winglets are disposed near the top of the fuselage. The fuselage is generally bullet-shaped.

[0010] U.S. Pat. No. 3,045,951, issued Jul. 24, 1962, to Freeland, and titled AIRCRAFT, describes an aircraft in which the four engines thereof are disposed within a fuselage that slopes inwardly and downwardly from a dome-shaped upper portion, but the lower portion is flared outwardly at the bottom thereof.

[0011] U.S. Pat. No. 3,120,359, issued Feb. 4, 1964, to Sprecher, and titled AIRCRAFT WITH EQUI-SPACED POWER PLANT, describes an aircraft that has four equally spaced engines disposed at an upper end of a fuselage and joined thereto by wings and four interposed wings disposed at a lower end of the fuselage and bearing at their distal ends landing gears. The fuselage is generally bullet-shaped.

[0012] U.S. Pat. No. 3,252,673, issued May 24, 1966, to Reichert, and titled SUPERSONIC VTOL AIRCRAFT AND LAUNCH VEHICLE, describes an aircraft having two engines disposed on the outside of a cylindrical shroud disposed in approximately the middle of a bullet-shaped aircraft, the shroud being supported from the aircraft by struts. Three wings are disposed at a lower end of the fuselage.

[0013] U.S. Pat. No. 4,123,018, issued Oct. 31, 1978, to Tassin de Montaigu, and titled HELICOPTER WITH COAXIAL ROTORS, OF CONVERTIBLE TYPE IN PARTICULAR, describes a helicopter that is clearly non-symmetrical.

[0014] U.S. Pat. No. 4,433,819, issued Feb. 28, 1984, to Carrington, and titled AERODYNAMIC DEVICE, describes a rotatable disk affixed to a central, generally dome-shaped body, the disk including a plurality of selectively vectorable jets. A plurality of reaction jets are attached to the central body.

[0015] U.S. Pat. No. 5,178,344, issued Jan. 12, 1993, to Dlouhy, and titled VTOL AIRCRAFT, describes, insofar as pertinent, a disk-shaped aircraft having a plurality of rotating sets of rotor blades disposed at least partially beneath the disk. The rotor blades may be pivotable to provide for horizontal motion of the aircraft.

[0016] U.S. Pat. No. 5,595,358, issued Jan. 21, 1997, to Demidov et al., and titled MULTIPURPOSE AIRBORNE VEHICLE, describes an aircraft having a plurality of rotor units disposed below a ring-shaped fuselage. U.S. Pat. No. 5,839,691, issued Nov. 24, 1998, to Lariviere, and titled VERTICAL TAKEOFF AND LANDING AIRCRAFT, describes such an aircraft that is clearly not symmetrical about its vertical axis.

[0017] U.S. Pat. No. 6,293,491, issued Sep. 25, 2001, to Wobben, and titled VERTICAL TAKE-OFF AND LANDING AIRCRAFT, describes another such aircraft that is clearly not symmetrical about its vertical axis.

[0018] Accordingly, it is a principal object of the present invention to provide a vertical takeoff aircraft that is aerodynamically stable.

[0019] It is a further object of the invention to provide such an aircraft that has high lift.

[0020] It is another object of the invention to provide such an aircraft that is highly symmetrical.

[0021] It is an additional object of the invention to provide novel landing gears, including ball wheels, for such an aircraft.

[0022] It is yet a further object of the invention to provide a novel method of adjusting pitches of rotating blades for such an aircraft.

[0023] Other objects of the present invention, as well as particular features, elements, and advantages thereof, will be

elucidated in, or be apparent from, the following description and the accompanying drawing figures.

SUMMARY OF THE INVENTION

[0024] The present invention achieves the above objects, among others, by providing in a preferred embodiment, an apparatus, comprising: a ball wheel; and means to cause said ball wheel to rotate in a selected direction.

BRIEF DESCRIPTION OF THE DRAWING

[0025] Understanding of the present invention and the various aspects thereof will be facilitated by reference to the accompanying drawing figures, provided for purposes of illustration only and not intended to define the scope of the invention, on which:

[0026] FIG. **1** is an isometric view of one embodiment of an aircraft according to the present invention.

[0027] FIG. **2** is a side elevational view of the embodiment of FIG. **1**.

