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(71) Applicant: **The Goodyear Tire & Rubber Company**
Akron, Ohio 44316 (US)

(72) Inventor: **HINQUE, Daniel Paul Luc Marie**
6720 Habay-la-Neuve (BE)

(74) Representative: **Kutsch, Bernd**
Goodyear S.A.
Patent Department
Avenue Gordon Smith
7750 Colmar-Berg (LU)

(54) ON-WHEEL AIR MAINTENANCE SYSTEM

(57) An air maintenance system is disclosed comprising a vehicle wheel or rim (9); a rotatable inner ring (11) secured to the vehicle wheel or rim (9); a stationary outer ring (13) configured to maintain a constant angular position; an occlusion roller (50) rotationally fixed to the stationary outer ring (13), the occlusion roller (50) having a protruding portion (51) preferably centered axially at a radially outer surface of the occlusion roller (50) with axially outer portions of the occlusion roller (50) being radially recessed from the protruding portion (51) and supported by bearing surfaces (12) of the rotatable inner ring (11); at least two spacer rollers (70) rotationally fixed to the stationary outer ring (13) and rotationally supported by the bearing surfaces (12); and a flexible tube (20) defining a pump cavity. The the air maintenance system (10) is configured for pumping a fluid from an ambient environment into a pneumatic tire mounted to the vehicle wheel or rim (9) by applying an occluding force against the flexible tube (20) periodically occluding portions of the pump cavity. The at least two spacer rollers (70) have axially outer surfaces (71) for rotational support by bearing surfaces (12) of the rotatable inner ring (11) and a recess (72) preferably centered axially at the outer surface (71) of the spacer rollers (70) for avoiding a contact between the spacer rollers (70) and the flexible tube (20).

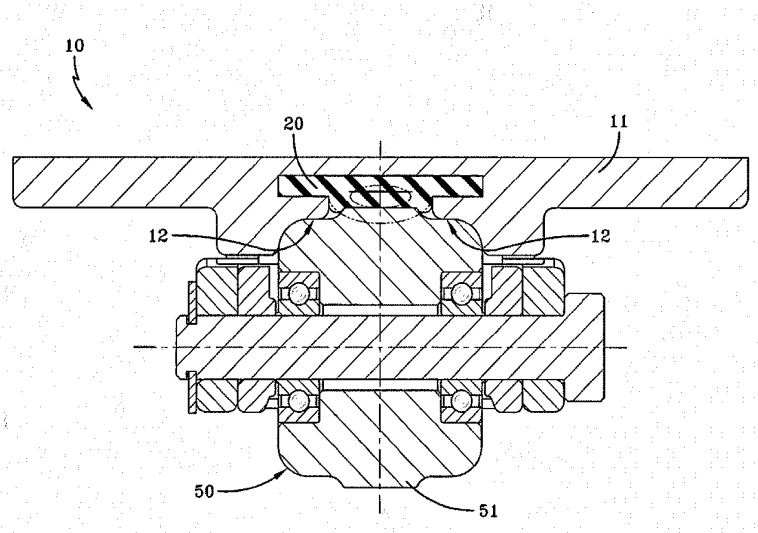

FIG-1

EP 3 178 677 A1

Description

Technical Field

[0001] The present invention relates generally to the automotive field, and more specifically, to a new and useful tire air maintenance system in the automotive field.

Background of the Present Invention

[0002] Non-optimally pressurized pneumatic tires contribute to low fuel efficiency. These effects are particularly felt in the trucking industry, where long distances and large loads amplify the effects of an underinflated tire. However, it is often inconvenient and inefficient for truck drivers to constantly stop, check, and inflate the vehicle tires to the optimal pressure, leading to the persistence of less-than-optimal fuel efficiency in truck fleets. This challenge has led to several conventional auto-inflating tire systems. Conventional auto-inflating tire systems may be either central or distributed, but each suffers from its own set of drawbacks. Central inflation systems are complex and expensive, and require significant work for aftermarket installation (drilling through axles, tapping existing air lines, etc.). Distributed systems are mounted at each wheel and can be less expensive, but the potential for reduced cost is typically at the expense of the continuous replacement of the device (which fails due to the harsh wheel environment). Thus, there is a need in the automotive field to create a new and useful air maintenance system for pneumatic tires.

