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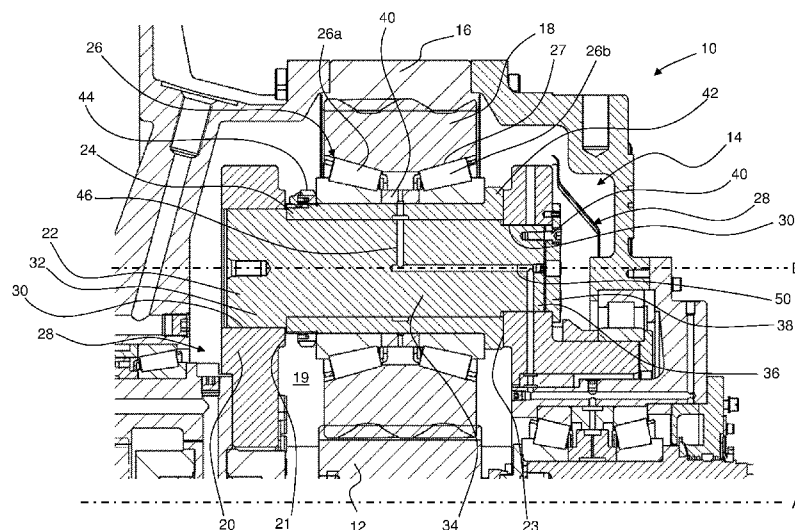


FIG. 1

(57) **Abstract:** A planetary gear assembly (14) comprises a planet gear (18) for engaging with a sun gear (12) and an annulus (16) of a planetary gearbox. A carrier (20) is provided for mounting the planet gear (18) within the planetary gearbox, and the carrier (20) comprises two mounting portions (28) one at each axial extent of the planet gear (18). A pin (22) is mounted to the two mounting portions (28) of the carrier (20). The planet gear (18) is mounted about the pin (22) such that the pin (22) defines an axis of rotation of the planet gear (18). A sleeve (24) is arranged around the pin (22), and a bearing arrangement (26) around the sleeve (24) mounts the planet gear (18) to the pin (22) via the sleeve (24). The fit between the sleeve (24) and the pin (22) is an interference fit.

Planetary Gear Assembly

FIELD OF THE INVENTION

The present invention relates to a planetary gear assembly, a planetary gearbox, a
5 method of assembly of a planetary gear assembly, and/or a method of assembly of a
planetary gearbox.

BACKGROUND OF THE INVENTION

Planetary gearboxes (also referred to as epicyclic gearboxes and inclusive of star type
arrangements) are known, and generally include a sun gear, one or more planet gears
10 and an annulus in singular or multiple arrangements. The planet gears are arranged
around and engage with the sun gear, and the annulus surrounds the planet gears and
the sun gear and engages with the planet gears. Depending on the type of gear
arrangement, the sun gear and annulus may rotate about a common axis, or one of the
sun gear or annulus may be fixed. The planet gears may be circumferentially fixed
15 with respect to the sun gear, so as not to orbit the sun gear, or alternatively the planets
may orbit the sun gear, the orbital rotation being driven by either an input or an output
of the gear box.

The planet gears are generally supported within the planetary gearbox as part of a
planetary gear assembly. The planetary gear assembly includes a carrier to which the
20 planet gear is mounted. Depending on the gearbox design the carrier may be fixed or
may rotate about a similar axis as the sun gear. There are three known methods of
mounting the pin to a carrier: cantilever mounting using a pin arranged to flex (known
as flex pin mounting), cantilever mounting where the pin is arranged to be
substantially rigid (i.e. to not flex substantially), and fixed pin mounting where the pin
25 is rigidly supported at both axial extents.

In the case of fixed pin mounting, the carrier is arranged to straddle the planet gear. A
pin extends through a central longitudinal axis of the planet gear and the planet gear is
mounted to the pin via a bearing. The pin is mounted at both its axial extents to the
carrier, i.e. the pin is substantially fixed with respect to the carrier at both axial ends.

The accuracy of location of the pin within the carrier must be precise to ensure correct alignment of components so as to improve the running accuracy of the gearbox and hence load capacity, life, noise and vibration performance. This is difficult to achieve. One method of overcoming this difficulty is to make the carrier in two parts, but this
5 makes the carrier expensive to manufacture and necessitates additional features and components, e.g. fasteners, spigots and location pins.

The end float and radial play of the bearing or bearings that mount the planet gear to the pin need to be controlled to tightly defined limits so as achieve a required clearance or preload. In the planetary gearboxes and planetary gear assemblies of the
10 prior art, compromises in choice of bearing type and clearance setting arrangements have to be made to permit assembly of the fixed pin arrangement. In many cases, this results in undesirably reduced bearing capacity and life.