[0028] FIG. **3** is a fragmentary, isometric view of an alternative embodiment of the top mast of the aircraft.

[0029] FIG. **4** is a fragmentary, side elevational view of the alternative embodiment of FIG. **3**.

[0030] FIG. **5** is a fragmentary, isometric view of an alternative embodiment of the covering of the upper part of the aircraft.

[0031] FIG. **6** is a side elevational view of the embodiment of FIG. **1** with jet engines disposed on the wings of the aircraft.

[0032] FIG. **7** is a bottom plan view of the embodiment of FIG. **6**.

[0033] FIG. **8** is a top plan view of the embodiments of FIGS. **3**, **4**, and **6**.

[0034] FIG. **9** is a side elevational, schematic view showing certain major elements of the aircraft of the present invention.

[0035] FIG. **10** is a fragmentary, isometric view showing a detail of the columns of the aircraft.

[0036] FIG. **11** is an isometric view of the aircraft with the landing gears thereof extended.

[0037] FIG. **12** is a fragmentary isometric view showing in more detail the mechanism of the landing gears of FIG. **11**.

[0038] FIG. **13** is a top plan view of the locking mechanism of the landing gear of the aircraft, in unlocked position, but being locked.

[0039] FIG. **14** is a top plan view of the locking mechanism of the landing gear of the aircraft in locked position.

[0040] FIG. **15** is a partially exploded isometric view of a ball wheel with, inter alia, a drive shaft tube, a fixed axle, and drive gears.

[0041] FIG. **16** is a partially exploded view of the elements in partially assembled relationship.

[0042] FIG. **17** is an exploded isometric view of the major components of the ball wheel assembly.

[0043] FIG. **18** is an end elevational view, partially in cross-section, of some of the components of the ball wheel assembly in assembled relationship.

[0044] FIG. **19** is a fragmentary top elevational view, partially in cross-section, taken along line "**19-19**" of FIG. **18**.

[0045] FIG. **20** is a fragmentary top elevational view, partially in cross-section, taken along line "**20-20**" of FIG. **18**.

[0046] FIG. **21** is an isometric view showing some of the major elements of the propeller raising and lowering mechanism.

[0047] FIG. **22** is a fragmentary side elevational view showing, inter alia, the elements of FIG. **21** installed in a column of the aircraft, two of the blades of the rotor in a raised or operating position.

[0048] FIG. **23** is a fragmentary isometric view showing a portion of a ball chain.

[0049] FIG. **24** is a fragmentary side elevational view showing a portion of a ball chain disposed over a ball chain engaging gear/pulley.

[0050] FIG. **25** is an isometric view of a gear/pulley for engaging a single ball chain.

[0051] FIG. **26** is an isometric view of a gear/pulley for engaging two ball chains.

[0052] FIG. **27** is a fragmentary side elevational view showing, inter alia, the elements of FIG. **21** installed in a column of the aircraft, with two of the blades of the rotor in a lowered position.

[0053] FIG. **28** is a fragmentary side elevational view showing how the ball chains are used to adjust the pitch of the distal ends of two of the blades, the blades being shown in their raised position.

[0054] FIG. **29** is a fragmentary isometric view showing the routing of the ball chains to adjust the pitch of the distal ends of the blades using the ball chains.

[0055] FIG. **30** is a fragmentary isometric view showing the routing of the ball chains to adjust the pitch of the distal ends of the blades using miter gears.

[0056] FIG. **31** is a fragmentary side elevational view of an alternative embodiment of the routing of a chain **860**.

[0057] FIG. **32** is a fragmentary top plan view of the embodiment of FIG. **31**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0058] Reference should now be made to the drawing figures on which similar or identical elements are given consistent identifying numerals throughout the various figures thereof, and on which parenthetical references to figure numbers, when used, direct the reader to the view(s) on which the element(s) being described is (are) best seen, although the element(s) may be seen on other figures also.