Summary of the Invention

[0003] The invention relates to a system in accordance with claim 1.

[0004] Dependent claims refer to preferred embodiments of the invention.

[0005] An air maintenance system in accordance with a preferred aspect of the present invention includes a rotatable or rotating radially inner ring secured to a vehicle wheel or rim, a stationary radially outer ring maintaining a constant angular position, an occlusion roller rotationally fixed to the stationary outer ring, the occlusion roller having a protruding portion centered axially at a radially outer surface of the occlusion roller with axially outer portions of the occlusion roller being radially recessed from the protruding portion and supported by bearing surfaces of the inner ring, spacer rollers rotationally fixed to the stationary outer ring and rotationally supported by the bearing surfaces, and a flexible tube defining a pump cavity, the air maintenance system pumping a fluid from the ambient environment into a pneumatic tire by applying an occluding force against the flexible tube, periodically occluding portions of the pump cavity. The spacer rollers have axially outer surfaces for rotational support by bearing surfaces of the inner ring and a recess centered axially at the outer surface of the spacer rollers for avoiding any contact between the spacer rollers and the flexible tube.

[0006] According to a preferred aspect of the invention, a pressure regulator assembly may harvest pressure generated by the system for maintaining appropriate air pressure within a tire cavity.

[0007] According to a preferred aspect of the invention, the rotating inner ring may rotate concentrically relative to the stationary outer ring.

[0008] According to a preferred aspect of the invention, the bearing surfaces of the inner rotating ring may provide a smooth surface for the spacer rollers and the occlusion roller.

[0009] According to a preferred aspect of the invention the stationary outer ring may encircle the air maintenance system and apply an inward radial force against the spacer rollers when assembled.

[0010] According to a preferred aspect of the invention the inward radial force may maintain the inner ring and the spacer rollers in a concentric relationship.

[0011] According to a preferred aspect of the invention the inner ring may have a substantially homogeneous weight distribution such that no portion of the inner rotating ring is substantially heavier than another portion.

[0012] According to a preferred aspect of the invention the inner ring may be substantially rigid and made of metal.

[0013] According to a preferred aspect of the invention the inner ring may be made of a rigid polymer.

[0014] According to a preferred aspect of the invention, the mass of the stationary outer ring overcomes inertia and friction generated by rotation of the inner rotating ring and rotating wheel or rim such that the stationary outer ring stays substantially static while the inner rotating ring and wheel or rim rotate.

[0015] According to a preferred aspect of the invention, the stationary outer ring maintains the angular position relative to a road surface as the vehicle wheel rotates and provides torque, generated by gravity that opposes the rotation of the stationary outer rotating ring with the vehicle wheel.

[0016] According to a preferred aspect of the invention, the mass of the stationary outer ring prevents the stationary outer ring from rotating with the vehicle wheel and the inner ring.

[0017] According to a preferred aspect of the invention, the spacer rollers retain non-slip contact between the spacer rollers and the bearing surfaces of the inner ring.

[0018] According to a preferred aspect of the invention, the system includes three spacer rollers.

[0019] According to a preferred aspect of the invention, the flexible tube defines a deformable surface that occludes the pump cavity.

[0020] According to a preferred aspect of the invention, the flexible tube has an oval cross section.

[0021] According to a preferred aspect of the invention, the flexible tube comprises a flexible, elastomeric material.

[0022] According to a preferred aspect of the invention, the flexible tube includes an inlet port and an outlet port each in fluid connection with a pressure regulator assembly.

Definitions

[0023] "Axial" and "axially" means lines or directions that are parallel to the axis of rotation of the tire or wheel or rim.

[0024] "Radial" and "radially" means directions radially toward or away from the axis of rotation of the tire or wheel or rim

Brief Description of Drawings

[0025] The present invention will be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 schematically illustrates a cross-sectional view of part of an air maintenance assembly in accordance with the present invention.

