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(72) **Inventor; and**
(71) **Applicant: ZARAPHONITIS, Panagiotis** [GR/GR]; 66 Othonos Amalias str., 231 00 Sparti Lakonias (GR).

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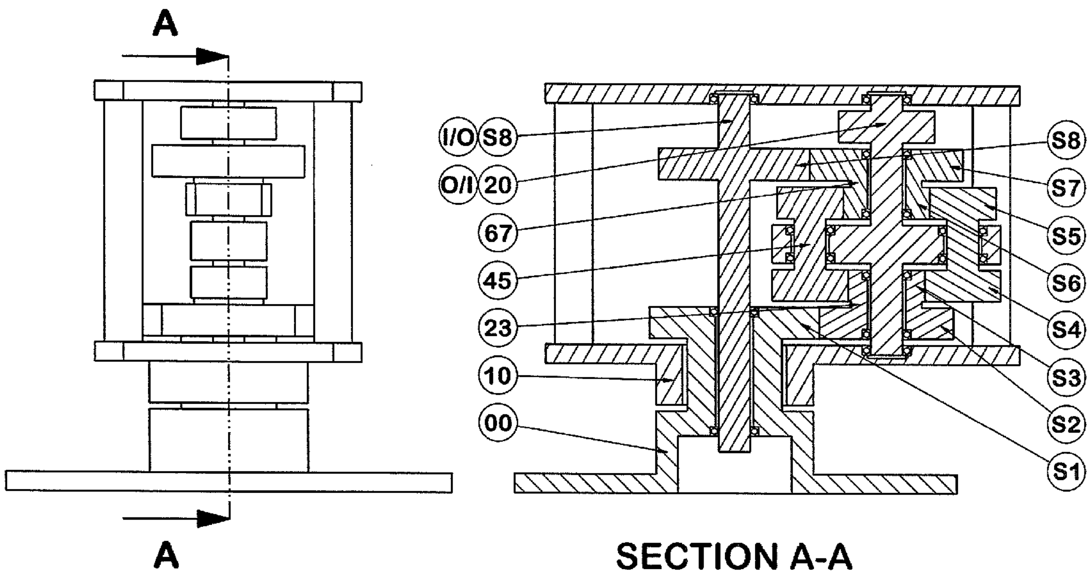

FIGURE 01

(57) **Abstract:** For the transmission of endless rotation from stationary frame to endlessly rotating carrier, or vice versa, independently of the rotation of the carrier, an efficient mechanical mechanism is missing. A Compound Planetary Mechanism, named "Eleuthero-Strophe", is proposed, with the already existing central carrier, two suns, an eccentric planetary carrier on which an eccentric satellite shaft rests bearing satellites, and planets which cooperate with the suns and the satellites, where all gear teeth numbers meet an Independence Condition. Main applications: -horizontal axis wind turbine, where endless rotation of propeller shaft is transmitted to stationary tower, -excavator or battle tank, where endless rotation is transmitted from chassis to turret, -holonomic vehicle, where endless rotation is transmitted from chassis to drive wheel, -propeller-driven aircraft, helicopter, propeller-driven craft, or wind turbine,

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where propeller pitch adjustment is achieved, independently of endless rotation of the nacelle, the turret, the steering bracket, and the propeller hub, respectively.

TRANSMISSION OF ENDLESS ROTATION TO A SHAFT ON AN ENDLESSLY ROTATING CARRIER INDEPENDENTLY OF THE ROTATION OF THE CARRIER

DESCRIPTION:

Technical Terms:

Frame, Carrier, Central Carrier, Planetary Carrier, Shaft, Planetary Shaft, Satellite Shaft, Sun, Planet, Sun-Planet, Satellite-Planet, Satellite, Gear, Spur Gear, Bevel Gear, External Gear, Internal Gear, Teeth Number, Rotation, Endless Rotation, Independent Rotation, "Independence Condition", Planetary Mechanism, "Epi-Planetary" Mechanism, Compound Planetary Mechanism, "Eleuthero-Strophic" Mechanism, "Eleuthero-Strophe".

Technical Field:

The present invention refers to a purely mechanical mechanism which transmits endless rotation from a driving shaft on a stationary frame to a driven shaft on an endlessly rotating carrier, or vice versa, independently of the rotation of the carrier.

Technical Problem to be solved:

In many applications, specific or not, there is the need to transmit endless rotation from a driving shaft on a stationary frame to a driven shaft on a rotating carrier, or vice versa, without the endless rotation of the carrier affecting this transmission.

Such an example is the horizontal axis wind turbine, the horizontal propeller shaft of which rests on a carrier, named "nacelle", which rotates about a vertical axis, and therefore any conventional way of transmission from the horizontal axis to a vertical axis on a frame which is stationary with respect to the ground, results in the prohibitive presence -to some extent- of the angular velocity of the nacelle in the finally produced angular velocity of the last element of this power-train.

This, of course, at the same time results in the presence of a torque on the nacelle, which is directly related to the transmitted torque of the propeller shaft; it is necessary to impose a torque on the nacelle in order to be always oriented at its optimal operating position for work production, but this orientation torque must have nothing to do with the transmitted torque from the propeller shaft to the stationary frame.

Other examples are the transmission of rotation between the chassis of a large excavator or a battle tank and their endlessly rotating turret, or between the chassis of a vehicle and its drive wheel which is supported on a -possibly endlessly- rotating steering bracket.

Another such example is the propeller pitch adjustment mechanism for a propeller-driven aircraft, a helicopter, a propeller-driven craft or a wind turbine, as well, although the existing mechanisms for these applications have satisfactory performance, as the required motion is finite and not endless.

There are, however, many other examples that require an independent endless rotational transmission to a shaft on an endlessly rotating carrier.

The aim, therefore, is to design a purely mechanical mechanism that performs a transmission of endless rotation from a driving shaft on a stationary frame to a driven shaft on an endlessly rotating carrier, or vice versa, independently of the rotation of the carrier, with the least possible number of moving parts and the highest possible degree of efficiency.

Relevant Prior Art:

The most known -and the most explanatory, at the same time- way of transmitting motion, in general, using purely mechanical means, to an element on an endlessly rotating carrier, independently of the rotation of the carrier, is the way to adjust the propeller pitch in a helicopter:

on the frame of the helicopter, the one end of a first rod moves linearly in a direction, resulting in moving, also linearly, the other end of this rod in a direction perpendicular to the previous one, while this direction coincides with the axis of rotation of the rotating propeller hub, and from this point, through axial thrust bearings, this motion is transmitted -independently of the endless rotation of the propeller hub with respect to the frame of the helicopter- at the one end of a second rod, the operation plane of which rigidly lays on the propeller hub, and in this way the other end of this rod finally performs the adjustment of the propeller pitch, independently of the endless rotation of the propeller hub with respect to the frame of the helicopter.

Therefore, if the first end of the first rod, of a similar mechanism, is driven by a crankshaft which rotates endlessly on the stationary frame of this mechanism, and the second end of the second rod drives another crankshaft which rotates endlessly on the also endlessly rotating carrier of this mechanism, a transmission of endless rotation from a driving shaft on a stationary frame to a driven shaft on an endlessly rotating carrier is achieved, independently of the rotation of the carrier.

However, the two conversions of endless rotary motion into reciprocating linear motion and vice versa, as well as the axial thrust, through the axial thrust bearings, are processes that require many moving parts in an inflexible and rather bulky arrangement and, of course, the overall degree of efficiency appears significantly low, while, in addition, there are problematic points -usually named "dead centers"- of instant indeterminacy of the direction of motion during the conversion of reciprocating linear motion into endless rotary motion.

Such a technique is described -in fact it is applied to a wind turbine- in the patent application TWI572779.

In the patent applications ES2273609 and CN102691629 there are attempts to transmit rotation from the nacelle to the base of the tower, through bevel gears and two coaxial vertical shafts or one, respectively.

In the patent application JP3157729 a proposal for a nacelle rigidly connected to a rotating tower is shown.

As for other applications except the wind turbine ones, perhaps there is no any relative proposal, and patent applications such as DE202005016021 and CN105848836 stand far from the concept of the present invention and do not solve directly and effectively the problem of independent transmission with the aforementioned requirements.

So, except the above described way, it seems that there is no other similar proposal, in the prior state of the art, of achieving, via purely mechanical means only, the required transmission independently of the rotation of the carrier.

Disclosure of the Invention:

In order to directly solve the aforementioned problems, using purely mechanical means, it is necessary to somehow remove the effects, kinematic and dynamic, of the endless rotation of the carrier on the transmitted rotation.

So, a Compound Planetary Mechanism is proposed, the planets of which belong to another Planetary Mechanism, which therefore may be named "Eccentric Planetary Mechanism", and this Compound Planetary Mechanism may be named "Epi-Planetary Mechanism", in a sense that this configuration is a Mechanism onto a Mechanism.

The Eccentric Planetary Mechanism can be any mechanical assembly with three ports, inputs or outputs, such as the classic differential mechanism of a vehicle, where the one input of this mechanism is the main rotation, which must be transferred, but mixed with the -in some way- undesired endless rotation of the carrier, with a positive sign, the other input is this undesired endless rotation of the carrier, with a negative sign, while its output is the filtered final endless rotation, directly related to the initial main rotation only.

The Compound Planetary Mechanism generally has a frame and a first carrier, which is the already existing one and rotates with the undesired endless rotation with respect to the frame, a first gear which is coaxial with the first carrier and rigidly connected to the frame, a second gear which is coaxial also with the first carrier and freely and endlessly rotates, constituting either the input or the output of the Compound Planetary Mechanism, and on the first carrier, eccentrically and preferably parallel to its axis, has also one -or more- Eccentric Planetary Mechanism.

Each Eccentric Planetary Mechanism, generally, has a second carrier, on which eccentrically and preferably parallel to its axis there is one -or more- axis, about which a first shaft rotates, with a third gear and a fourth gear rigidly connected to both ends of it, while on the one side of the second carrier, coaxially with it, freely and endlessly rotates a second shaft, with a fifth gear and a sixth gear rigidly connected to both ends of it, cooperating with the first gear and the third gear, respectively, and on the other side, also, of the second carrier, coaxially with it, freely and endlessly rotates a third shaft, with a seventh gear and an eighth gear rigidly connected to both ends of it, cooperating with the second gear and the fourth gear, respectively.

Depending on the design, either the second carrier or the third shaft constitutes either the output or the input of the Compound Planetary Mechanism, inversely depending on the role of the second gear.

The Compound Planetary Mechanism, as a whole, is designed so that the flow of the power, from its input to its output, is performed independently, kinematically and dynamically, of the rotation of the already existing carrier and for this purpose there is a mathematical relation between the teeth numbers of all the gears involved, which is proposed to be named: "Independence Condition".

Since it seems that this mechanism is a really new configuration solving several important problems, instead of its long name-description: "Mechanism for Transmission of Endless Rotation to a Shaft on an Endlessly Rotating Carrier Independently of the Rotation of the Carrier", it is proposed to be named "Eleuthero-Strophic Mechanism", which means an Independent Rotation Mechanism, or even "Eleuthero-Strophe", which means an Independently Rotating Hub; the term "Eleutheros" is already used in English language, in History, Anthropology and Botany, but not in Engineering, so there is no any possibility to be confused with another meaning, similar or not.