[0059] FIGS. **1** and **2** illustrate an aircraft, constructed according to the present invention, and generally indicated by the reference numeral **100**. Aircraft **100** includes a transparent dome **110** near the top thereof, the dome being provided as a shield for the pilot of the aircraft. Aircraft **100** includes a centrally disposed upper portion **120** comprising an inverted hemisphere covered with a plurality of Z-shaped, overlapping zig-zag tiles, as at **122**. A plurality of windows, as at **130**, is disposed at the lower edge of the upper portion **120** and a plurality of lights, as at **132**, is disposed in an inverted truncated conical transitional portion **140** connecting the upper portion to a generally cylindrical lower portion **142**. The diameter of the upper end of generally cylindrical lower portion **142** is slightly greater than the diameter of the lower end thereof, while the diameter of the upper end thereof is less than the diameter of the lower end of the upper portion **120**. A horizontal air intake **144** for a rocket motor (not shown) disposed in generally cylindrical lower portion **142** is disposed at the intersection of the transitional portion **140** and the lower end of upper portion **120**.

[0060] Aircraft **100** includes four vertical columns **150** attached to lower portion **142** by four wings **152** and connected to transitional portion **140** by four support struts **154**

(only three visible on FIGS. **1** and **2**). Sixteen generally horizontal blades, as at **160**, operatively connected to turboprop engines (not shown), four in each column **150**, are disposed near the top of the columns. Of course, other than turboprop engines may be provided as well. Each wing **152** contains an elevator **170** (only three visible on FIG. **1** and only two visible on FIG. **2**).

[0061] Generally cylindrical lower portion **142** includes four radiator grills, as at **180** (only one shown on FIG. **1** and none visible on FIG. **2**), the radiators being disposed for engine cooling.

[0062] At the base of each vertical column **150** is a support pad **190** (only three visible on FIGS. **1** and **2**) on which aircraft **100** generally is disposed. On each vertical column **150** is disposed an outwardly facing landing gear **200** (only three visible on FIGS. **1** and **2**) strapped to its respective vertical column by means of straps, as at **202**. The construction and operation of landing gears **200** is described in more detail, infra.

[0063] A vertical top mast centrally disposed atop and rising vertically from transparent dome **110** on upper portion **120** includes at the distal end thereof a shock ring **210**, a smooth primary sphere **212** underneath the shock ring, and a fluted secondary sphere **214** underneath the primary sphere.

[0064] FIGS. **3** and **4** illustrate an alternative embodiment of the vertical top mast and includes a vertical pointed spike **250** at the top thereof, underneath which is a first spherical globe **252**, underneath which is a second spherical globe **254** having a diameter greater than that of the first spherical globe, and underneath the second spherical globe is a third spherical globe **256** having a diameter greater that that of the second spherical globe.

[0065] FIG. **5** illustrates an alternative covering for upper portion **120**, here a plurality of rosettes, as at **260**, each disposed on a tile, as at **262**.

[0066] FIG. **6** illustrates pairs of vertically disposed jet engines **280** on each of wings **152** (only four shown on FIG. **6**).

[0067] FIG. **7** illustrates a bottom plan view of the embodiment of FIG. **6** and also shows extending downwardly from a lower surface of generally cylindrical lower portion **142** four outlet nozzles **300** of the rocket engine (not shown) disposed in lower portion **142**.

[0068] FIG. **8** illustrates a top plan view of the embodiment of FIG. **3**, **4**, or **6**, without the covering of top portion **120**.

[0069] FIG. **9** illustrates schematically the engines **320**, the generators **330** operatively connected to the engines, and fuel tanks **350**, **352**, and **354**. Fuel tanks **350** may supply fuel to engines **320**, fuel tank **352** may supply fuel to the rocket engine (not shown), and fuel tanks **354** may supply fuel to jet engines **280** (FIG. **6**). Generators **330** may supply power to power-consuming elements of aircraft **100**.

[0070] The arrows on FIG. **9** illustrate the symmetrical flow of air past aircraft **100** when the aircraft is in flight caused by the symmetry of aircraft **100**. The shape of the fuselage of aircraft **100** also contributes to high lift.

[0071] FIG. **10** illustrates that columns **150** (FIG. **1**) may have vertical flutes, as at **380**.

[0072] FIGS. **1-10** illustrate aircraft **100** in position for takeoff, or shortly after takeoff. At takeoff, aircraft **100** rests on support pads **190** (FIG. **1**) which are disposed on a generally horizontal surface (not shown). At takeoff, horizontal blades **160** are rotating and are adjusted to their maximum pitches. The rocket engine (nozzles **300** shown on FIG. **7**) is ignited. If jet engines **280** (FIG. **6**) are used, they have been ignited. The thrust thus developed by the various engines causes aircraft **100** to take off.

