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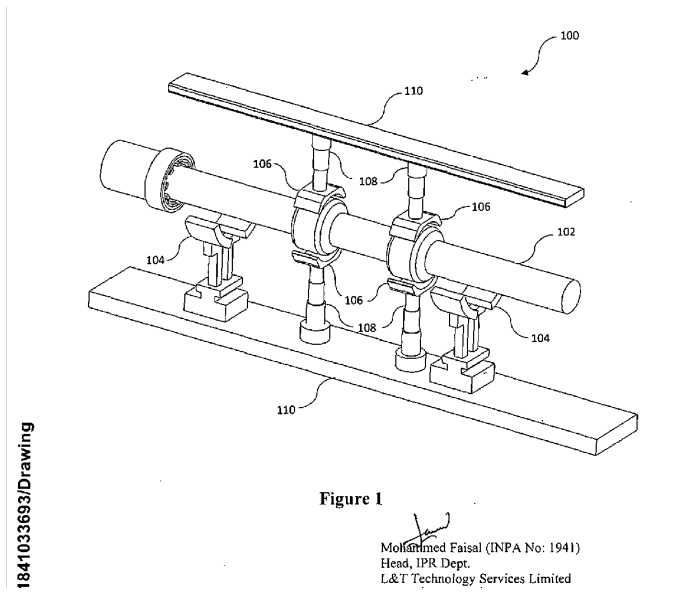
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(54) Title: AN ARRANGEMENT FOR SUPPORTING A ROTATABLE MAGNETICALLY LEVITATED SHAFT

(57) Abstract: According to an embodiment, an arrangement 100 for supporting a magnetically levitated shaft 102 is disclosed. The shaft 102 may be rotatable about a shaft axis. The arrangement 100 for supporting the magnetically levitated shaft 102 may include at least one substantially semi-circular bearing 106. The semi-circular bearing 106 may have an outer surface and an inner surface. The semi-circular bearing 106 may be arranged in such a manner that the inner surface may engage and disengage the shaft 102 without obstructing the rotation of the shaft 102. The arrangement 100 may further include an actuator 108. The actuator 108 may be coupled to the outer surface 108 of the semi-circular bearing 106. The coupling between the actuator 108 and the semi-circular bearing 106 may enable the actuator 108 to selectively control the engagement and disengagement of the semi-circular bearing 106 with the shaft 102.