Fig. 2 schematically illustrates a cross-sectional view of another part of an air maintenance assembly in accordance with the present invention.

Fig. 3 schematically illustrates a perspective view of the entire air maintenance assembly of Figs. 1 and 2.

Detailed Description of Example Embodiments of the Present Invention

[0026] A conventional tire inflation system may mount to the wheel of a vehicle. The tire inflation system may include a pumping ring that rotates with the wheel and a positioning system rotatably coupled to the wheel. The positioning system may include a positioning mechanism and an eccentric mass. A planetary roller may be disposed in non-slip contact with the pumping ring and the positioning system. A flexible diaphragm may define a pump cavity wherein relative motion between the pumping ring and positioning system may be translated by the planetary roller into an occluding force that deforms the diaphragm and thereby occludes the pump cavity. Relative motion between the pumping ring and the positioning system may be achieved by coupling the eccentric mass to the positioning mechanism to offset the center of mass of the positioning system from the center of rotation of the positioning system. Such a system has been disclosed in US-B-8,763,661.

[0027] Another example air maintenance system may include a rotating inner ring, a stationary outer ring, an eccentric mass, an occlusion roller located proximate to the eccentric mass, and a flexible tube that defines a pump cavity. The air maintenance system may be coupled to a rotating wheel wherein the rotating inner ring rotates with the rotating wheel while the eccentric mass maintains a constant angular position relative to the rotating wheel. This arrangement may thereby generate relative motion between the rotating inner ring and the eccentric mass. The air maintenance system may translate this relative motion into mechanical work or other energy forms. The air maintenance system may pump a fluid from the ambient environment into a pneumatic tire seat to the rotating wheel by applying an occluding force against the flexible tube, periodically occluding portions of the pump cavity. The air maintenance system may be coupled to the rim of the wheel, such as that of a truck, compact vehicle, motorcycle, bicycle and/or other vehicle. Relative diameters between the inner rotating ring and roller elements may collaborate to achieve a desired gear ratio and pumping speed. The pumping rate, pressure, and frequency may also be controlled with a passive or an active control mechanism.

[0028] The inner rotating ring may apply an occluding force against the flexible tube. The inner rotating ring also may provide a smooth bearing surface for the roller elements and an occlusion roller, and may additionally contain or constrain other components of the air maintenance system. The inner rotating ring may rotate with the rotating wheel, and may be statically, but removably, coupled to the rotating wheel. An outer ring may encircle the air maintenance system and apply an inward radial force against the rollers when assembled. This inward radial force may maintain the inner rotating ring and the rollers. The inner rotating ring may have a substantially homogeneous weight distribution such that no portion of the inner rotating ring is substantially heavier than another portion. The inner rotating ring may be substantially rigid and made of metal (e.g. stainless steel, aluminum, titanium), but may alternately be made of a rigid polymer (e.g. polyacetylenes, polyfluroenes, nylon, and polyimides) or a ceramic.

[0029] The eccentric mass may overcome the inertia and friction generated by the rotation of the inner rotating ring and rotating wheel such that the eccentric mass stays substantially static while the inner rotating ring rotates. Further, the eccentric mass may be coupled to the air maintenance system to maintain the angular position of the eccentric mass relative to the road surface (which is contacted by the wheel) as the wheel rotates and provides torque, generated by gravity, that opposes the rotation of the inner rotating ring with the wheel. In other words, the eccentric mass may prevent the outer ring from rotating with the wheel and the inner rotating ring. This relative motion, enabled by the gravitational pull on the eccentric mass, may be harvested to do mechanical work.

[0030] This relative motion may occur because the center of mass of the eccentric mass is not located at the center of rotation such that the pull of gravity on the eccentric mass may allow it to remain substantially static relative to the road surface while the inner rotating ring rotates relative to the road surface. The weight of the eccentric mass may be large enough to generate the amount of mechanical work desired, in addition to being

large enough to overcome friction and adequately dampen induced oscillations resulting from non-rotating motion (e.g. from bumps). The eccentric mass may be rectangular, spherical, or amorphous. The eccentric mass may be made of metal, such as stainless steel, copper, aluminum, etc., but may alternately be made of plastic, ceramic, and/or a fluid/gel. The roller elements may additionally retain non-slip contact between the roller elements and the inner rotating ring, but may not provide a direct occluding force. The air maintenance system may include two, three, five, or any suitable number of rollers. Alternatively, the stationary outer ring may be weighted such that relative motion between the stationary outer ring and the rotating inner ring may only occur during acceleration or deceleration of the system.