[0073] FIG. **11** illustrates landing gears **200** deployed for maneuvering aircraft **100** on a surface (not shown).

[0074] FIG. **12** illustrates in more detail the construction of a deployed landing gear **200**. Landing gear **200** includes a generally vertical outer housing **400** that is strapped to a column **150** with a plurality of straps, as at **202**. A support/drive housing **410** closes generally vertical outer housing **400** when the support/drive housing is in a retracted position (FIG. **1**). It will be understood that a ball wheel **420** disposed at the distal end of support/drive housing **410** is below support pad **190** when the support/drive housing **410** is in the extended position shown.

[0075] Internally of generally vertical outer housing **400** are fixedly mounted two hydraulic motors **430** that are operatively connected to a horizontal shaft **432** on which is mounted two vertical drive pulleys **434**. Drive pulleys **434** drive vertical two endless belts (or chains) **440** that are looped around at their bottoms two idler pulleys **442** fixedly disposed with respect to horizontal shaft **432**. A plate **450** is fixedly attached to two vertical belts **440** such that the plate rides up and down in generally vertical outer housing **400**. Rotatably attached to plate **450** and to support/drive housing **410** is a retraction/support strut **460**. It will be understood that, as plate **460** is lowered in generally vertical outer housing **400**, support/drive housing **410** will be extended as shown on FIG. **12**, and, as plate **460** is raised in the generally vertical outer housing, the support/drive housing will be retracted to its closed position (FIG. **1**).

[0076] Ball wheel **420** is disposed in ball drive assembly **480** and disposed atop the ball wheel, as shown on FIG. **12**, is locking member **500**, the structure and function of these elements being described in detail, infra.

[0077] FIG. **13** illustrates support/drive housing **410** being locked in retracted position. Two hydraulic cylinders **510** are fixedly mounted in column **150**. Two catches **520** are fixedly disposed at the ends of two pistons **522** movable within the hydraulic cylinders, the catches being disposed so as to lock locking member **500** in place in column **150** as the catches are moved in the direction indicated by the arrows on FIG. **13**.

[0078] On FIG. **14**, catches **520** have fully engaged locking member **500** and support/drive housing **410** securely closes generally vertical outer housing **400**.

[0079] FIG. **15** illustrates ball wheel **420** with a fixed axle **540** that is inserted through the ball wheel and a drive shaft tube **550** that fits rotatingly over the fixed axle. First and second drive gears **560** and **562**, respectively, are fixedly disposed at the ends of drive shaft tube and a counter gear **564** drives second drive gear **562**. As will be seen, infra, this arrangement permits first and second drive gears **560** and **562** to be driven by a ring gear (not shown on FIG. **15**). A bracket **570** is provided to hold counter gear **564**. Ball wheel hubs **580** are fixedly disposed on either side of ball wheel **420** through which fixed axle **540** and drive shaft tube **550** pass.

[0080] FIG. **16** illustrates the elements of FIG. **15** in partially assembled relationship.

[0081] FIG. **17** is an exploded isometric view of the major elements of ball drive assembly **480**. Starting at the top and working downwardly, first there is the locking member **500**, then a top ball wheel cover **600**, then a top gasket **602**, then a ball housing cover **604**, then a cover member **606**, with four circumferentially equally spaced vertical slots formed on the

outer periphery of the cover member, and then a first bearing ring **610**. First bearing ring **610** includes (not shown in detail) top and bottom bearing races between which is disposed a plurality of needle bearings. Subsequent bearing rings have a similar same structure.

[0082] Continuing to refer to FIG. **17**, next, there is a drive gear ring **620** (shown on FIG. **17** inverted for clarity), with teeth formed on its outer periphery and on its lower inside surface, followed by a second bearing ring **622**, and then ball wheel **420**. Next, is a ball wheel housing mid-section **630**, with seven upper idler gears **632** vertically disposed in an upper portion thereof, and with four circumferentially equally spaced vertical slots **634** formed on the outer periphery of the ball wheel housing mid-section. Also shown with ball wheel housing mid-section **630** is a ball wheel steering motor and gearing **636**, with the latter portion of that element extending into the interior of the ball wheel housing mid-section to engage teeth of a ball wheel steering gear. Also shown with ball wheel housing mid-section **630** is a ball wheel drive motor and gearing **638**, with the latter portion of that element extending into the interior of the ball wheel housing mid-section to engage the gear teeth formed on the outer periphery of drive gear ring **620**.