Finally, looking at this issue from a wider perspective, it should be noted that the Mechanism for Transmission of Endless Rotation to a Shaft on an Endlessly Rotating

Carrier Independently of the Rotation of the Carrier or Eleuthero-Strophe, while radically differs (especially: in the present invention the amplitude of the involved oscillation is just zero) from the previous cases WO/2007/125373, WO/2009/040588, WO/2018/020279 and PCT/GR2021/000012 (where, also, the amplitude of the involved oscillation is just zero), falls within the broadly defined category under the name:
"DISTRIBUTIVE OSCILLATING TRANSMISSION" ("DOT").

Application examples:

Here is an exhaustive presentation of the Compound Planetary Mechanism.

In the drawings of the first six figures, the most important elements are denoted as follows:

00: Frame
10: Central Carrier
20: Planetary Carrier
23: Planetary Reaction Shaft
45: Satellite Shaft
67: Planetary Action Shaft
S1: Spur External Reaction Sun
I1: Spur Internal Reaction Sun
S2: Spur Reaction Sun-Planet
S3: Spur Reaction Satellite-Planet
B3: Bevel Reaction Satellite-Planet
S4: Spur Reaction Satellite
B4: Bevel Reaction Satellite
S5: Spur Action Satellite
B5: Bevel Action Satellite
S6: Spur Action Satellite-Planet
B6: Bevel Action Satellite-Planet
S7: Spur Action Sun-Planet
S8: Spur External Action Sun
I8: Spur Internal Action Sun

Remarks:

- the eight gears involved are either spur or bevel, either straight or helical, and finally, either external or internal, unless the type of a gear is stated otherwise, therefore they are characterized by a letter which is either the "S" for a spur gear or the "B" for a bevel gear or the "I" for an internal gear,
- in addition to this notation, for the element which is coincident with the input or the output of the mechanism, is preceded by an "I/O" marking, while for the other element, which -inversely depending on the role of the just mentioned element- is coincident with the output or the input of the mechanism, is preceded by an "O/I" marking.

The drawings present:

"FIGURE 01": a side view and the meridian section A-A of a mechanism with spur gears exclusively.

"FIGURE 02": a side view and the meridian section B-B of a mechanism with spur and bevel gears.

"FIGURE 03": an exploded oblique view of the same mechanism as in FIGURE 01, where the planetary carrier has been rotated at a random angle, in order to present clearly the satellites.

"FIGURE 04": an exploded oblique view of the same mechanism as in FIGURE 02, where the planetary carrier, also, has been rotated at a random angle, in order to present clearly the satellites.

"FIGURE 05": a side view and the meridian section C-C of a mechanism with spur and bevel gears, the reaction sun of which is an internal gear.

"FIGURE 06": a side view and the meridian section D-D of a mechanism with spur and bevel gears, the reaction sun and the action sun of which are internal gears.

"FIGURE 07": an oblique view and a meridian section of an application of the mechanism -using spur gears only for the main mechanism- to a wind turbine, which clarify the structural details of this application.

"FIGURE 08": an oblique view and a meridian section of an application of the mechanism -using spur and bevel gears for the main mechanism- to a wind turbine, which clarify, also, the structural details of this application.

"FIGURE 09": an oblique view (a) and a meridian section (b) of an excavator, as well as a close-up of the same meridian section (c), which can be, also, the meridian section of a battle tank, or even of a building such as a lighthouse or a rotating tower.

"FIGURE 10": an oblique view (a) and a meridian section (b) of a steering bracket unit, as well as its application to a purely military vehicle 8X8X8 (c), an extreme sport utility vehicle 6X6X6 (d) and a classic passenger car 4X2X2 with a normal steering angle (e) and an extraordinary one (f).

"FIGURE 11": an oblique view (a) and a meridian section (b) of the start of the power-train for a wind turbine or of the end of the power-train for a propeller-driven aircraft, an oblique view (c) and a meridian section (d) of the end of the power-train for a helicopter, and an oblique view (e) and a meridian section (f) of the end of the power-train for a propeller-driven craft; all these drawings refer to a propeller pitch adjustment mechanism.

Remarks:

- the FIGURE 01 and the FIGURE 02 are sufficient for the complete understanding of the structure and the operation of the Compound Planetary Mechanism; however the FIGURE 03 and the FIGURE 04 clarify even more structural details,

- the FIGURE 05 and the FIGURE 06 give a rather shallow presentation of two more specific implementations, so in these drawings all the elements involved have the notation as in the FIGURE 02, unless their notation is stated otherwise,

- because the shaft which carries the action sun (S8) does not carry any other gear, in the drawings this shaft is indicated with the same notation S8,

- for better understanding of all these drawings, where the elements are rigidly connected together, either are depicted as a single element or their cross-hatches are the same in density and angle.

Therefore, the Compound Planetary Mechanism has a frame (00), which conventionally is stationary in space or rigidly connected to a movable or temporarily stationary structure, and a first carrier, named "central carrier" (10), the axis of which is named "central axis", and which is supported on the frame (00) and is able to rotate freely and endlessly about the central axis.

The Compound Planetary Mechanism has, also, a first spur gear, named "reaction sun", being either external (S1) or internal (I1), rigidly connected to the frame (00) coaxially with the central axis and having a teeth number Z_{S1} or Z_{I1}, respectively, and a second spur gear, named "action sun", being either external (S8) or internal (I8), supported on the frame (00) coaxially with the central axis and able to rotate freely and endlessly about the central axis, constituting either the input or the output of the Compound Planetary Mechanism and having a teeth number Z_{S8} or Z_{I8}, respectively.

The central carrier (10) has a plurality of axes, each of them named "planetary axis", preferably parallel to the central axis and at a distance from the central axis common for all the planetary axes, preferably equally angularly distributed around the central axis.

A second carrier (20) corresponds to each of these planetary axes, named "planetary carrier", which is supported on the central carrier (10) coaxially with its corresponding planetary axis and is able to rotate freely and endlessly about this planetary axis, while each planetary carrier (20) has a plurality of axes, each of them named "satellite axis", preferably parallel to this planetary axis and at a distance from this planetary axis common for all these satellite axes, preferably equally angularly distributed around this planetary axis.

A first shaft (45) corresponds to each of these satellite axes, named "satellite shaft", which is supported on the planetary carrier (20) coaxially with its corresponding satellite axis, is able to rotate freely and endlessly about this satellite axis, and has a third gear, named "reaction satellite", coaxially and rigidly connected to the one end of this satellite shaft (45), being either spur (S4) or bevel (B4) and having a teeth number Z_{S4} or Z_{B4}, respectively, and has, also, a fourth gear, named "action satellite", coaxially and rigidly connected to the other end of this satellite shaft (45), being either spur (S5) or bevel (B5) and having a teeth number Z_{S5} or Z_{B5}, respectively.

A second shaft (23) corresponds to each of the planetary axes, named "planetary reaction shaft", which is supported on the planetary carrier (20) coaxially with its corresponding planetary axis, is able to rotate freely and endlessly about this planetary axis, and has a fifth spur gear (S2), named "reaction sun-planet", coaxially and rigidly connected to the one end of this planetary reaction shaft (23), cooperating with the reaction sun (S1 or I1) and having a teeth number Z_{S2}, and has, also, a sixth gear, named "reaction satellite-planet", coaxially and rigidly connected to the other end of this planetary reaction shaft (23), being either spur (S3) or bevel (B3), cooperating with the reaction satellite (S4 or B4, respectively) and having a teeth number Z_{S3} or Z_{B3}, respectively.

A third shaft (67) corresponds, also, to each of the planetary axes, named "planetary action shaft", which is supported on the planetary carrier (20) coaxially with its corresponding planetary axis, is able to rotate freely and endlessly about this planetary axis, and has a seventh spur gear (S7), named "action sun-planet", coaxially and rigidly connected to the one end of this planetary action shaft (67), cooperating with the action sun (S8 or I8) and having a teeth number Z_{S7}, and has, also, an eighth gear, named "action satellite-planet", coaxially and rigidly connected to the other end of this planetary action shaft (67), being either spur (S6) or bevel (B6), cooperating with the action satellite (S5 or B5, respectively) and having a teeth number Z_{S6} or Z_{B6}, respectively.

Depending on the design of the Compound Planetary Mechanism, in its generalized configuration, either any of the planetary carriers (20) or any of the planetary action shafts (67) constitutes either the output or the input of the Compound Planetary Mechanism -inversely depending on the role of the action sun (S8 or I8)- and is named "eccentric shaft" (20 or 67).
Therefore, the local angular velocity of this eccentric shaft (20 or 67) about its own axis with respect to the central carrier (10) is required to be independent of the angular velocity of the central carrier (10) with respect to the frame (00), while is required, also, to be only dependent on the angular velocity of the action sun (S8 or I8) with respect to the frame (00), and to achieve these requirements the teeth numbers of all the gears involved is necessary to satisfy the aforementioned "Independence Condition".

More specifically, there are the following implementations of the Compound Planetary Mechanism:

- with the exclusive use of spur gears, exactly as shown in FIGURE 01 and FIGURE 03, where the only planetary carrier (20) is coincided with the eccentric shaft (20 or 67), while the Independence Condition is:
$Z_{S1}/Z_{S2}*Z_{S3}/Z_{S4}*Z_{S5}/Z_{S6}*Z_{S7}/Z_{S8} = 1$,
- using spur and bevel gears, generally as shown in FIGURE 02 and FIGURE 04, where the only planetary action shaft (67) is coincided with the eccentric shaft (20 or 67), while the Independence Condition, generally, is:
$(Z_{S1}/Z_{S2}*Z_{S7}/Z_{S8}-1)*Z_{B3}/Z_{B4}*Z_{B5}/Z_{B6} = 1$,
as well as in the case of merging of the two bevel satellites, which are rigidly connected to the satellite shaft (45), into a single bevel gear, exactly as shown in FIGURE 02 and FIGURE 04, where the Independence Condition is simplified as follows:
$Z_{S1}/Z_{S2}*Z_{S7}/Z_{S8} = 2$,
- using spur and bevel gears, while the reaction sun (I1) is an internal gear and all the other gears are external, where the only planetary carrier (20) is coincided with the eccentric shaft (20 or 67) and the bevel satellites are merged into a single bevel gear, exactly as shown in FIGURE 05, while the Independence Condition is:
$Z_{I1}/Z_{S2}*Z_{S7}/Z_{S8} = 1$,
- using spur and bevel gears, while the reaction sun (I1) and the action sun (I8) are internal gears and all the other gears are external, where the only planetary action shaft (67) is coincided with the eccentric shaft (20 or 67) and the bevel satellites, also, are merged into a single bevel gear, exactly as shown in FIGURE 06, while the Independence Condition is:
$Z_{I1}/Z_{S2}*Z_{S7}/Z_{I8} = 2$.

Note: in all the above cases the Independence Condition is elegant and simple; however, special care should be taken so that the individual local transmission ratios do not lead to indeterminacy of the angular position of any moving part involved.