[0031] The flexible tube may define the pump cavity that holds a fluid and a deformable interface that occludes the pump cavity. The flexible tube may have a circular or oval cross section. The flexible tube may comprise a flexible, elastomeric material such as rubber or thermosets, thermoplastics, or any other suitable material. The flexible tube may include an inlet port and an outlet port each in fluid connection with tubes and a pressure regulator assembly.

[0032] The pressure regulator assembly may include a control valve, check valves, a filter, and an inlet port for receiving ambient air. A housing of the pressure regulator assembly may be secured to the wheel with the inlet port located externally to the tire cavity of the tire and the remaining structures of the pressure regulator assembly located internally to the tire cavity.

[0033] The air maintenance system may utilize a peristaltic or reciprocating pump method. In the peristaltic method, the occlusion roller may constrict a portion the flexible tube that is adjacent the occlusion roller thereby deforming the flexible tube segment by segment between an expanded condition and an at least partially collapsed condition in response to respective segment by segment deformation by the occlusion roller located, with the eccentric mass, by gravity statically at the bottom of the outer ring.

[0034] The rotating inner ring may be disposed concentrically within the stationary outer ring with the roller elements determining its orientation relative to the stationary outer ring. The roller elements may be rotatably secured to the stationary outer ring by a shaft. The stationary outer ring may comprise a plurality of segments (e.g., 3, 4, 5, etc.) having a female mating connection at one end and a male connection at its opposite end. The rotating inner ring may comprise a roller element track for receiving the roller elements, a plurality of segments (e.g., 1, 2, 3, 4, etc.) with a female recess at one end for mating with a male clip connection at its opposite end. Each end may further have slots for securing the flexible tube. The rotating inner ring may be secured to wheel by connecting the ends. The occlusion roller may be rotatably attached to the stationary outer ring by a shaft such that the occlusion roller, held stationary by the eccentric mass, rolls and squeezes the flexible tube as the rotating inner ring and wheel rotate. The roller elements may travel along the roller element track and the occlusion roller may sequentially squeeze the flexible tube as the wheel rotates. The housing of the pressure regulator assembly may include a fill port for regular tire pressure maintenance (e.g., an initial air fill up, etc.). Such an example system is disclosed in US-A-2016/0167465.

[0035] As shown in Fig. 1, a system 10 in accordance with the present invention includes an occlusion roller 50. The occlusion roller 50 includes a protruding portion 51 for constricting a portion a flexible tube 20 that is adjacent the occlusion roller and deforming the flexible tube, segment by segment, between an expanded condition and an at least partially collapsed condition in response to respective segment by segment deformation by the occlusion roller sustained, with an eccentric mass (not shown), by gravity statically at the bottom of an outer ring (not shown). The flexible tube 20 is fixed to an inner ring 11. The inner ring 11 is fixed to a vehicle rim 9. The protruding portion 51 may be centered axially at a radially outer surface of the occlusion roller 50 with axially outer portions of the occlusion roller being radially recessed from the protruding portion and supported by bearing surfaces 12 on the inner ring 11.

[0036] As shown in Fig. 2, the system 10 further includes at least two spacer rollers 70 (one shown in Fig. 2) for maintaining a concentric relationship between the inner ring 11 and an outer ring 13 to which the occlusion roller 50 is rotationally secured. The spacer rollers 70 have axially outer surfaces 71 for rotational support by the bearing surfaces 12 of the inner ring 11. A recess 72 of the spacer rollers 70 may be centered axially at the outer surface of the spacer rollers for avoiding any contact between the spacer rollers and the flexible tube 20. A pressure regulator assembly 30 may be used to harvest the pressure generated with the system 10 for maintaining appropriate air pressure within a tire cavity 28 (Fig. 3).