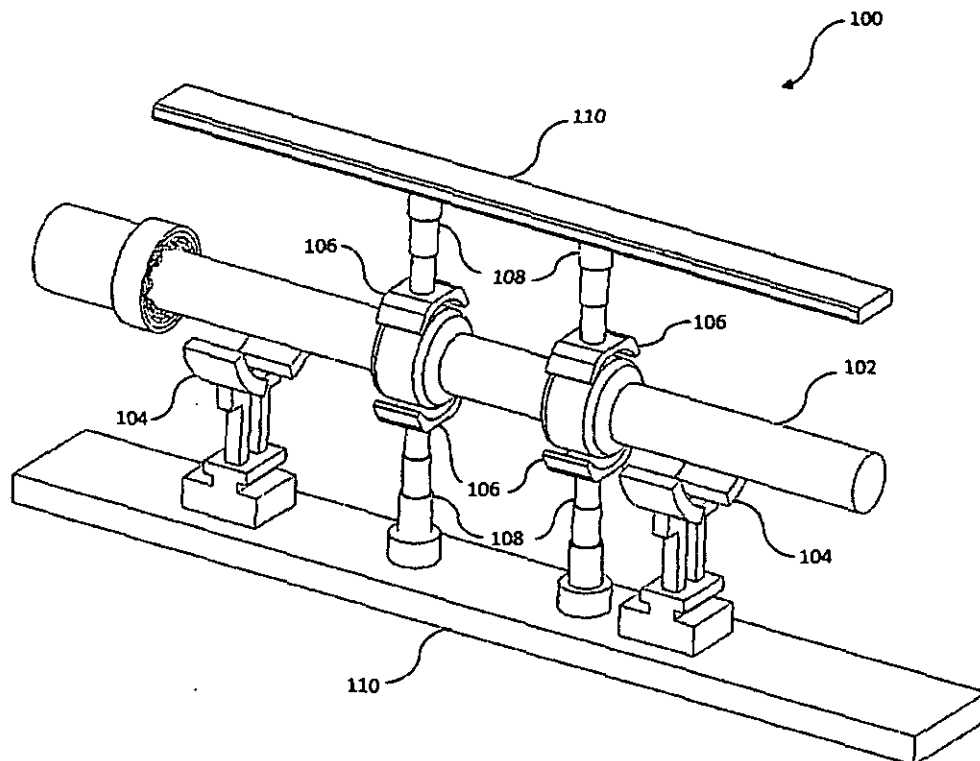




## ABSTRACT

### An arrangement for supporting a rotatable magnetically levitated shaft

According to an embodiment, an arrangement 100 for supporting a magnetically levitated shaft 102 is disclosed. The shaft 102 may be rotatable about a shaft axis. The arrangement 100 for supporting the magnetically levitated shaft 102 may include at least one substantially semi-circular bearing 106. The semi-circular bearing 106 may have an outer surface and an inner surface. The semi-circular bearing 106 may be arranged in such a manner that the inner surface of the semi-circular bearing 106 may engage and disengage the shaft 102 without obstructing the rotation of the shaft 102. The arrangement 100 may further include an actuator 108. The actuator 108 may be coupled to the outer surface of the semi-circular bearing 106. The actuator 108 may be operable to selectively control the engagement and disengagement of the inner surface of the semi-circular bearing 106 with the shaft 102.



PATENT OFFICE CHENNAI 30/08/2019 13:11



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We claim:

1. An arrangement 100 for supporting a magnetically levitated shaft 102, the shaft 102 being rotatable about a shaft axis, the arrangement 100 comprising:  

at least one substantially semi-circular bearing 106 having an outer surface and an inner surface, the semi-circular bearing 106 is arranged such that the inner surface engages and disengages the shaft 102 without obstructing the rotation of the shaft 102;  
and  
  

an actuator 108 coupled to the outer surface of the semi-circular bearing 106 that selectively controls the engagement and disengagement of the inner surface of the semi-circular bearing 106 to the shaft 102.
2. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the shaft 102 is supported in a horizontal position.
3. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the shaft 102 is a main shaft of a horizontal axis wind turbine.
4. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the shaft 102 is magnetically levitated by at least one magnet 104.
5. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the outer surface of the semi-circular bearing 106 includes a provision to fixedly couple the semi-circular bearing 106 to the actuator 108.

INVENTOR OFFICE CHENNAI 30/08/2019 13:11

6. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the inner surface of the semi-circular bearing 106 includes a plurality of freely rotatable rollers or balls.
7. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the inner radius of the semi-circular bearing is more than the radius of the magnetically levitated shaft 102.
8. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the actuator 108 is actuated automatically.
9. The arrangement 100 for supporting the magnetically levitated shaft 102 as claimed in claim 1, wherein the actuator 108 is actuated manually.

Dated this 7<sup>th</sup> day of September 2018



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## FIELD OF INVENTION

The invention generally relates to a supporting arrangement for a shaft and more particularly to a supporting arrangement for a rotatable magnetically levitated mechanical shaft.

## BACKGROUND

Mechanical shafts are commonly used in mechanical devices to transmit power from one component to another component. Mechanical shafts are longitudinal shafts having substantially circular cross section. The mechanical shafts are employed in various kinds of machines such as a wind turbine or an automobile, to transmit power between the components of the machine. Specifically, in a wind turbine, a main shaft transmits torque from a rotor connected at one end of the main shaft to a gearbox connected at another end of the main shaft. The main shaft is usually driven at a slow speed by the rotor blades. This slow speed rotation of the main shaft is then transformed in the transmission gearbox into a fast rotation for driving an electric power generator.

Typically, the main shaft is connected to the gearbox through a mechanical bearing. The mechanical bearing provides friction in the movement of the main shaft with respect to the gearbox which further affects the transmission of torque from the main shaft to the gearbox. In a magnetically levitated main shaft, the friction between the main shaft and the gearbox is eliminated by replacing the mechanical bearing with a magnetic bearing. Although the magnetically levitated main shaft eliminates the initial friction, it usually must bear heavy

vibrations or misalignments at high rotational speeds.