Thereafter, some more specialized applications of the Compound Planetary Mechanism are presented:

An interesting case, as it is already referred above, is its application to a horizontal axis wind turbine, so that the power generated on the horizontal propeller shaft is transmitted from the endlessly rotating nacelle, which, in fact, is the carrier (10) of the Compound Planetary Mechanism, on which it rests, to the stationary tower, which, in fact also, is the frame (00) of the Compound Planetary Mechanism, where this transmission is completely -kinematically and dynamically- independent of the endless rotation of the nacelle (10), a motion which is required so that the plane of rotation of the propellers takes the best possible orientation for the optimal exploitation of the available wind energy.

More specifically, these are two representative implementations:

- with the exclusive use of spur gears for the Compound Planetary Mechanism only, as shown in FIGURE 07, where also is shown the way in which the horizontal propeller shaft transmits power to the only planetary carrier (20) of the Compound Planetary Mechanism, through bevel gears,
- using spur and bevel gears, as shown in FIGURE 08, where also is shown, again, the way in which the horizontal propeller shaft transmits power to the only planetary action shaft (67) of the Compound Planetary Mechanism, also through bevel gears.

In all the above cases, if the electric generator and possibly the gearbox of the wind turbine are located on the base of its tower or near it, the shaft which has the duty to transmit power from the action sun (S8 or I8), which is located on the top of the tower of the wind turbine, to its base or near it, can be an elongate space frame structure of sufficient strength and torsional stiffness, supported with bearing units in specific locations along the longitudinal axis of the tower, which can also be used as a ladder for accessing the top of the wind turbine for inspection and maintenance purposes -after its secure immobilization, of course- at regular intervals.

Note: such a total transmission ratio must be achieved, so that the shaft, which undertakes to transmit power from the top of the tower of the wind turbine to its base or near it, rotates at a frequency sufficiently far from its natural frequency.

An application, also, of the Compound Planetary Mechanism, as generally shown in FIGURE 09, is to a construction, which is either a building or any other structure with its base stationary with respect to the ground, such as a lighthouse or a rotating tower (the "OTE Tower" of the Thessaloniki International Fair, for example), or movable, such as a large excavator or a battle tank, the structure of which has, at least, two compartments with the possibility of endless angular motion of each compartment with respect to its neighboring one, where the one compartment of the structure, such as the ground or the chassis in these examples, is coincided with the frame (00) of the Compound Planetary Mechanism, while the next compartment, such as the tower or the turret in these examples, is coincided with the endlessly rotating central carrier (10) of the Compound Planetary Mechanism, with the final result of transmitting endless rotation from a driving shaft on the one compartment to a driven shaft on the next compartment, independently of the endless relative rotation between these compartments; of course this procedure can be repeated from the one compartment to its neighboring one, as many times as it is required by the number of the compartments.

More specifically, for an excavator there is the capability of carrying the engine and the hydraulic equipment in place B, as shown in FIGURE 09 (c), as currently happens, and in place A, as shown, also, in FIGURE 09 (c), can be the mechanical differential and the rest of the purely mechanical power-train in order to transmit power to the wheels, or the capability of carrying the engine -preferably a boxer one- in place A and the hydraulic equipment only in place B, keeping the gravity center in the lower possible level, thus rendering the use of this excavator more safe and effective.

Another application of the Compound Planetary Mechanism, as shown in FIGURE 10, is to a steering bracket which carries the drive wheel of a vehicle, where this steering bracket is supported on the chassis of the vehicle and rotates about an axis preferably perpendicular to the axis of rotation of the wheel, for the purpose of steering the vehicle, so the transmission of power from the chassis which is coincided with the frame (00) of the Compound Planetary Mechanism to the endlessly rotating drive wheel of this vehicle is achieved, independently of the rotation of the steering bracket, which is coincided with the central carrier (10) of the Compound Planetary Mechanism; this steering rotation is usually finite, while, thanks to this configuration, can be also endless, rendering in this way the vehicle really holonomic.

As shown in FIGURE 10 (b) the output of the Compound Planetary Mechanism, which is the planetary carrier (20) of the FIGURE 01, is connected to a coaxial splined shaft, thus constituting a telescopic transmission shaft of variable length, within a steering bracket frame of variable length as well, giving in this way one more degree of freedom to the wheel, while, with similar mechanical engineering tricks, the wheel can gain all the necessary degrees of freedom, so that the Compound Planetary Mechanism can supersede the ball-bearing constant velocity joint in many applications.

Finally, one more application of the Compound Planetary Mechanism, as shown in FIGURE 11, is its use for the adjustment of the propeller pitch for a propeller-driven aircraft, a helicopter, a propeller-driven craft, but also a wind turbine, where the propeller hub is coincided with the endlessly rotating carrier (10) of the Compound Planetary Mechanism, and the aircraft frame, the helicopter frame, the craft frame, the rotating nacelle of the wind turbine in case of a horizontal axis type or the stationary tower of the wind turbine in any other case, is coincided with the frame (00) of the Compound Planetary Mechanism, while in this application the rotation for adjusting the propeller pitch may be even endless; for this application the configuration of the FIGURE 06 has been used, with the two internal gears, since it results in the most compact and robust overall configuration.

Advantages:

The basic configuration of the present invention includes only five moving parts, namely the action sun, the planetary action shaft, the satellite shaft, the planetary reaction shaft and the planetary carrier, with the addition, of course, of a sixth moving part, which is the central carrier; this central carrier, of course, already exists since the very beginning of the design and in fact is the moving part with the -in some way- undesired motion.

The operation of the basic configuration of the present invention, also, is based on the cooperation of only four pairs of cooperating gears, while all these gears can be and moreover is preferable to be standard ones.

Even more, there is no any other element which must be specialized; therefore the result is the simplest and most cost-effective possible construction and maintenance, while, at the same time, due to the least possible number of moving parts, the highest possible degree of efficiency is achieved, leading to the most productive possible operation.

It is also important that, by the design of the present invention per se, the most balanced arrangement of the diameters of the gears can be achieved, resulting in the avoidance of the problematic pinion, which is the weakest link in any power-train.

Moreover, taking into account some specific applications of the present invention, the advantages become more obvious and understandable:

- relocation of the vast majority of the operating elements of a wind turbine, from its rotating nacelle to its stationary tower, resulting in the drastic lightening of the nacelle and the drastic, also, reducing of the construction and maintenance costs,
- in addition, combining the concept of the application PCT/GR2021/000012 with the one of the present invention, the result is a configuration with a total transmission ratio as high as it is required by the design of the wind turbine as a whole, thus this configuration comprises a highly effective speed increaser, taking low speed from the propeller shaft and providing high speed to the electric generator, superseding the currently used speed increaser, and the achievement of all these is performed by the insertion of five new moving parts only,
- transmission of the electric power via the simplest possible way, avoiding an unnecessarily complex configuration, with low performance and short-lived elements, such as the electric slip rings,
- achievement of purely endless rotation of the turret of a large excavator or a battle tank, with respect to their chassis, while with the existing technology either the rotation is finite and with a significantly shorter angular path than a full revolution or it is much more expensive in construction and maintenance if an endless rotation is available but with a special sealing for rotation of the hydraulic piping,
- lowering of the level of the gravity center of the excavator or the battle tank as much as possible, thus rendering the use of the excavator or the battle tank more effective and safe,
- designing of an all-wheel drive and all-wheel steering vehicle, a really holonomic one, as the steering brackets can be rotated, for steering, in an absolutely endless way,
- designing, also, of a vehicle with extremely high clearance from the ground, for special use -for firefighting in rugged and jungly terrain, for instance- as the height of each steering bracket unit can be as great as it is required,
- achievement of the capability of transmitting of a huge amount of power via wheels which propel and steer the vehicle at the same time, even in a classic front-wheel drive car, with a normal steering angle amplitude, because this transmission is performed via robust gears instead of delicate balls of the ball-bearing constant velocity joint, a fact that can render this application of the present invention the new and promising proposal for the propulsion of a vehicle of any type, especially a military one or even a supercar,
- achievement of the most elegant, compact and robust configuration, even in the case of the propeller pitch adjustment, although the currently used mechanisms are effective because of the need of finite operating stroke, rotational or linear,
- achievement of the capability of even endless rotation for the adjustment of the propeller pitch, with whatever this implies.

In conclusion, these are a number of merits of the present invention which are easily contrasted as advantages over a competition, which in fact does not exist, or, in the few and individual cases in which it does exist, is rather moderate.

CLAIMS:

1. Compound Planetary Mechanism which consists of:
- a frame (00), conventionally stationary or movable in space,
- a first gear, named "reaction sun", which is rigidly connected to the frame (00), is a spur gear and is either external (S1) or internal (I1), with a teeth number Z_{S1} or Z_{I1}, respectively, while its axis is named "central axis",
- a second gear, named "action sun", which is supported on the frame (00) coaxially with the central axis, is able to rotate freely and endlessly about the central axis and is either the input or the output of this Compound Planetary Mechanism, is a spur gear and is either external (S8) or internal (I8), with a teeth number Z_{S8} or Z_{I8}, respectively,
- a first carrier (10), named "central carrier", which is supported on the frame (00) coaxially with the central axis, is able to rotate freely and endlessly about the central axis and has a plurality of axes, each of them named "planetary axis", preferably parallel to the central axis and at a distance from the central axis common for all planetary axes, and preferably equally angularly distributed around the central axis,

while this Compound Planetary Mechanism is characterized by the following:
- a simple Planetary Mechanism corresponds to each of these planetary axes and consists of:
  - a second carrier (20), named "planetary carrier", which is supported on the central carrier (10) coaxially with its corresponding planetary axis, is able to rotate freely and endlessly about this planetary axis and has a plurality of axes, each of them named "satellite axis", preferably parallel to this planetary axis and at a distance from this planetary axis common for all satellite axes, and preferably equally angularly distributed around this planetary axis, while a first shaft (45), named "satellite shaft", corresponds to each of these satellite axes, is supported on the planetary carrier (20) coaxially with its corresponding satellite axis, is able to rotate freely and endlessly about this satellite axis, and has a third gear, named "reaction satellite", coaxially rigidly connected to the one end of this satellite shaft (45), which is either spur (S4) or bevel (B4), with a teeth number Z_{S4} or Z_{B4}, respectively, as well as a fourth gear, named "action satellite", coaxially rigidly connected to the other end of this satellite shaft (45), which is either spur (S5) or bevel (B5), with a teeth number Z_{S5} or Z_{B5}, respectively,
  - a second shaft (23), named "planetary reaction shaft", which is supported on the planetary carrier (20) coaxially with its corresponding planetary axis, is able to rotate freely and endlessly about this planetary axis, and has a fifth gear (S2), named "reaction sun-planet", coaxially rigidly connected to the one end of this planetary reaction shaft (23), being a spur gear and cooperating with the reaction sun (S1 or I1), with a teeth number Z_{S2}, as well as a sixth gear, named "reaction satellite-planet", coaxially rigidly connected to the other end of this planetary reaction shaft (23), being either spur (S3) or bevel (B3) and cooperating with the reaction satellite (S4 or B4, respectively), with a teeth number Z_{S3} or Z_{B3}, respectively,
  - a third shaft (67), named "planetary action shaft", which is supported on the planetary carrier (20) coaxially with its corresponding planetary axis, is able to rotate freely and endlessly about this planetary axis, and has a seventh gear (S7), named "action sun-planet", coaxially rigidly connected to the one end of this planetary action

shaft (67), being a spur gear and cooperating with the action sun (S8 or I8), with a teeth number Z_{S7}, as well as an eighth gear, named "action satellite-planet", coaxially rigidly connected to the other end of this planetary action shaft (67), being either spur (S6) or bevel (B6) and cooperating with the action satellite (S5 or B5, respectively), with a teeth number Z_{S6} or Z_{B6}, respectively,

- all these eight gears are either straight or helical, spur or bevel, external or internal, unless it is stated otherwise,
- either the output or the input of this Compound Planetary Mechanism -inversely depending on the role of the action sun (S8 or I8)- is coincident with either any of the planetary carriers (20) or any of the planetary action shafts (67), and is named "eccentric shaft" (20 or 67),
- while the teeth number of each of these eight gears is such that the local angular velocity of the eccentric shaft (20 or 67) about its own axis with respect to the central carrier (10), is independent of the angular velocity of the central carrier (10) with respect to the frame (00) and dependent only on the angular velocity of the action sun (S8 or I8) with respect to the frame (00).