[0083] Then, there is a third bearing ring **640**, followed by a steering gear ring **642**, with two holes **643** (only one visible on FIG. **17**) for the journaling therein of fixed axle **540** and with teeth formed on its outer periphery, and then a fourth bearing ring **644**. Next, there is a ball wheel housing base **650**, with seven vertically disposed idler gears **652** rising from an upper surface of the ball wheel housing base, and with four circumferentially equally spaced slots **654** formed on the outer periphery of the ball wheel housing base.

[0084] Next, there is a ball wheel bearing housing **660** into the circular portion of which are disposed the above elements beginning with cover member **606**. Four vertical flanges are formed on the interior periphery of the circular portion of ball wheel housing **660** to engage slots **608**, **634**, and **654** to keep the respective elements of which the slots are a part from rotating with respect to the wheel bearing housing. Also shown as part of ball wheel housing **660** are cutouts **680** and **682** to accommodate, respectively, steering motor and gearing **636** and drive motor and gearing **638**. Finally, there is a bottom gasket **690**.

[0085] FIG. **18** illustrates some of the major elements of wheel drive assembly **480** in assembled relationship. A description of these elements of ball drive assembly **480** is given with reference to FIG. **17**. In addition, bearing balls, as at **700**, are disposed between ball wheel **420** and ball wheel cover **602** to bear some of the load presented by the ball wheel.

[0086] FIG. **19** illustrates some of the major elements of ball wheel drive assembly **480** in assembled relationship. A description of these elements of ball drive assembly **480** is given with reference to FIG. **17**.

[0087] FIG. **20** illustrates some of the major elements of ball wheel drive assembly **480** in assembled relationship. A description of these elements of ball drive assembly **480** is given with reference to FIG. **17**.

[0088] FIG. **21** illustrates some of the major elements of the mechanism to raise and lower blades **160** (FIG. **1**). At the heart of the mechanism is a vertical splined core **800** that, at its bottom, fits adjacent a clamp cap base **802**. A tooth ring **810** having complementarily shaped teeth on its inner periphery fits over splined core **800** and a spacer ring **812** also having complementarily shaped teeth on its inner periphery fits over the splined core and engages and separates adjacent tooth rings **810**.

[0089] FIG. **22** illustrates the elements of FIG. **21** installed in a column **150**. Blades **160** have been raised to their operating position by the piston **820** of a stationary hydraulic cylinder **822** lowering splined core **800**, as is indicated by the arrows on FIG. **22**, and a tooth ring **810** engaging uppermost indentations **830** in the proximal ends of blades **160**. It will be understood that a second pair of blades **160** (not shown on FIG. **22**) will be disposed orthogonal to the blades shown on FIG. **22**. Rotational motion is imparted to the assembly by means of a rotating shaft **840** operatively connected to a motor **320** (FIG. **9**). A short spacer ring **842** is disposed at the top of splined core **800** and a long spacer ring **844** is disposed at the bottom of the splined core.

[0090] Also shown as rotating elements on FIG. **22** are a vertical housing **850**, a truncated cone **852**, to compress incoming air, attached to the top of the vertical housing, four counterbalance balls **854** (only two shown on FIG. **22**) fixedly attached to the housing, pins **856** to attach all the spacers to splined core **800**, and ball chains **860**, the function of which is described, infra.

[0091] Non-rotating elements shown on FIG. **22**, in addition to piston **820** and hydraulic cylinder **822**, include column **150**, supporting strut **154**, and a bull nose **870**.

[0092] FIG. **23** illustrates a ball chain **860** comprises a plurality of balls, as at **900**, adjacent pairs of which are held together by pins, as at **902**, having enlarged heads (not shown) at either end thereof. Ball chain **860** is highly flexible and strong.