29-Aug-2019/72559/201841033693/Description(Complete)

PATENT OFFICE CHENNAI 30/08/2019 13:11

Hence there is a need for an arrangement for supporting the rotatable magnetically levitated shaft.

## **SUMMARY OF THE INVENTION**

According to an embodiment of the invention, an arrangement for supporting a magnetically levitated shaft is disclosed. The shaft may be rotatable about a shaft axis. The arrangement for supporting the magnetically levitated shaft may include at least one substantially semi-circular bearing. The semi-circular bearing may have an outer surface and an inner surface. The semi-circular bearing may be arranged in such a manner that the inner surface of the semi-circular bearing may engage and disengage the shaft without obstructing the rotation of the shaft. The arrangement for supporting the magnetically levitated shaft may further include an actuator. The actuator may be coupled to the outer surface of the semi-circular bearing. The actuator may be operable to selectively control the engagement and disengagement of the inner surface of the semi-circular bearing with the shaft.

## **BRIEF DESCRIPTION OF DRAWINGS**

Other objects, features, and advantages of the invention will be apparent from the following description when read with reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

Figure 1 illustrates an isometric view of an arrangement for supporting a magnetically levitated shaft according to an exemplary embodiment of the invention.

29-Aug-2019/72559/201841033693/Description(Complete)

PATENT INFORMATION 30/08/2019 13:11

Figure 2 illustrates a front view of an arrangement for supporting a magnetically levitated shaft according to an exemplary embodiment of the invention.

## DETAILED DESCRIPTION OF DRAWINGS

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skilled in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

Figure 1 and figure 2 illustrates an isometric view and a front view respectively of an arrangement 100 for supporting a magnetically levitated shaft 102 according to an exemplary embodiment of the invention. The arrangement 100 may be employed in systems such as wind turbine, that include shafts for transmission of power from one component to another. In the following, the terms 'magnetically levitated shaft' and 'shaft' may be used interchangeably without restricting the invention in any way. The shaft 102 may be a mechanical shaft having a substantially circular cross-section. The shaft 102 may be magnetically levitated in a horizontal position and may be free to rotate about a shaft axis. According to an embodiment, the shaft 102 may be constructed from a metal. According to another embodiment, the shaft 102 may be constructed from materials or combination of materials that may include, but are

not limited to one or more of metal, alloy, and any other suitable material known in the art. The

arrangement for magnetically levitating the shaft 102 may include one or more magnets 104 placed in proximity to the shaft 102. The one or more magnets 104 may be spaced along the length of the shaft 102. The height of the one or more magnets 104 may be adjustable as required for proper levitation of the shaft 102. The one or more magnets 104 may be arranged in such a manner that they provide a repulsive force on the shaft 102 and enable the shaft 102 to levitate. According to an embodiment, the magnets 104 may further enhance the rotation of the shaft 102 about the axis of the shaft 102. According to an embodiment, the one or more magnets 104 may be permanent magnets. According to another embodiment, the one or more magnets 104 may be electromagnets. According to yet another embodiment, the one or more magnets 104 may include both the permanent magnets and the electromagnets in combination. It will be apparent to a person skilled in the art that the magnetic levitation of the shaft 102 may be achieved by various arrangements of the one or magnets 104 along the length of the shaft 102. As will be appreciated by those skilled in the art, the magnetically levitated shaft 102 may be employed in multiple systems for efficient power transmission between components.

According to another embodiment of the invention, an arrangement for supporting a magnetically levitated shaft 102 of a wind turbine (not shown in figure) is disclosed. The magnetically levitated shaft 102 may be a main shaft 102 of the wind turbine. The shaft 102 may be housed within a nacelle of the wind turbine. It should be noted that the shaft 102 may be housed in a horizontal axis wind turbine. The shaft 102 may be a hollow cylindrical shaft, connected to a rotor at a first end and to a gearbox at a second end. The rotor may include two or more blades that rotate due to the effect of wind and transfer the wind energy into the gearbox through the main shaft 102. The connection between the shaft 102 and the rotor may be

achieved by a fastening means. The first end of the shaft 102 may be formed into a flat circular

structure having a provision for fastening the shaft 102 to the rotor. The second end of the shaft 102 may be connected to the gearbox through a magnetic bearing. The magnetic bearing may enable the second end of the shaft 102 to levitate and have a contactless connection with the gearbox. The contactless connection between the shaft 102 and the gearbox may enable a frictionless motion between the shaft 102 and the gearbox. It will be apparent to a person skilled in the art that each ends of the shaft will be connected to different components depending on the system the shaft is employed in.