2. Compound Planetary Mechanism, according to Claim 1, being characterized by that the reaction sun (S1 or I1), remaining supported on the frame (00) coaxially with the central axis, can freely and endlessly rotate about the central axis, either before or during the operation for which this Compound Planetary Mechanism is designed, in synchronization with this operation or independently.

3. Compound Planetary Mechanism, according to Claim 1 or 2, being characterized by that:

- all eight gears are spur,
- the eccentric shaft (20 or 67) is coincident with any of the planetary carriers (20),
- while for the teeth numbers of these eight gears this relation applies:

$Z_{S1}/Z_{S2}*Z_{S3}/Z_{S4}*Z_{S5}/Z_{S6}*Z_{S7}/Z_{S8} = 1$.

4. Compound Planetary Mechanism, according to Claim 1 or 2, being characterized by that:

- the reaction satellite-planet (B3) and the action satellite-planet (B6) are bevel gears,
- the reaction satellite (B4) and the action satellite (B5) are bevel gears, with their own satellite axes intersecting their corresponding planetary axis perpendicularly,
- the other four gears are spur,
- the action sun-planet (S7) is rigidly connected to its planetary carrier (20),
- the eccentric shaft (20 or 67) is coincident with any of the planetary action shafts (67),
- while for the teeth numbers of these eight gears this relation applies:

$(Z_{S1}/Z_{S2}*Z_{S7}/Z_{S8}-1)*Z_{B3}/Z_{B4}*Z_{B5}/Z_{B6} = 1$,

while, when the reaction satellite (B4) and the action satellite (B5) form a single bevel gear, which cooperates simultaneously with the reaction satellite-planet (B3) and the action satellite-planet (B6), for the teeth numbers of these four spur gears this relation applies:

$Z_{S1}/Z_{S2}*Z_{S7}/Z_{S8} = 2$.

5. Compound Planetary Mechanism, according to Claim 4, being characterized by that:
- the reaction sun (I1) is an internal gear,
- the other seven gears are external,
- the action sun-planet (S7) is rigidly connected to its planetary action shaft (67),
- the eccentric shaft (20 or 67) is coincident with any of the planetary carriers (20),
- while for the teeth numbers of the said four spur gears this relation applies:
$Z_{I1}/Z_{S2}*Z_{S7}/Z_{S8} = 1$.

6. Compound Planetary Mechanism, according to Claim 4, being characterized by that:
- the reaction sun (I1) is an internal gear,
- the action sun (I8) is an internal gear,
- the other six gears are external,
- the action sun-planet (S7) is rigidly connected to its planetary carrier (20),
- the eccentric shaft (20 or 67) is coincident with any of the planetary action shafts (67),
- while for the teeth numbers of the said four spur gears this relation applies:
$Z_{I1}/Z_{S2}*Z_{S7}/Z_{I8} = 2$.

7. Compound Planetary Mechanism, according to Claim 1 or 2 or 3 or 4 or 5 or 6, being characterized by that:
- is applied to a horizontal axis wind turbine, where the tower of the wind turbine is coincident with the frame (00) of this Compound Planetary Mechanism, and the nacelle of the wind turbine is coincident with the endlessly rotating central carrier (10) of this Compound Planetary Mechanism, so that the propeller shaft of the wind turbine transmits power, either via bevel gears or by any other means, to the eccentric shaft (20 or 67), which is the input of this Compound Planetary Mechanism, and the action sun (S8), which is the output of this Compound Planetary Mechanism, drives an electric generator stationary with respect to the frame (00), either directly or through a gearbox, either on the top or on any other location of the longitudinal axis of the tower, independently of the endless rotation of the nacelle (10) with respect to the tower (00),
- while, when the electric generator and possibly the gearbox are on the base of the tower or near it, the shaft which has the duty to transmit power from the action sun (S8), which is located on the top of the tower, to the base of the tower or near it, can be an elongate space frame structure of sufficient strength and torsional rigidity, supported with bearing units in specific locations along the longitudinal axis of the tower and can also be used as a ladder for accessing the top of the tower.

8. Compound Planetary Mechanism, according to Claim 1 or 2 or 3 or 4 or 5 or 6, being characterized by that:
- is applied to a structure, such as a building or an excavator or a battle tank, stationary or movable in space, which has, at least, two compartments with the capability of endless rotation of each compartment with respect to its neighboring one, where each compartment of this structure is coincident with the frame (00) of this Compound Planetary Mechanism, and the next compartment is coincident with the endlessly rotating central carrier (10) of this Compound Planetary Mechanism, so that an endless rotation is transmitted from a driving shaft on the one compartment (00) to a driven shaft on the next compartment (10), independently of the endless relative rotation between them.

9. Compound Planetary Mechanism, according to Claim 1 or 2 or 3 or 4 or 5 or 6, being characterized by that:
- is applied to each of the steering brackets of a vehicle, while this steering bracket supports an endlessly rotating drive wheel and this steering bracket can be rotated about an axis preferably perpendicular to the axis of rotation of the drive wheel for the purpose of changing the direction of the vehicle, where the vehicle chassis is coincident with the frame (00) of this Compound Planetary Mechanism, and the steering bracket is coincident with the endlessly rotating central carrier (10) of this Compound Planetary Mechanism, so that an endless rotation is transmitted from a driving shaft on the vehicle chassis (00) to a driven shaft on the rotating steering bracket (10) which finally drives the drive wheel of the vehicle, independently of the rotation of the steering bracket (10) with respect to the vehicle chassis (00), finite or endless.

10. Compound Planetary Mechanism, according to Claim 1 or 2 or 3 or 4 or 5 or 6, being characterized by that:
- is applied to a propeller-driven aircraft, or a helicopter, or a propeller-driven craft, or a wind turbine of any type, where the propeller hub is coincident with the endlessly rotating central carrier (10) of this Compound Planetary Mechanism, and the aircraft frame, the helicopter frame, the craft frame, the rotating nacelle in case of a horizontal axis wind turbine or the stationary tower of the wind turbine in any other case, are coincident with the frame (00) of this Compound Planetary Mechanism, so that a rotation, finite or endless, is transmitted from a driving shaft on said frame (00) to a driven shaft on the rotating propeller hub (10), independently of the endless rotation of the propeller hub (10) with respect to said frame (00), mainly for the purpose of the adjustment of the propeller pitch.

AMENDED CLAIMS
received by the International Bureau on 14 December 2021 (14.12.2021)

AMENDED CLAIMS:

CLAIMS:

1. A compound planetary mechanism which has:
- a frame (00),
- a first carrier (10), named "central carrier", the axis of rotation of which is named "central axis", while the central carrier (10) is supported on the frame (00) and able to rotate freely and endlessly about the central axis,
- a first gear, named "reaction sun", which is either preferably rigidly connected to the frame (00) coaxially with the central axis or supported on the frame (00) and able to rotate freely and endlessly about the central axis, is preferably a spur gear and either external (S1) or internal (I1), with a teeth number Z_{S1} or Z_{I1}, respectively,
- a second gear, named "action sun", which is supported on the frame (00) and able to rotate freely and endlessly about the central axis, is preferably a spur gear and either external (S8) or internal (I8), with a teeth number Z_{S8} or Z_{I8}, respectively, and is either the input or the output of the compound planetary mechanism,
and is characterized by the following:
- it has, at least, one simple planetary mechanism which consists of:
  - a second carrier (20), named "planetary carrier", which is supported on the central carrier (10) and able to rotate freely and endlessly about an axis, named "planetary axis", preferably parallel to the central axis and at a distance from the central axis, while the planetary carrier (20) has, at least, one first shaft (45), named "satellite shaft", which is supported on the planetary carrier (20) and able to rotate freely and endlessly about an axis, named "satellite axis", which has a specific and permanent direction between parallel and perpendicular to the planetary axis, preferably either exactly parallel to the planetary axis and at a distance from the planetary axis or exactly perpendicular to the planetary axis, while there is a third gear, named "reaction satellite", rigidly connected to the one end of the satellite shaft (45) coaxially with the satellite axis, which is either spur (S4) or bevel (B4), with a teeth number Z_{S4} or Z_{B4}, respectively, as well as a fourth gear, named "action satellite", rigidly connected to the other end of the satellite shaft (45) coaxially with the satellite axis, which is either spur (S5) or bevel (B5), with a teeth number Z_{S5} or Z_{B5}, respectively,
  - a second shaft (23), named "planetary reaction shaft", which is supported on the planetary carrier (20) and able to rotate freely and endlessly about the planetary axis, while there is a fifth gear (S2), named "reaction sun-planet", rigidly connected to the one end of the planetary reaction shaft (23) coaxially with the planetary axis, being such a gear as to properly cooperate with the reaction sun (S1 or I1), with a teeth number Z_{S2}, as well as a sixth gear, named "reaction satellite-planet", rigidly connected to the other end of the planetary reaction shaft (23) coaxially with the planetary axis, being either spur (S3) or bevel (B3) and cooperating with the reaction satellite (S4 or B4, respectively), with a teeth number Z_{S3} or Z_{B3}, respectively,