[0093] FIG. **24** illustrates ball chain **860** being engaged by a circular gear/pulley **910**. Gear/pulley **910** has a plurality of teeth, as at **920**, equidistantly spaced about the outer periphery of the gear/pulley, adjacent pairs of which teeth about the outer periphery of the gear/pulley engage one of the balls **900** of ball chain **860**. Gear/pulley **910** may drive ball chain **860** or it may be an idler gear/pulley.

[0094] FIG. **25** illustrates a gear/pulley **930** for engaging a single ball chain **860**. It will be noticed that teeth **920** are disposed in side-by-side pairs, with each pair of teeth lying in a plane parallel to the central plane of gear/pulley **930**.

[0095] FIG. **26** illustrates a gear/pulley **940** for engaging two ball chains **860**. It will be noticed that teeth **920** are disposed side-by-side three abreast, with each triplet of teeth lying in a plane parallel to the central plane of gear/pulley **940**.

[0096] FIG. **27** illustrates blades **160** in a lowered position, the blades having been brought to this position by the raising of splined core **800**, in the direction of the arrow on FIG. **27**, such that the lower of tooth rings **810** engages the lower of indentations **830** on the proximal ends of the blades. This is the position blades **160** assume when aircraft **100** (FIG. **1**) has reached a certain speed. Of course, motor **320** (FIG. **9**) would be shut off when blades **160** are lowered.

[0097] FIG. **28** illustrates how ball chains **860** are used to adjust the pitch of the distal ends of opposing blades **160**. Note that gear/pulley **1000** is driven by a hydraulic motor (not shown). The rest of the gear/pulleys are idlers. The opposite side is a mirror image of the side shown, including a hydraulic drive motor synchronized to the hydraulic motor driving gear/pulley **1000**. It will be understood that a second pair of drivers similar to that shown will be employed to adjust the distal ends of a pair of blades **160** orthogonal to those shown.

[0098] FIG. **29** illustrates the routing of ball chains **860** to adjust the pitches of the distal ends of blades **160** using the ball chains. Note that there are four motorized gear pulleys **1010** (only three visible on FIG. **29**) that drive the ball chains **860**. The rest of the gear/pulleys are idlers. For greater clarity, the teeth on the gear/pulleys have been omitted.

[0099] FIG. **30** illustrates the routing of ball chains **860** to adjust the pitch of the distal ends of blades **160** using miter gears. Again, there are only four motorized gear/pulleys that drive ball chains **860**, the rest of the gear/pulleys being idlers. Again, for greater clarity, the teeth on the gear/pulleys have been omitted.

[0100] FIG. **31** illustrates an alternative embodiment of the routing of ball chain **860**. Again, only gear/pulley **1020** is motorized.

[0101] FIG. **32** is another view of the alternative embodiment of FIG. **31**.

[0102] It should be noted that the embodiment of FIGS. **22-30** has four ball chains **860** per side for a total of sixteen chains, while the embodiment of FIGS. **31** and **32** has only one ball chain per side for a total of four chains.

[0103] In the embodiments of the present invention described above, it will be recognized that individual elements and/or features thereof are not necessarily limited to a particular embodiment but, where applicable, are interchangeable and can be used in any selected embodiment even though such may not be specifically shown.

[0104] Spatially orienting terms such as "above", "below", "upper", "lower", "inner", "outer", "inwardly", "outwardly", "vertical", "horizontal", and the like, when used herein, refer to the positions of the respective elements shown on the accompanying drawing figures and the present invention is not necessarily limited to such positions.

[0105] It will thus be seen that the objects set forth above, among those elucidated in, or made apparent from, the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown on the accompanying drawing figures shall be interpreted as illustrative only and not in a limiting sense. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus, comprising:

(a) a ball wheel; and

(b) means to cause said ball wheel to rotate in a selected direction.

2. An apparatus, as defined in claim **1**, further comprising: means to change said selected direction.

3. An apparatus, as defined in claim **1**, wherein: said means comprises a hydraulic motor and associated gearing.

4. An apparatus, as defined in claim **2**, wherein: said means comprises a hydraulic motor and associated gearing.

5. An apparatus, as defined in claim **1**, further comprising: a plurality of bearing balls disposed between an upper surface of said ball wheel and a cover over said ball wheel such that said cover absorbs at least some of the force applied to said ball wheel.

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