The arrangement 100 for supporting the magnetically levitated shaft 102 may be employed in a system to restrict the vibrations of the magnetically levitated shaft 102 rotating at a high speed. The arrangement 100 may include at least one substantially semi-circular bearing 106. The semi-circular bearing 106 may be arranged to support the magnetically levitated shaft 102. The semi-circular bearing 106 may be constructed from materials or combination of materials that may include, but are not limited to one or more of metal, alloy, and any other suitable material known in the art. The radius of the semi-circular bearing 106 may vary depending on the radius of the shaft 102 to be supported. The semi-circular bearing 106 may have an outer surface and an inner surface. The inner surface of the semi-circular bearing 106 may be arranged in such a way that the inner surface may engage and disengage the shaft 102. In other words, the inner surface of the shaft 102 may come in contact with the shaft 102 when the shaft 102 is engaged. It will be apparent to a person skilled in the art that the radius of the inner surface of the semi-circular bearing 106 may be slightly greater than the radius of the shaft 102 so as to accommodate the shaft 102. According to an embodiment, the inner surface of the semi-circular bearing 106 may include a plurality of freely rotatable rollers. The plurality of rollers may enable the semi-circular bearing 106 to support the rotating shaft 102 without obstructing the rotation of the shaft 102. According to another embodiment, the semi-circular

bearing 106 may be a semi-circular needle roller bearing. According to yet another embodiment, the semi-circular bearing 106 may be a roller bearing. The outer surface of the semi-circular bearing may include a provision to fixedly couple the semi-circular bearing 106 to an actuator 108. It will be apparent to a person skilled in the art that the outer surface of the semi-circular bearing 106 may be coupled to the actuator 108 by any means such as, but not limited to, nut and bolt, riveting, welding etc.

The arrangement 100 for supporting the magnetically levitated shaft 102 may include one actuator 108 fixedly coupled to the outer surface of each of the semi-circular bearing 106. According to an embodiment, the actuator 108 may be a linear actuator having a fixed end and a movable end. According to another embodiment, the semi-circular bearing may be directly arranged on a platform movable in a linear motion. It will be apparent to a person skilled in the art that the diameter of the actuator 108 may depend on the diameter of the shaft 102. The fixed end of the actuator 108 may be perpendicularly mounted to a platform 110. The movable end of the actuator 108 may be coupled to the outer surface of the semi-circular bearing 106. On actuating the actuator 108, the movable end may move in a reciprocating motion. The actuator 108 may be actuated by any means such as, but not limited to, hydraulic means, electric means, mechanical means, pneumatic means etc. The actuator 108 may be in a retracted position during a non-actuated state and may move to an extended position during an actuated state.