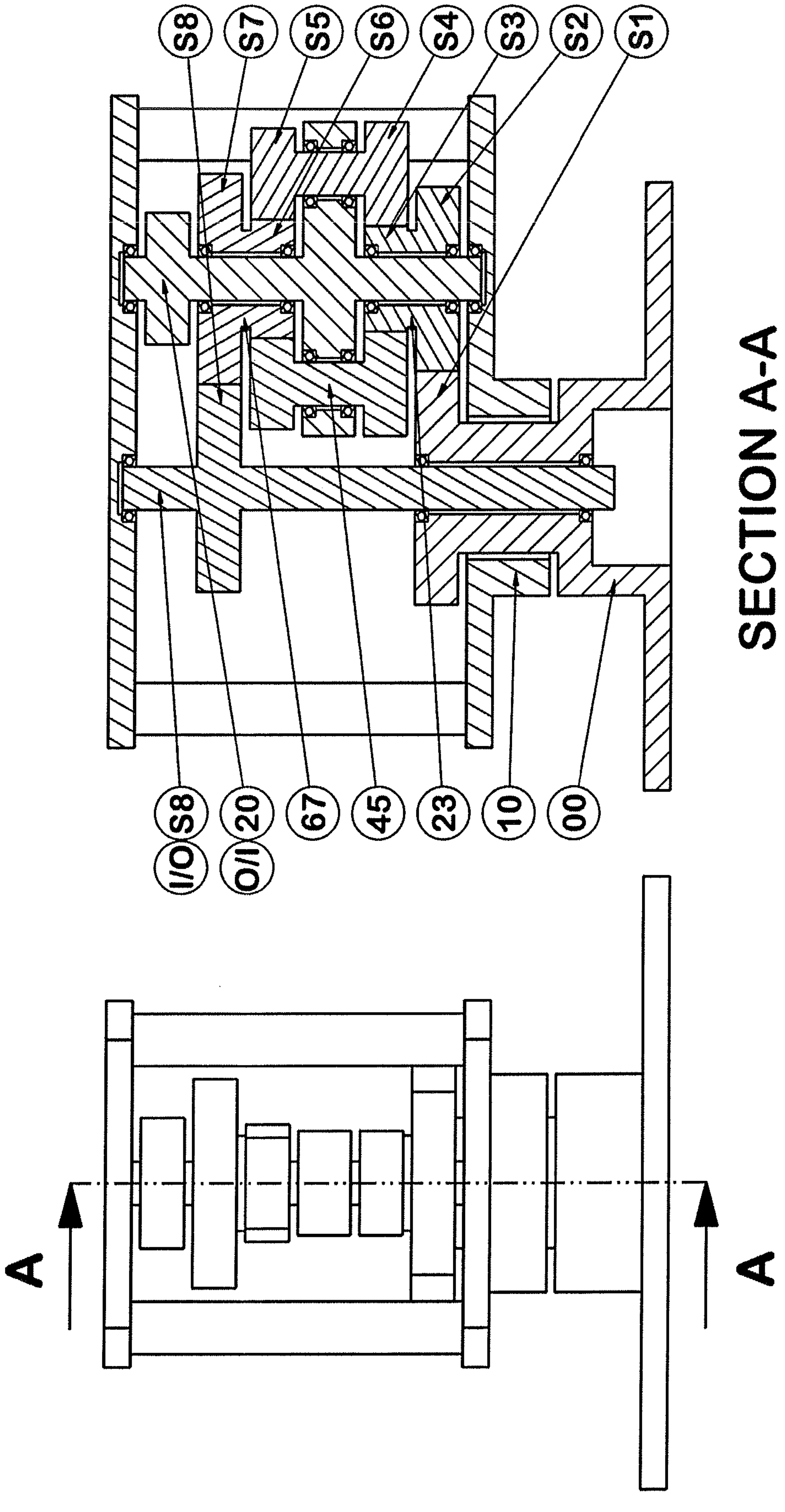
- a third shaft (67), named "planetary action shaft", which is supported on the planetary carrier (20) and able to rotate freely and endlessly about the planetary axis, while there is a seventh gear, named "action satellite-planet", rigidly connected to the one end of the planetary action shaft (67) coaxially with the planetary axis, being either spur (S6) or bevel (B6) and cooperating with the action satellite (S5 or B5, respectively), with a teeth number Z_{S6} or Z_{B6}, respectively,
while the action sun (S8 or I8) cooperates with an eighth gear (S7), named "action sun-planet", being such a gear as to properly cooperate with the action sun (S8 or I8), with a teeth number Z_{S7}, which is rigidly connected coaxially with the planetary axis:
- either to the other end of the planetary action shaft (67), and therefore the planetary carrier (20) is either the output or the input of the compound planetary mechanism, while the relation which applies to all involved gears is: K*L=1,
- or to the planetary carrier (20), and therefore the planetary action shaft (67) is either the output or the input of the compound planetary mechanism, while the relation which applies to all involved gears is: (1-K)*L=1,
where:
$K=Z_{S1}/Z_{S2}*Z_{S7}/Z_{S8}$ or $K=-Z_{I1}/Z_{S2}*Z_{S7}/Z_{S8}$ or $K=-Z_{S1}/Z_{S2}*Z_{S7}/Z_{I8}$ or $K=Z_{I1}/Z_{S2}*Z_{S7}/Z_{I8}$
and:
$L=Z_{S3}/Z_{S4}*Z_{S5}/Z_{S6}$ or $L=-Z_{B3}/Z_{B4}*Z_{B5}/Z_{B6}$,
so that, the compound planetary mechanism transmits endless rotation from the action sun (S8 or I8), on the frame (00), to either the planetary carrier (20) or the planetary action shaft (67), on the central carrier (10), or vice versa, independently of the endless rotation of the central carrier (10) with respect to the frame (00).

2. A horizontal axis wind turbine with a compound planetary mechanism, according to Claim 1, wherein the frame (00) is configured to be coincident with the stationary tower of the wind turbine and the central carrier (10) is configured to be coincident with the rotating nacelle of the wind turbine, and wherein either the planetary carrier (20) or the planetary action shaft (67) is the input of the compound planetary mechanism and is configured to be connected to the propeller shaft of the wind turbine, either via bevel gears or via any other means, while the action sun (S8 or I8) is the output of the compound planetary mechanism and is configured to be connected to the shaft of an electric generator, stationary with respect to the tower, either directly or through a gearbox, either on the top or on any other location of the longitudinal axis of the tower, so that an endless rotation is transmitted from the propeller shaft, on the rotating nacelle, to the shaft of an electric generator, on the stationary tower, independently of the endless rotation of the nacelle with respect to the tower,
- while, when the electric generator and possibly the gearbox are on the base of the tower or near it, the shaft which is configured to transmit endless rotation from the action sun (S8), which is located on the top of the tower, to the base of the tower or near it, preferably is an elongate space frame structure of sufficient strength and torsional rigidity, supported with bearing units in specific locations along the longitudinal axis of the tower and can also be used as a ladder for accessing the top of the tower.

3. A structure, stationary or movable in space, such as a building or an excavator or a battle tank or a robot, which has, at least, two compartments with the capability of endless rotation of each compartment with respect to its neighboring one, with a compound planetary mechanism, according to Claim 1, wherein the frame (00) is configured to be coincident with the one compartment of this structure and the central carrier (10) is configured to be coincident with the next compartment, so that an endless rotation is transmitted from a driving shaft, on the one compartment, to a driven shaft, on the next compartment, independently of the endless relative rotation between them.

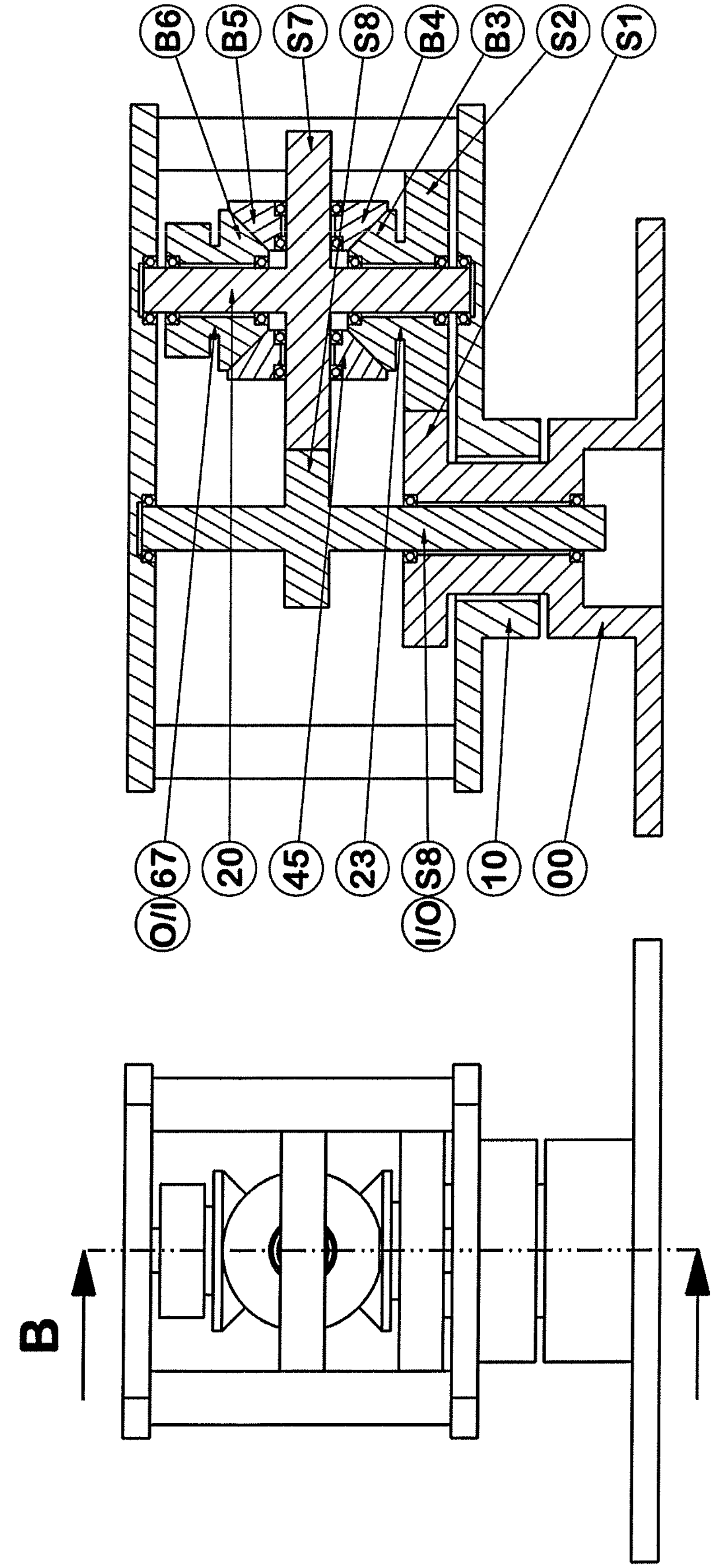
4. A steering bracket of a vehicle, which supports an endlessly rotating drive wheel, wherein the steering bracket can be rotated about an axis preferably perpendicular to the axis of rotation of the drive wheel for the purpose of changing the direction of the vehicle, with a compound planetary mechanism, according to Claim 1, wherein the frame (00) is configured to be coincident with the vehicle chassis and the central carrier (10) is configured to be coincident with the rotating steering bracket, so that an endless rotation is transmitted from a driving shaft, on the vehicle chassis, to a driven shaft, on the steering bracket, wherein the driven shaft finally drives the drive wheel of the vehicle, independently of the rotation, finite or endless, of the steering bracket with respect to the vehicle chassis.