Claims

1. An air maintenance system comprising:

   a vehicle wheel or rim (9);
   a rotatable inner ring (11) secured to the vehicle wheel or rim (9);
   a stationary outer ring (13) configured to maintain a constant angular position;
   an occlusion roller (50) rotationally fixed to the stationary outer ring (13), the occlusion roller (50) having a protruding portion (51) preferably centered axially at a radially outer surface of the occlusion roller (50) with axially outer portions of the occlusion roller (50) being radially recessed from the protruding portion (51) and supported by bearing surfaces (12) of the rotatable inner ring (11);

at least two spacer rollers (70) rotationally fixed to the stationary outer ring (13) and rotationally supported by the bearing surfaces (12); and
a flexible tube (20) defining a pump cavity;

wherein the air maintenance system (10) is configured for pumping a fluid from an ambient environment into a pneumatic tire mounted to the vehicle wheel or rim (9) by applying an occluding force against the flexible tube (20) periodically occluding portions of the pump cavity; and
wherein the at least two spacer rollers (70) have axially outer surfaces (71) for rotational support by bearing surfaces (12) of the rotatable inner ring (11) and a recess (72) preferably centered axially at the outer surface (71) of the spacer rollers (70) for avoiding a contact between the spacer rollers (70) and the flexible tube (20).

2. The air maintenance system as set forth in claim 1 further including a pressure regulator assembly (30) for harvesting pressure generated by the system (10) for maintaining appropriate air pressure within a tire cavity (28).

3. The air maintenance system as set forth in claim 1 or 2 wherein the rotatable inner ring (11) is configured to rotate concentrically relative to the stationary outer ring (13).

4. The air maintenance system as set forth in at least one of the previous claims wherein the bearing surfaces (12) of the inner ring (11) provide a smooth surface for the spacer rollers (70) and the occlusion roller (50).

5. The air maintenance system as set forth in at least one of the previous claims wherein the stationary outer ring (13) encircles the air maintenance system (10) and/or applies an inward radial force against the spacer rollers (70) when assembled.

6. The air maintenance system as set forth in claim 5 wherein the inward radial force maintains the inner ring (11) and the spacer rollers (70) in a concentric relationship.

7. The air maintenance system as set forth in at least one of the previous claims wherein the inner ring (11) has a substantially homogeneous weight distribution such that no portion of the inner ring (11) is substantially heavier than another equivalent portion.

8. The air maintenance system as set forth in at least one of the previous claims wherein the inner ring (11) is substantially rigid and made of metal, or wherein the inner ring (11) is made of a rigid polymer.

9. The air maintenance system as set forth in at least one of the previous claims wherein the mass of the stationary outer ring (13) is configured to overcome inertia and friction generated by rotation of the inner ring (11) and the rotating wheel or rim (9) such that the stationary outer ring (13) stays substantially static while the inner ring (11) and wheel or rim (9) rotate.

10. The air maintenance system as set forth in at least one of the previous claims wherein the stationary outer ring (13) is configured to maintain the angular position relative to a road surface as the vehicle wheel or rim (9) rotates and provides torque, generated by gravity, that opposes the rotation of the stationary outer rotating ring (13) with the vehicle wheel or rim (9).

11. The air maintenance system as set forth in at least one of the previous claims wherein the mass of the stationary outer ring (13) prevents the stationary outer ring (13) from rotating with the vehicle wheel or rim (9) and the inner ring (11).

12. The air maintenance system as set forth in at least one of the previous claims wherein the spacer rollers (70) retain non-slip contact between the spacer rollers (70) and the bearing surfaces (12) of the inner ring (11).

13. The air maintenance system as set forth in at least one of the previous claims wherein the system (10) includes three spacer rollers (70).

14. The air maintenance system as set forth in at least one of the previous claims wherein the flexible tube (20) defines a deformable surface that occludes the pump cavity and/or wherein the flexible tube (20) comprises a flexible, elastomeric material.