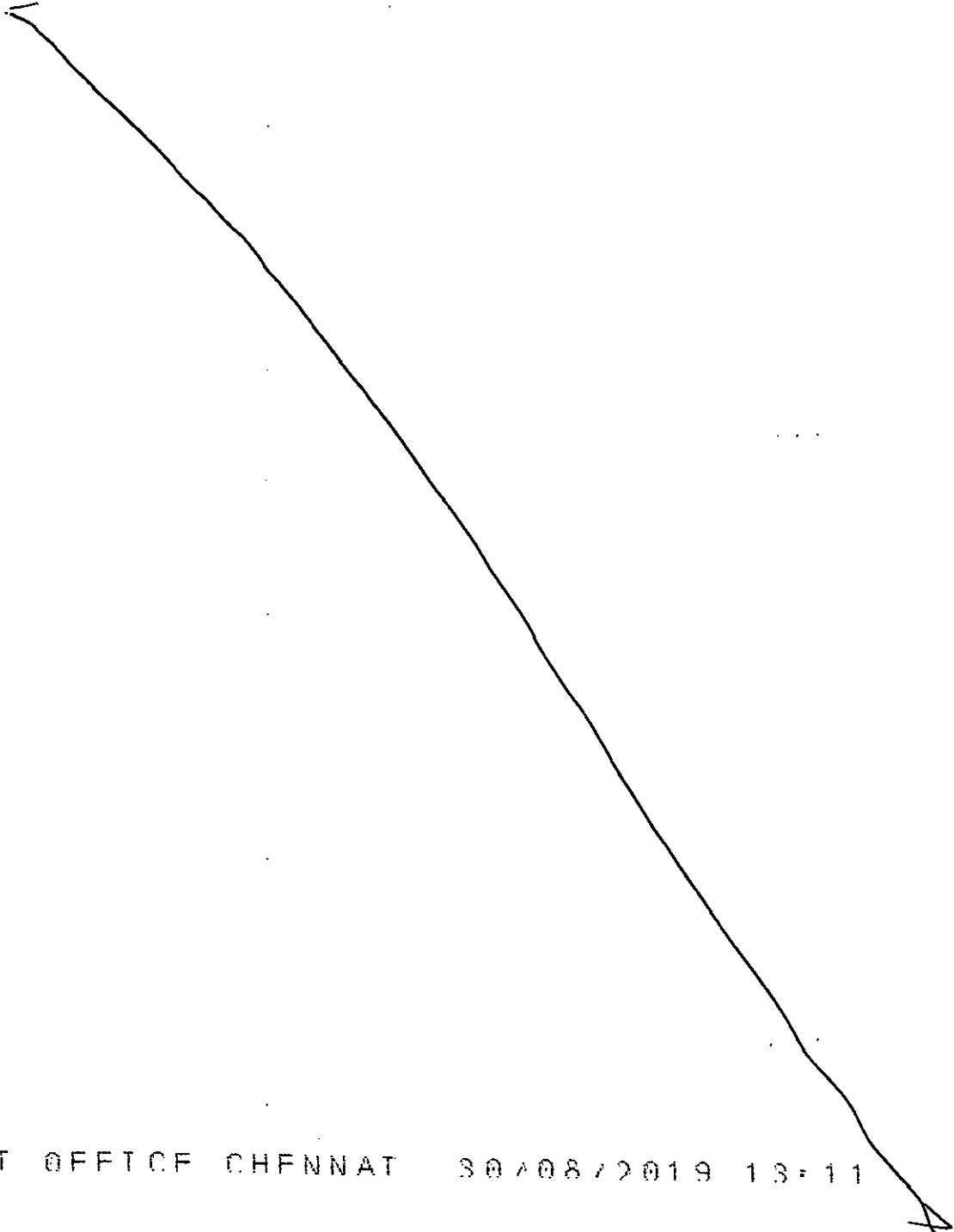
According to an embodiment, for an arrangement 100 for supporting the magnetically levitated shaft 102 having only one actuator 108, the actuator 108 may be vertically mounted on a horizontal platform 110 below the shaft 102 to support the shaft 102 from the bottom. According to another embodiment, the actuator 108 may be vertically mounted in an inverted manner on a horizontal platform 110 above the shaft 102 to support the shaft 102 from the top.

According to yet another embodiment, the actuator 108 may be horizontally mounted on a vertical platform (not shown) beside the shaft 102 to support the shaft 102 from left side. According to yet another embodiment, the actuator 108 may be horizontally mounted on a vertical platform (not shown) beside the shaft 102 to support the shaft 102 from right side. According to yet another embodiment, for an arrangement for supporting the magnetically levitated shaft 102 having more than one actuators 108, the actuators 108 may be mounted in combination of the above arrangements to support the shaft 102 from different sides. Supporting the magnetically levitated shaft 102 from different sides may reduce the vibration and misalignment of the shaft 102 during rotational movement. According to another embodiment, the linearly moving platform may have a provision to mount a plurality of the semi-circular bearing on the same platform. The plurality of semi-circular bearing 106 may move together along with the platform for supporting the rotating magnetically levitated shaft 102.