5. A helicopter, or a propeller-driven aircraft, or a propeller-driven craft, or a wind turbine of any type, with a compound planetary mechanism, according to Claim 1, wherein the frame (00) is configured to be coincident with the helicopter frame, or the aircraft frame, or the craft frame, or either the rotating nacelle of a horizontal axis wind turbine or the tower of the wind turbine in any other case, respectively, and the central carrier (10) is configured to be coincident with the rotating propeller hub, so that a rotation, finite or endless, is transmitted from a driving shaft, on said frame, to a driven shaft, on the endlessly rotating propeller hub, independently of the rotation of the propeller hub with respect to said frame, mainly for the purpose of the adjustment of the propeller pitch.



SECTION A-A

FIGURE 01



SECTION B-B

FIGURE 02

03/10

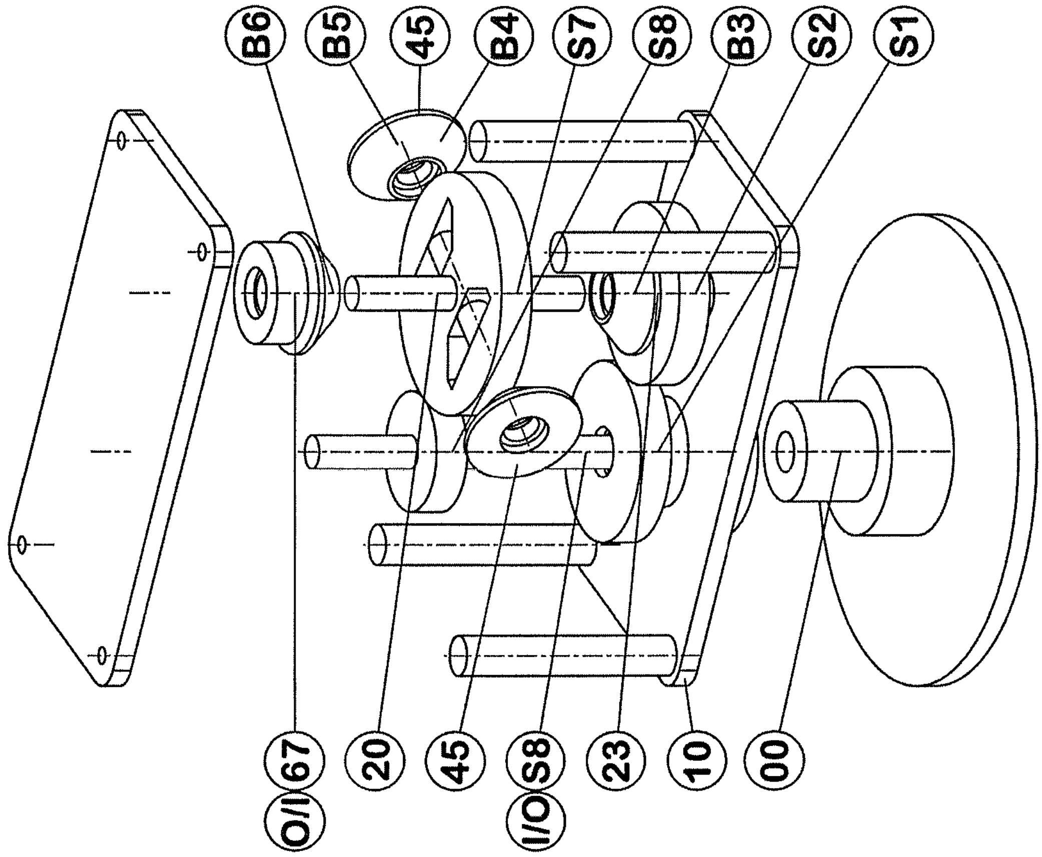


FIGURE 04

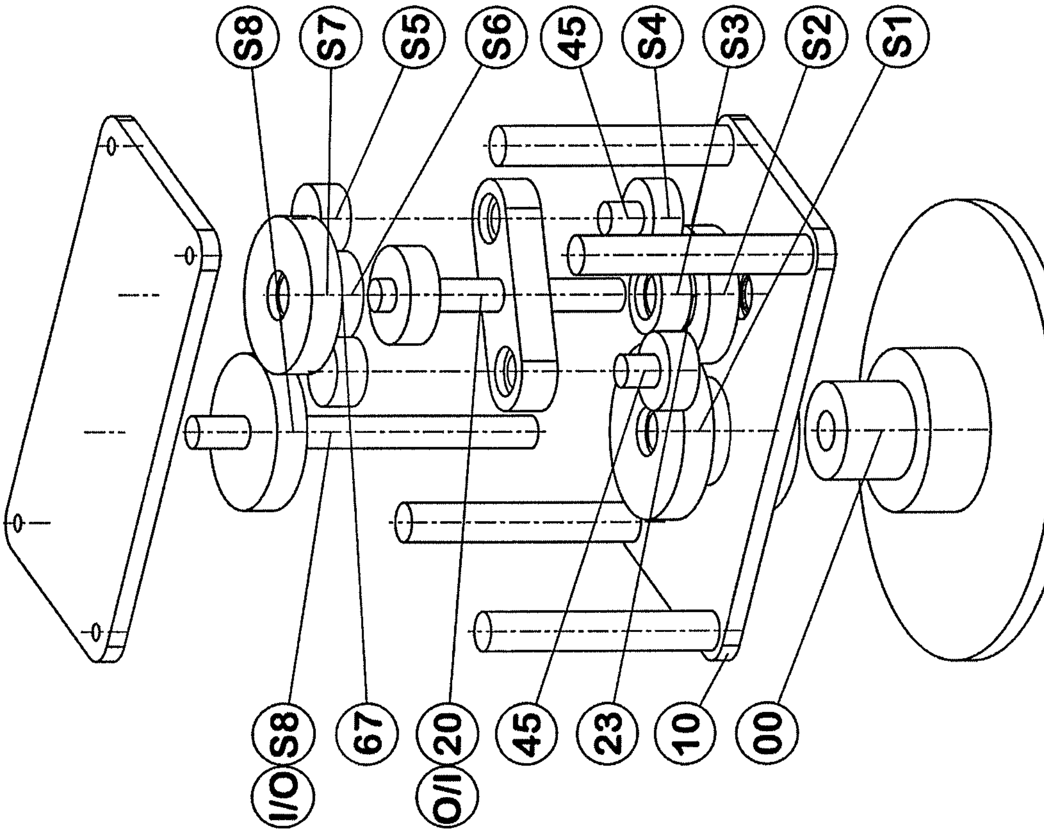


FIGURE 03

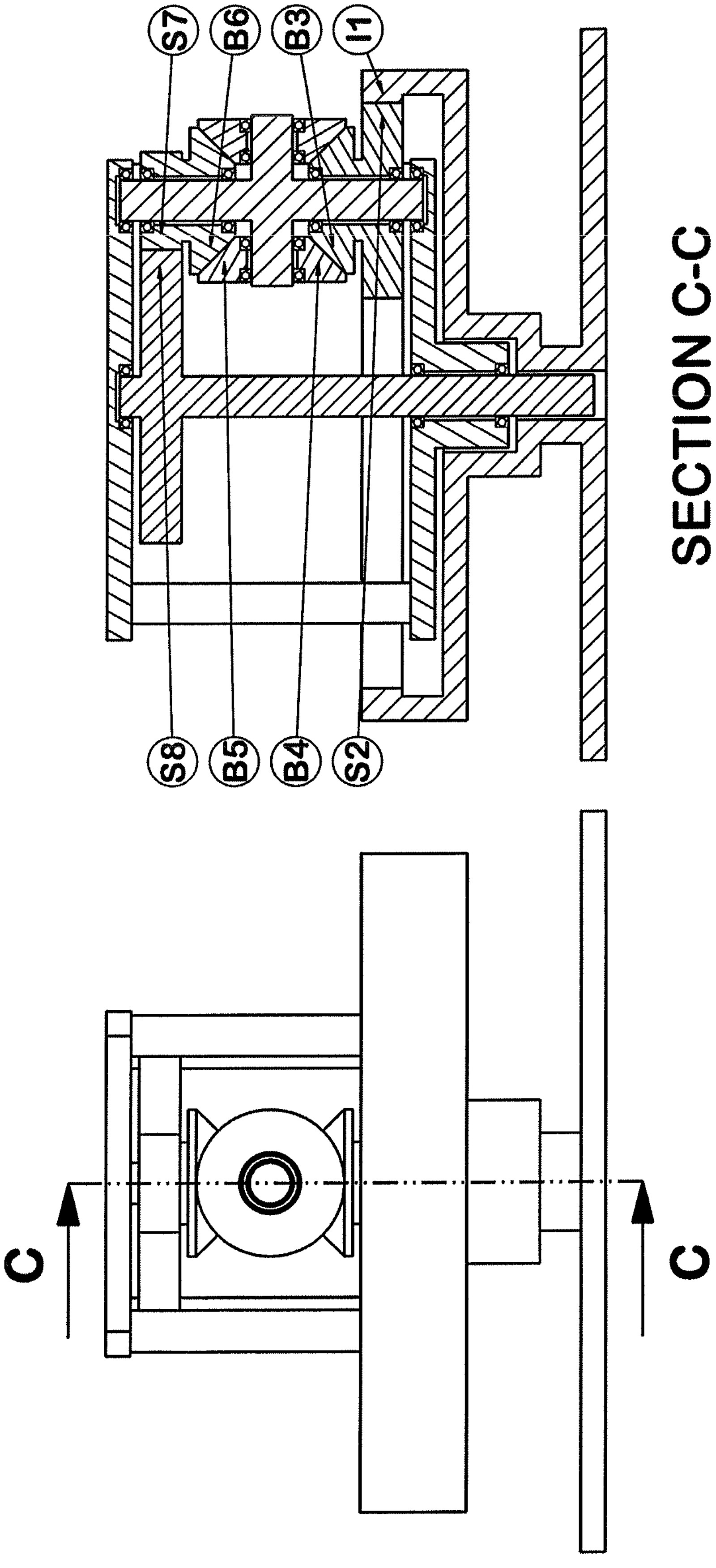


FIGURE 05

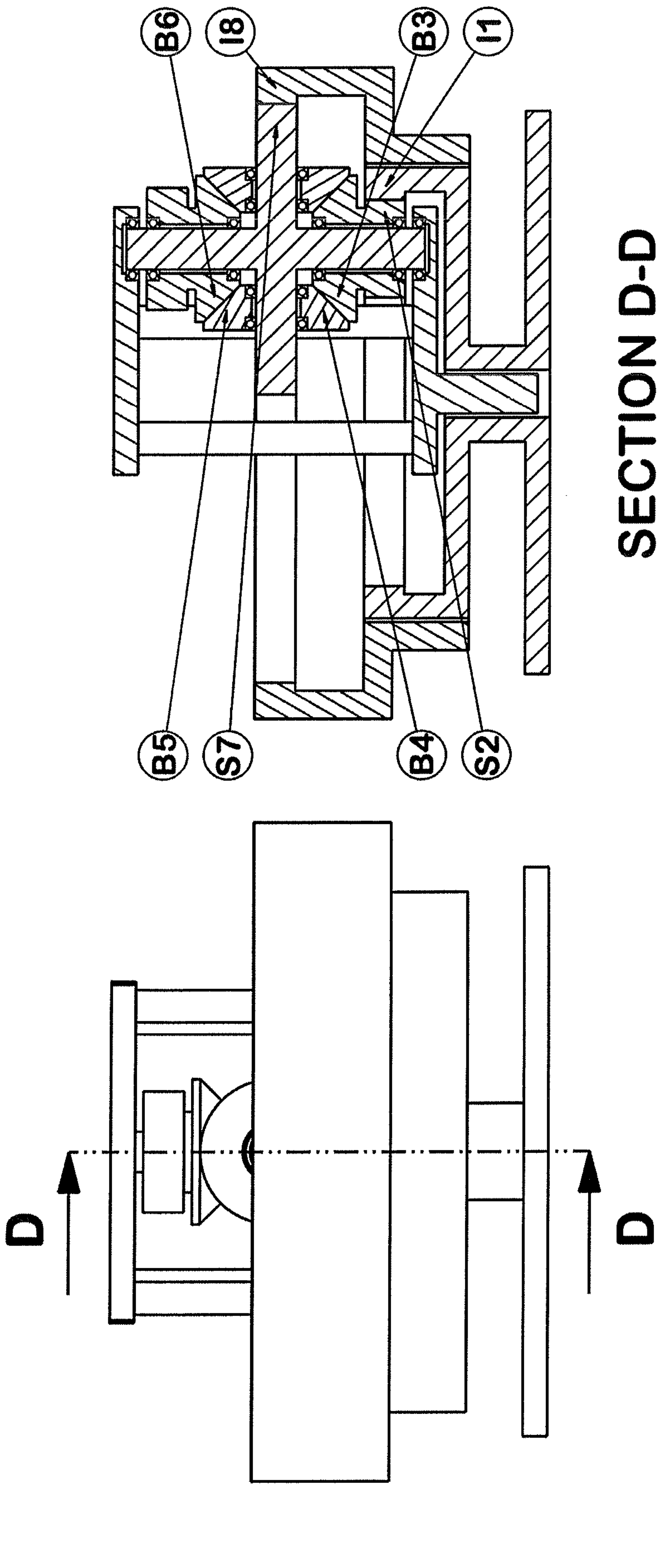


FIGURE 06

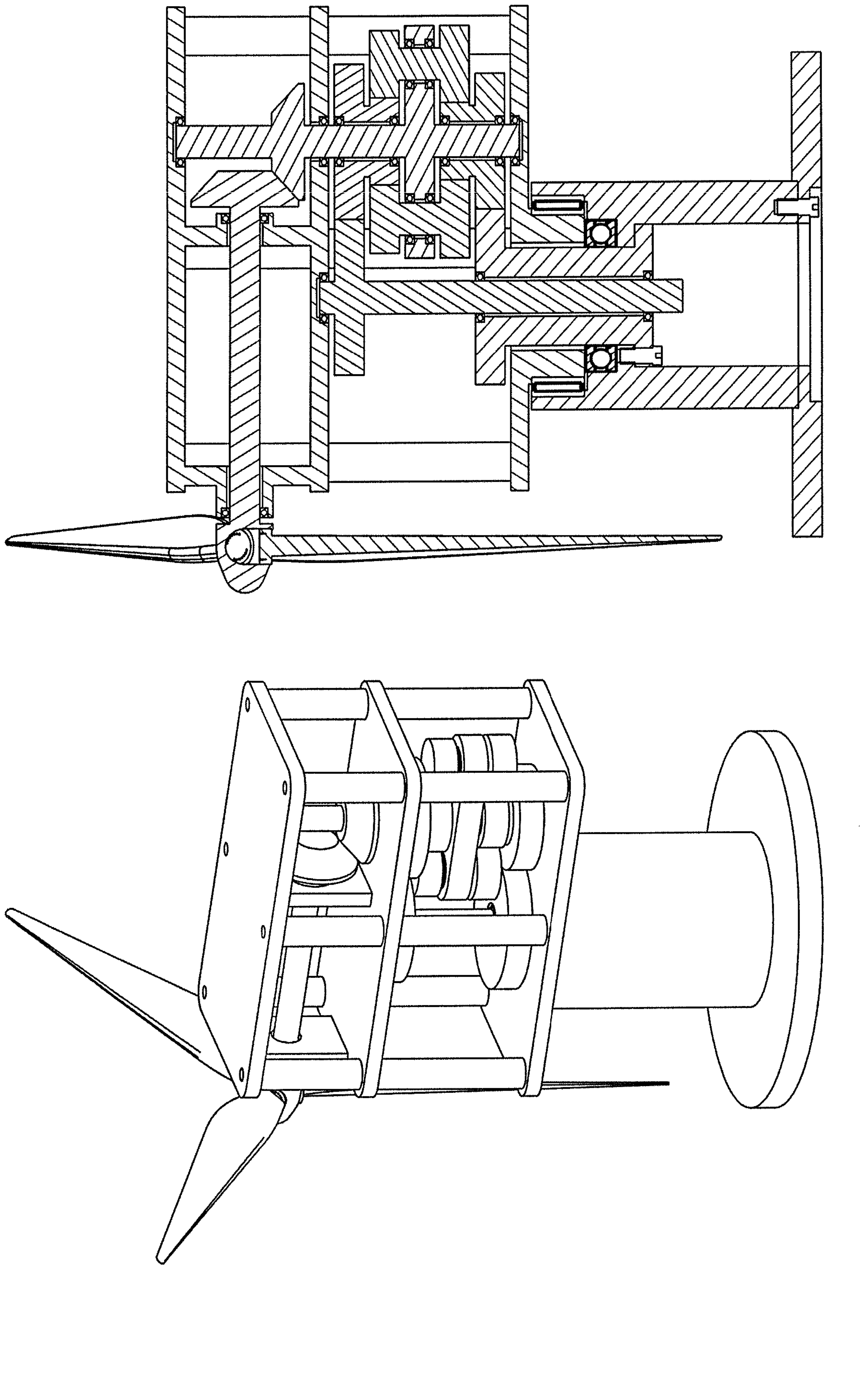


FIGURE 07

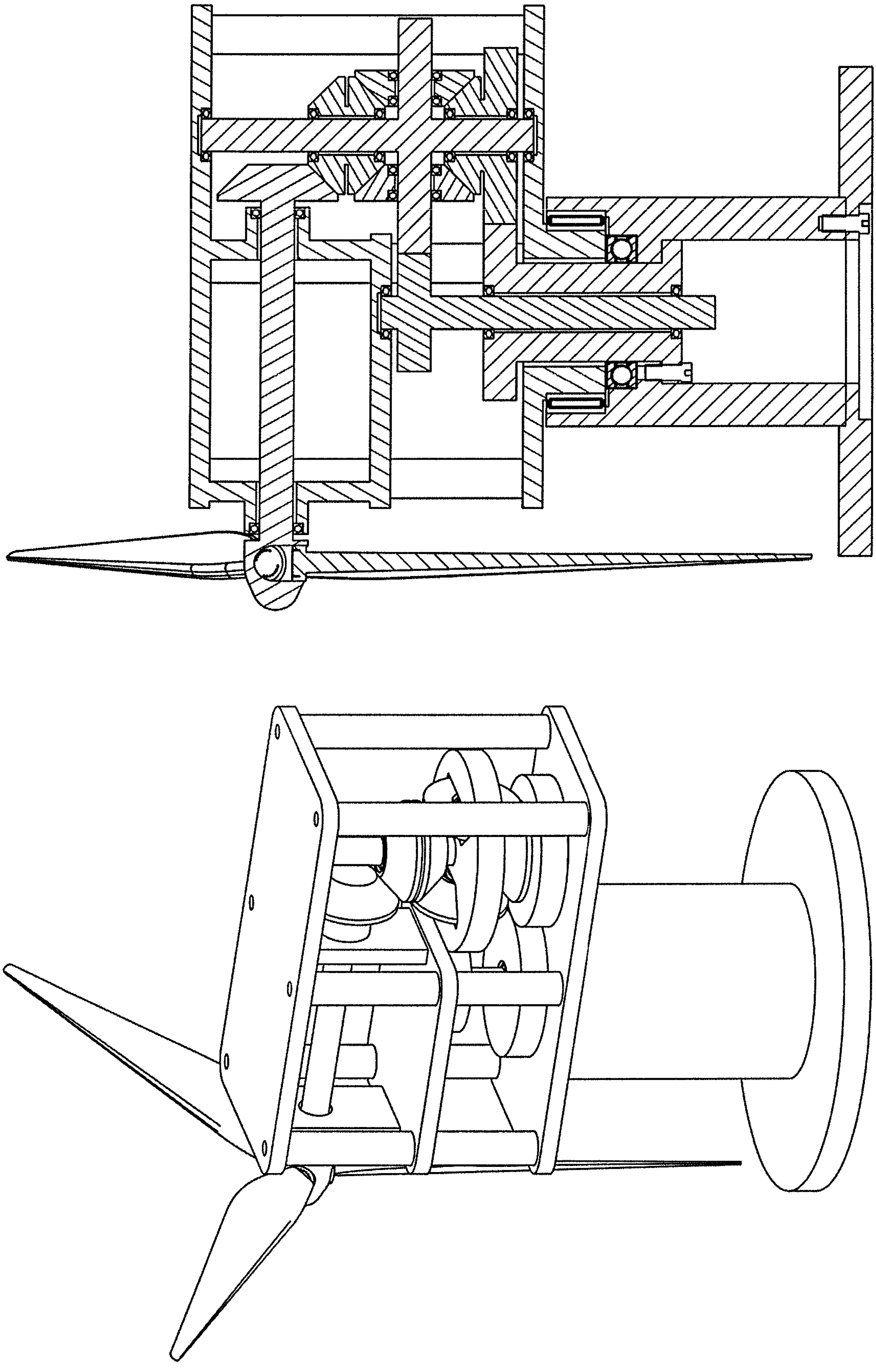


FIGURE 08

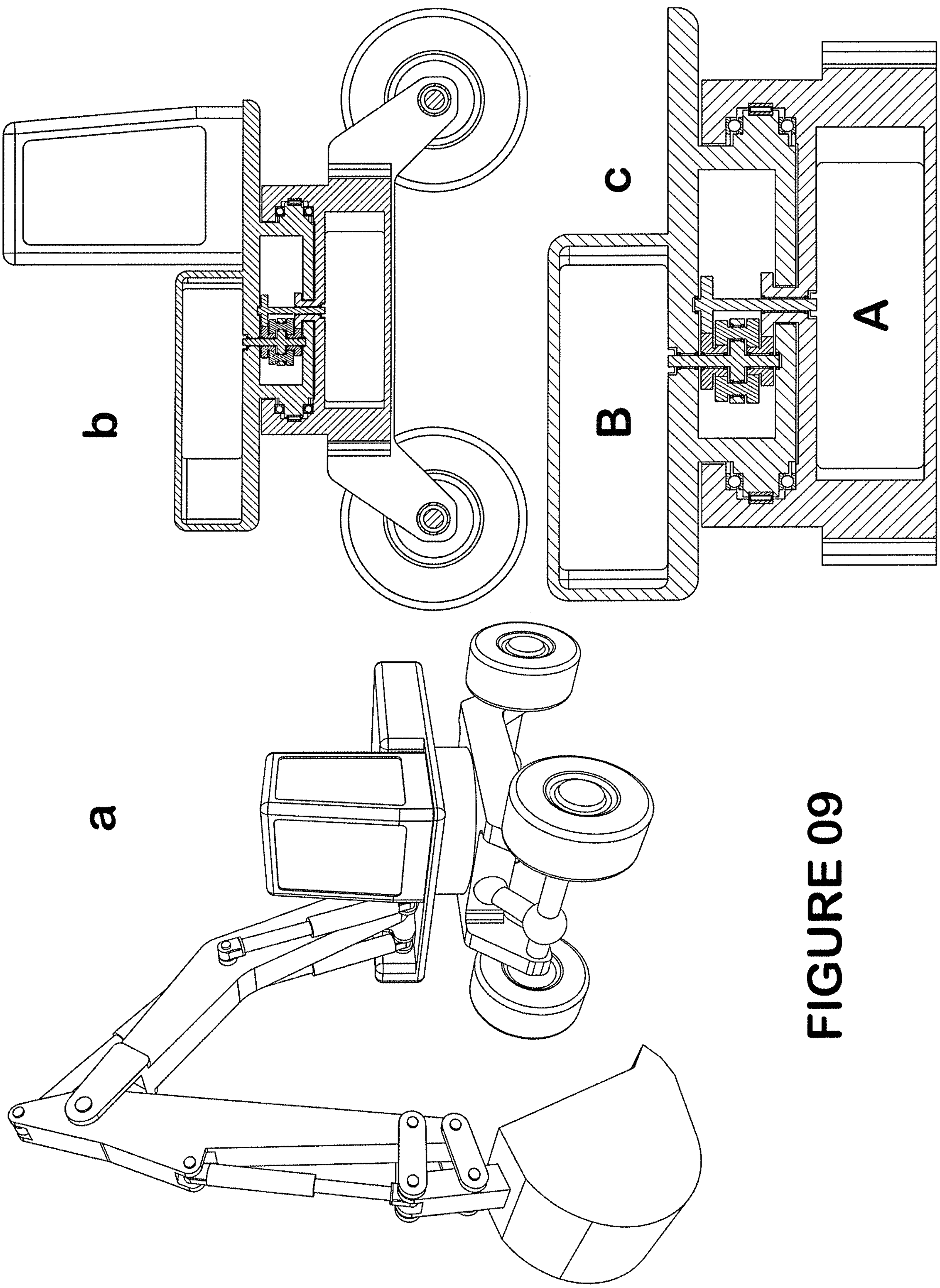


FIGURE 09

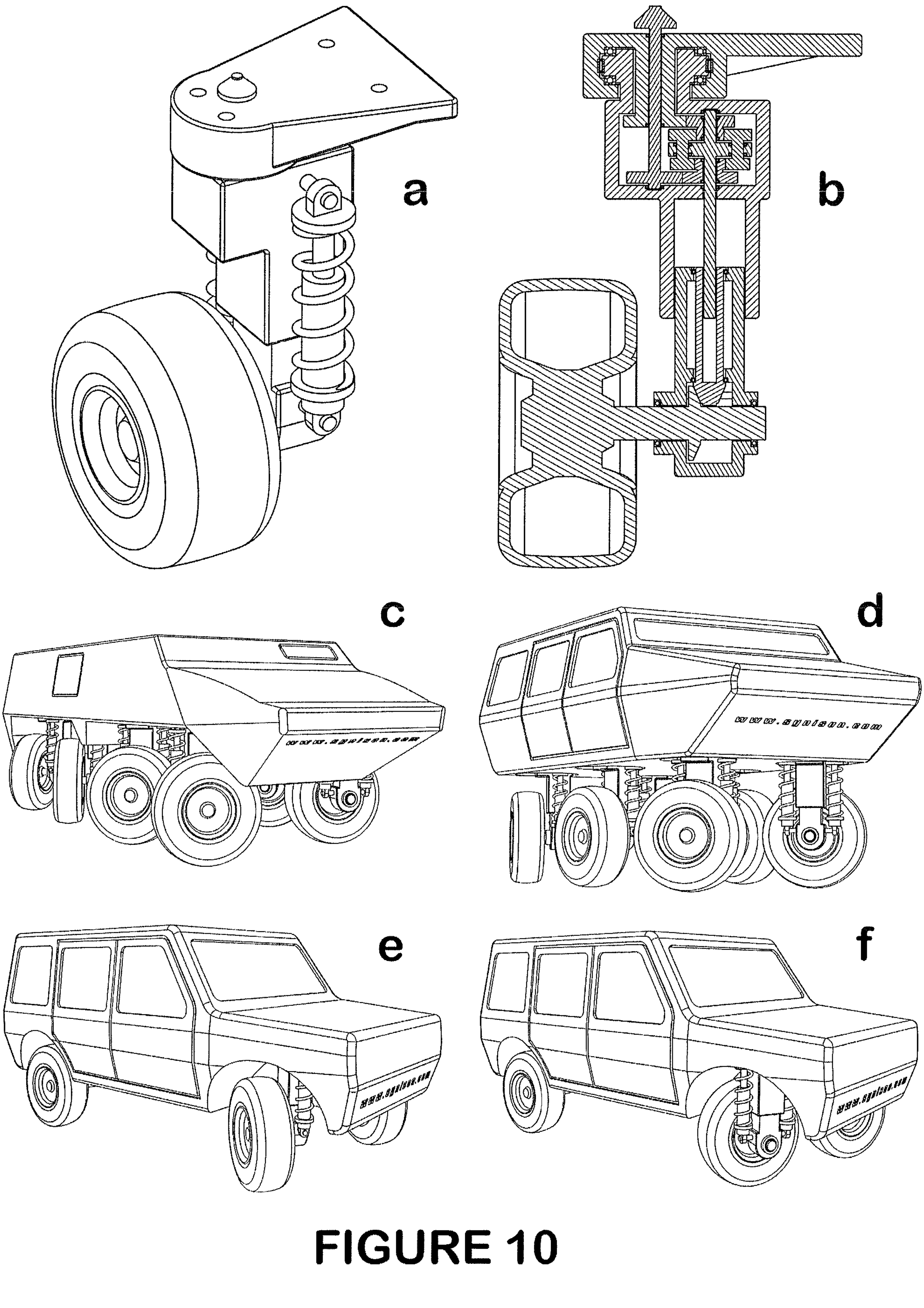


FIGURE 10

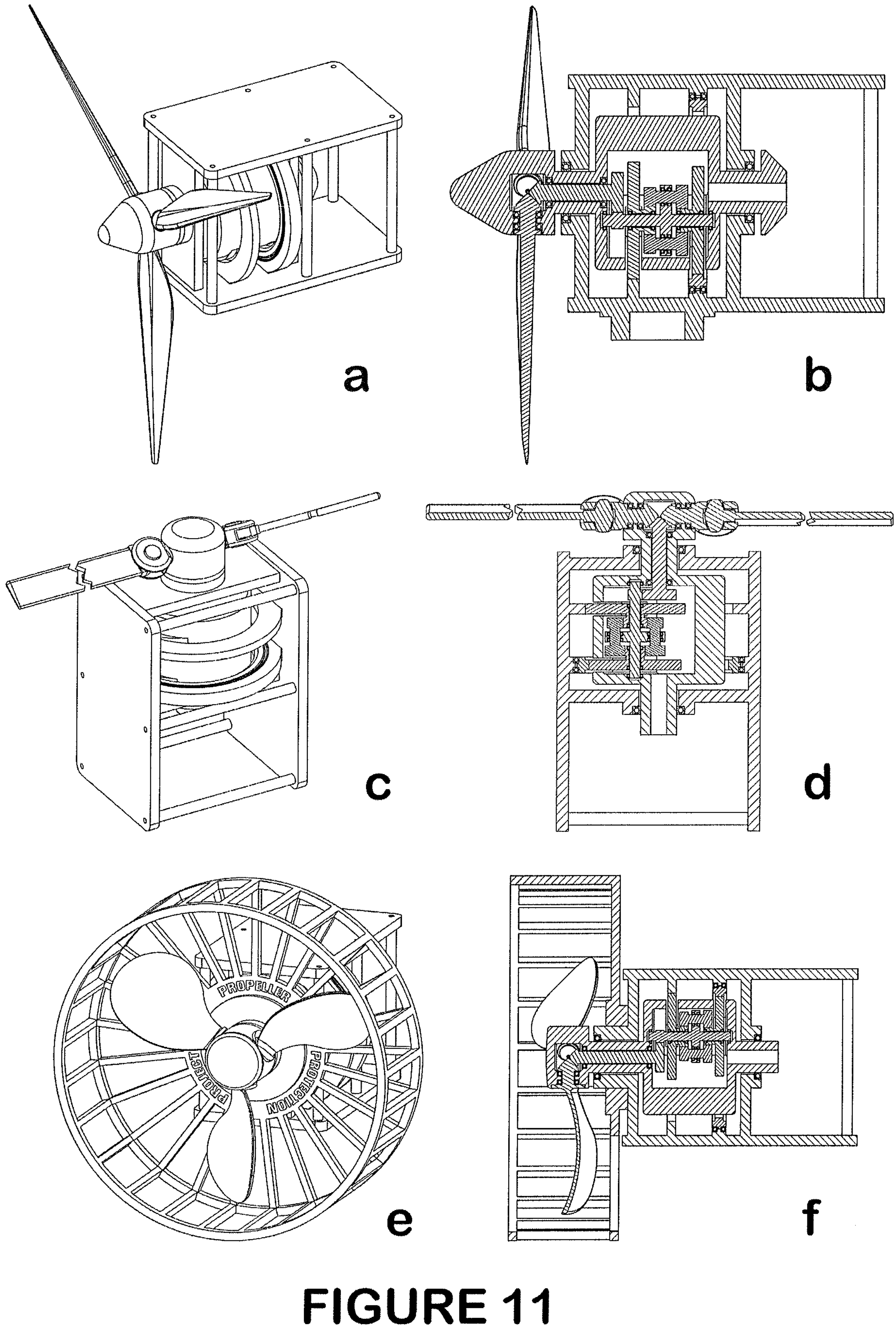


FIGURE 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/GR2021/000039

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H1/28
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16H F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2016/016645 A2 (INVOLUTION TECHNOLOGIES LTD [GB]) 4 February 2016 (2016-02-04) figures 1, 5 the whole document -----	1-10
A	DE 10 2017 207787 A1 (ZAHNRADFABRIK FRIEDRICHSHAFEN [DE]) 15 November 2018 (2018-11-15) figures 1, 2 the whole document -----	1-10
A	RU 2 677 952 C1 (STANOVSKOJ VIKTOR VLADIMIROVICH [RU]) 22 January 2019 (2019-01-22) figures 1, 2, 5, 6, 7 the whole document -----	1-10
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2021	06/10/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ehrsam, Adrian

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GR2021/000039

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 594 819 A1 (GEN ELECTRIC [US]) 22 May 2013 (2013-05-22) figures 2, 4 the whole document -----	1-7

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GR2021/000039

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		DK 2594819 T3	19-12-2016
		EP 2594819 A1	22-05-2013
		US 2012134805 A1	31-05-2012