15. The air maintenance system as set forth in at least one of the previous claims wherein the flexible tube (20) has an oval cross section; and/or wherein the flexible tube (20) includes an inlet port and an outlet port each in fluid connection with a pressure regulator assembly (30).

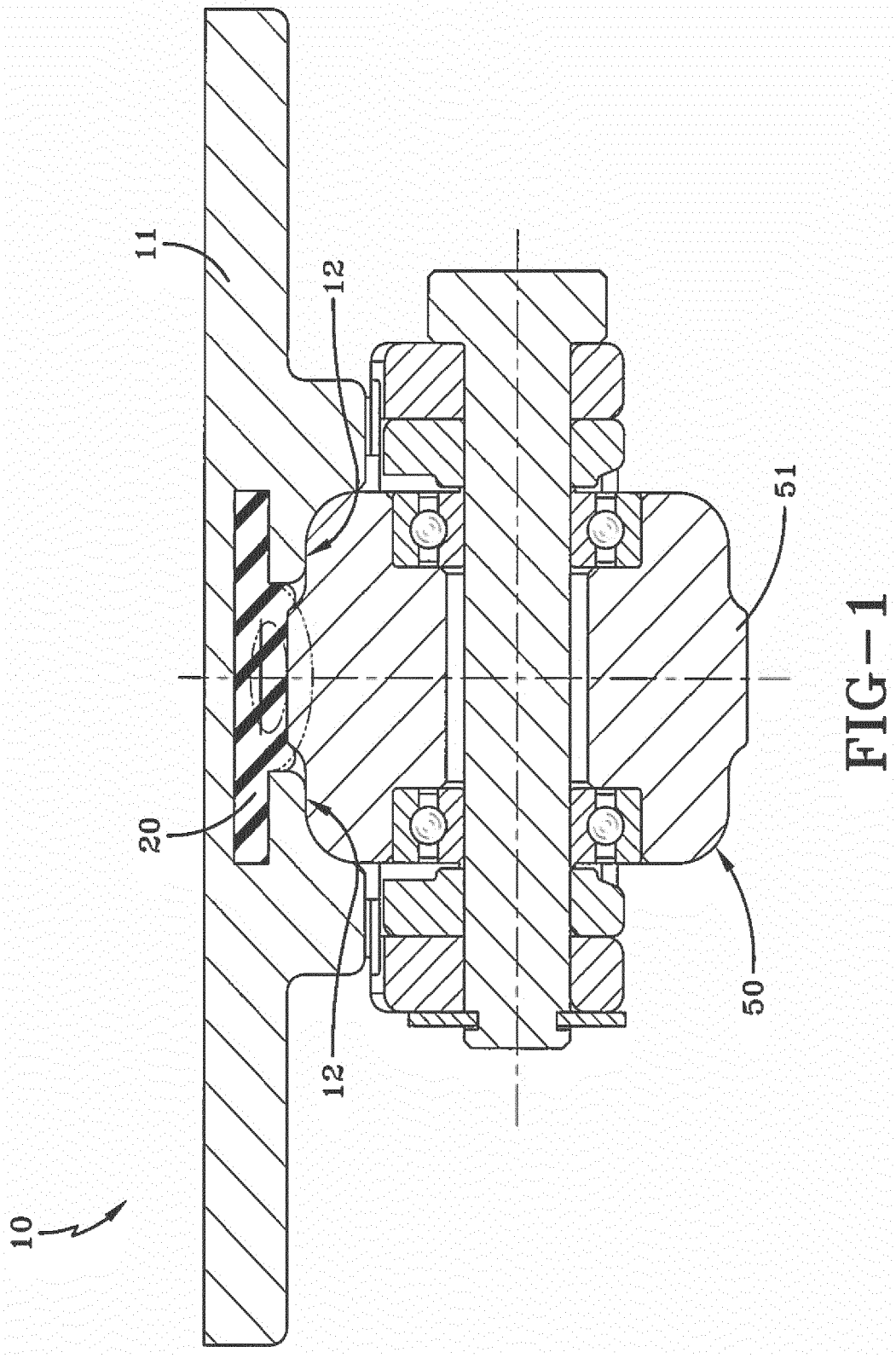

FIG-1

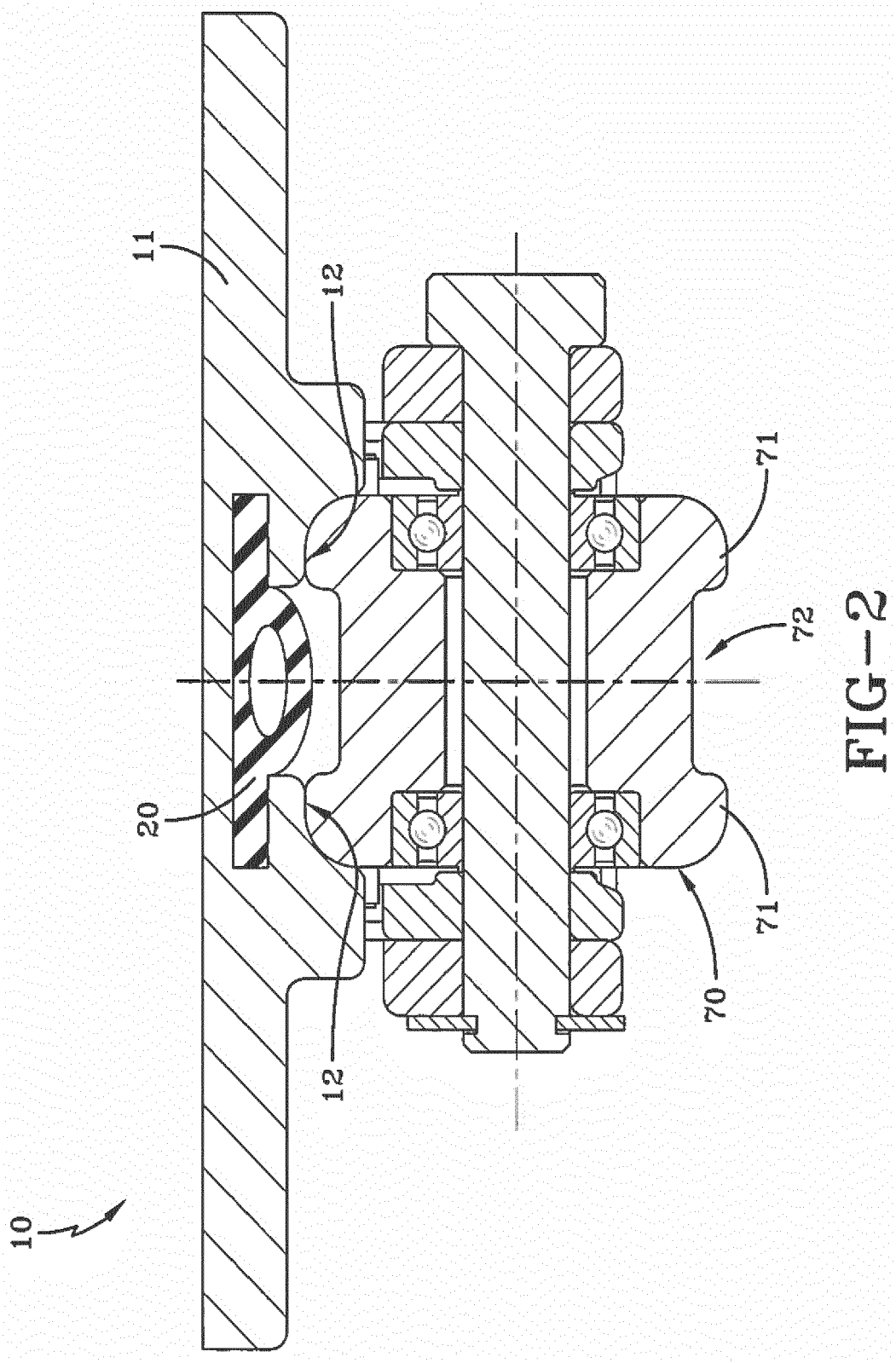

FIG-2

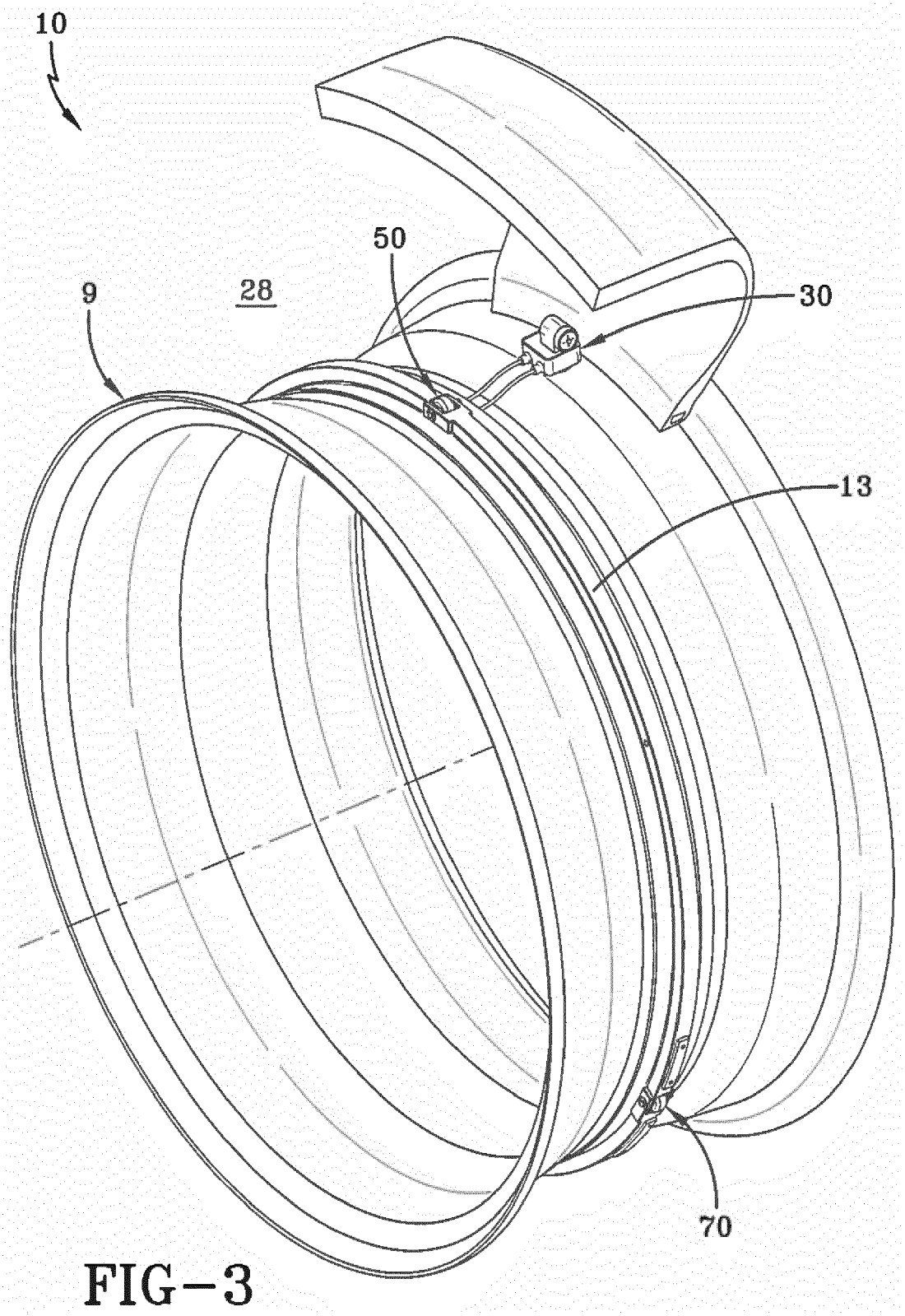

FIG-3

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 1130

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)
B60C
F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 April 2017	Schork, Willi

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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