When the shaft 102 is in a non-operational state, the actuator 108 may be in the retracted position. Once the shaft 102 rotation speed exceed a predefined speed, the actuator 108 may be actuated to move to the extended position. According to an embodiment, the actuation of the actuator 108 may be performed manually. According to another embodiment, the actuation of the actuator 108 may be performed automatically. The automatic actuation may be performed by a controller when the shaft 102 exceeds the predefined speed. Once the actuator 108 moves to the extended position, the inner surface of the semi-circular bearing 106 engages the rotating shaft 102 without obstructing the rotation of the shaft 102.

It is understood that the above description is intended to be illustrative, and not restrictive. It

the spirit and scope of the invention as defined in the appended claims. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively.



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Total number of Sheets: 2  
Sheet No. 1 of 2

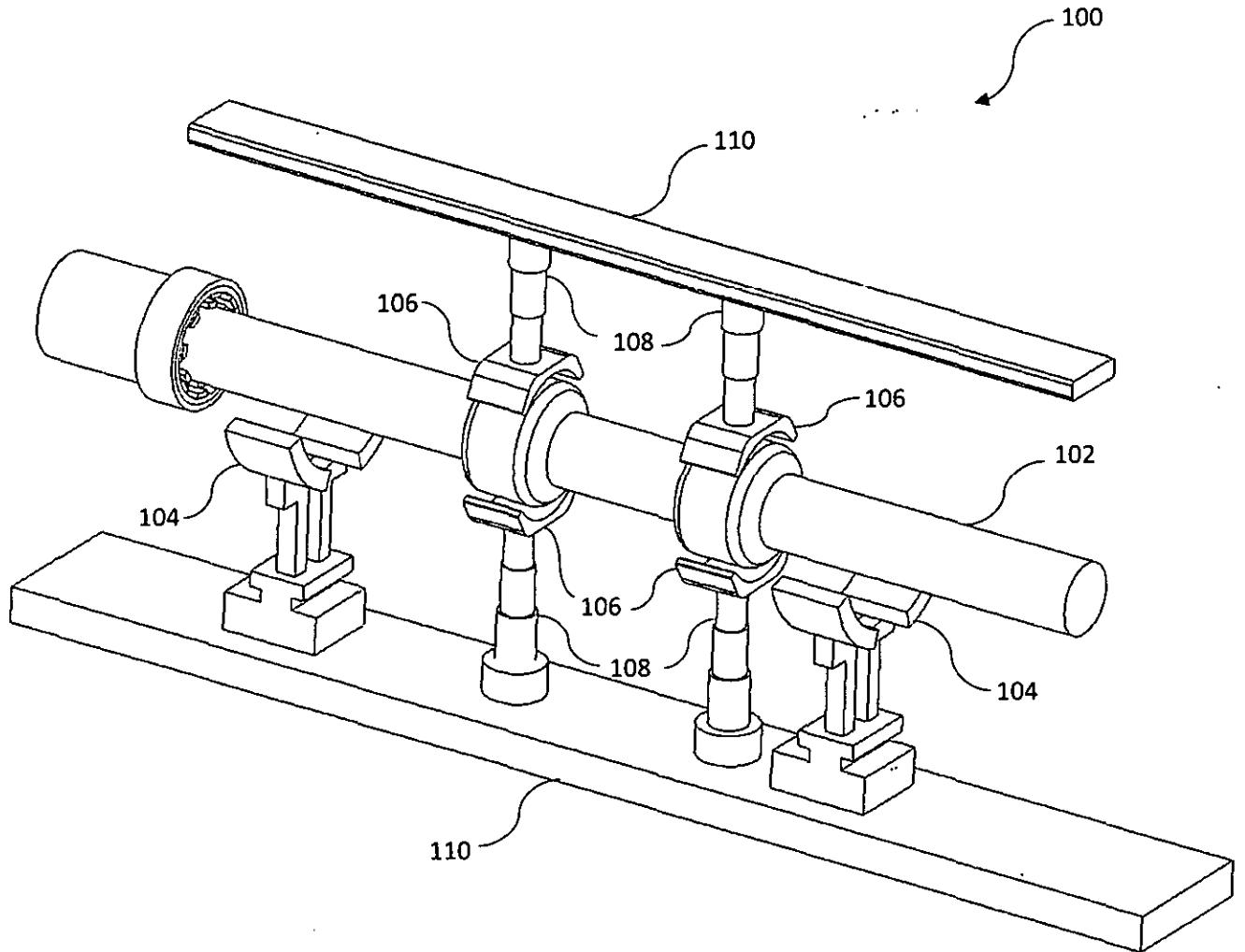



Figure 1

  
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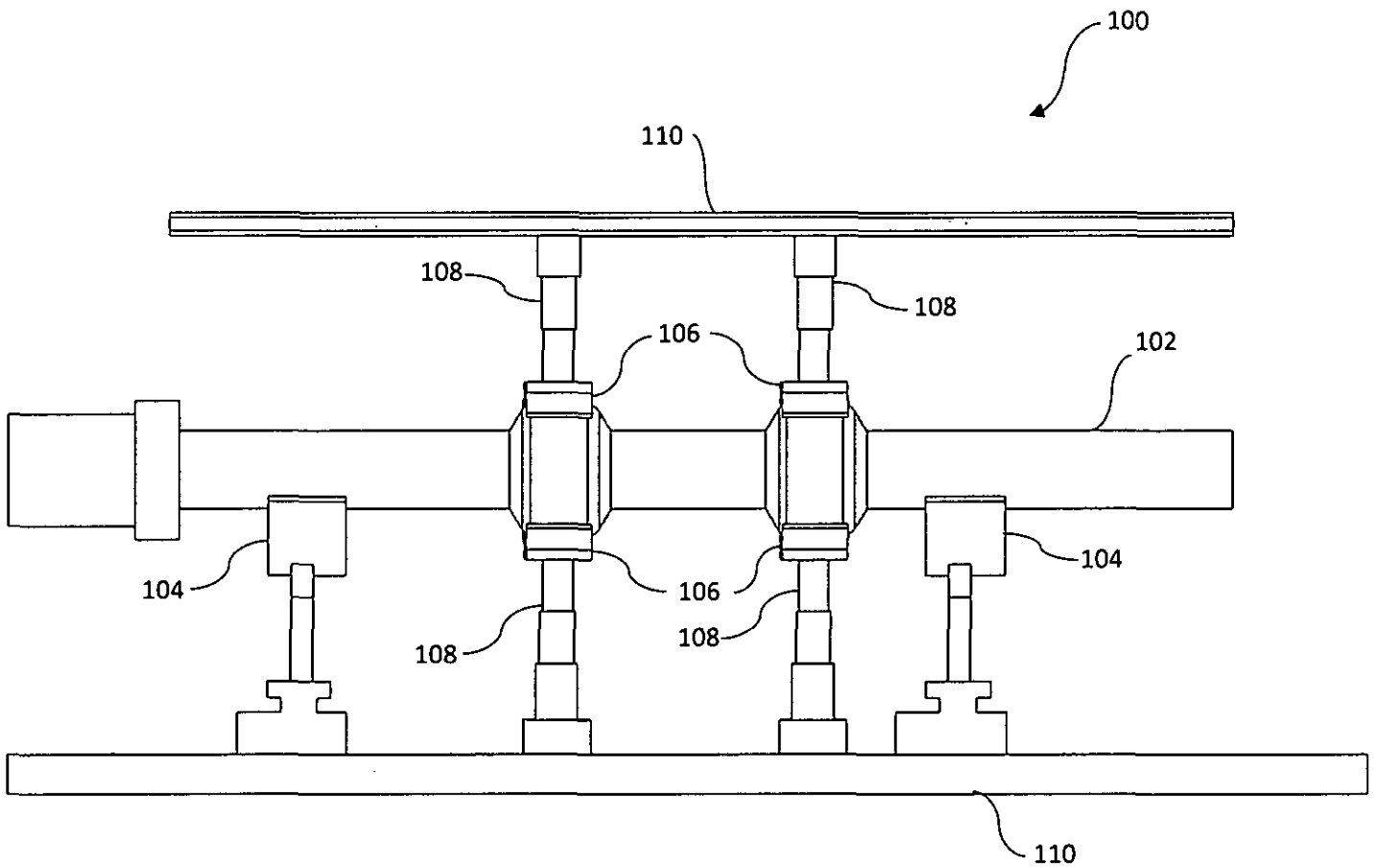


Figure 2

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