SUMMARY OF THE INVENTION

A first aspect of the invention provides a planetary gear assembly for engagement
15 with a sun gear and an annulus in a planetary gearbox, the planetary gear assembly comprising: a planet gear for engaging with a sun gear and an annulus of a planetary gearbox; a carrier for supporting the planet gear within a planetary gearbox, the carrier comprising two mounting portions one at each axial extent of the planet gear; a pin
20 mounted to the two mounting portions of the carrier and about which the planet gear is arranged such that the pin defines an axis of rotation of the planet gear; a sleeve arranged around the pin; and a bearing arrangement mounting the planet gear to the pin via the sleeve; wherein the fit between the sleeve and the pin is an interference fit.

The planetary gear assembly of the first aspect permits the planet gear, bearing arrangement and sleeve to be assembled as a pre-assembled module before mounting
25 to the carrier. Such modular assembly eases manufacture, whilst permitting the end float and radial play of bearings comprised in the bearing arrangement to be closely controlled. Modular assembly is particularly advantageous for planet gear assemblies intended for use in large gearboxes, e.g. gearboxes for use in wind or tidal power turbines.

Provision of an interference fit between the sleeve and the pin enables a radial preload to be applied to the bearing arrangement.

Further, the interference fit between the sleeve and the pin reduces fretting between the sleeve and pin, and also between the carrier and sleeve and/or pin.

- 5 The two mounting portions may each comprise an aperture. The pin may extend through the apertures of the mounting portions. The fit between the pin and the apertures of the mounting portions of the carrier may be an interference fit. Provision of an interference fit between the carrier and the pin further reduces fretting. Further, the interference fit between the carrier and the pin helps to ensure that the fit between
10 the pin and the carrier is tight to improve accuracy of a gearbox, in operation.

The bearing arrangement may comprise one or more caged bearings. Caged bearings ease assembly of the planetary gear assembly, give higher operating speed capability and improve power efficiency compared to uncaged rolling element bearings.

The carrier may be a one piece carrier.

- 15 The planetary gear assembly may comprise a clamping arrangement at an axial end of the pin to axially and rotationally fix the pin with respect to the carrier. Positive axial retention of the pin at one end further reduces the risk of fretting. Further, the clamping arrangement provides positive torque reaction of the planet pin, which can prevent rotational creep of the pin that may result from relative rotational movement
20 of the planet gear and carrier. Yet further, the clamping arrangement can ease manufacture and assembly of the carrier because features for connection to the pin are positioned at one end, which means the carrier can be machined in a single setting.

- The clamping arrangement may include a clamp plate positioned at said axial end of the pin. The clamp plate may overlap an axial face of the pin and the carrier. A
25 fastener (e.g. a locking fastener, for example a lock nut) may lock the clamp plate with respect to the pin and the carrier. The fastener may fasten to (e.g. screw into) the pin. Alternatively, the fastener may fasten to (e.g. screw into) the carrier.

The sleeve may comprise a flange at an end nearest to the clamping arrangement. The flange may abut against an axial face of the carrier.

The pin may comprise a stepped portion at an end furthest from the clamping arrangement. The stepped portion may define a section of wider diameter, which in an exemplary embodiment is positioned in one of the apertures of the mounting portion of the carrier, and a section of narrower diameter along which the sleeve is positioned.

The sleeve may be arranged to be adjacent to an axial face of the carrier at a position furthest from the clamping arrangement. For example, the sleeve may be arranged to be near to but spaced from an axial face of the carrier at a position furthest from the clamping arrangement.

- 10 The planetary gear assembly may comprise an arrangement that fixes the position of the bearing arrangement, or bearings of the bearing arrangement, relative to the sleeve and the planet gear for setting a desired clearance or preload. The desired clearance or preload may be selected to account for an additional preload applied by the interference fit between the sleeve and the pin.
- 15 The bearing arrangement may comprise one or more cylindrical bearings. The interference fit between the sleeve and the pin is particularly advantageous when used with cylindrical bearings because the interference fit permits controlled radial preloading of the cylindrical bearings, which is not generally possible with planetary gear assemblies having cylindrical bearings of the prior art.
- 20 The bearing arrangement may comprise two taper roller bearings arranged to have opposing tapers. For example, the taper roller bearings may have an O-layout. "O-layout" is a term known in the art.

The planetary gear assembly may comprise an arrangement that fixes the position of the taper roller bearings relative to the sleeve and the planet gear for setting a desired clearance or preload. In such examples, the desired clearance or preload is selected to account for a preload applied by the interference fit between the sleeve and the pin. Preloading the taper bearings improves alignment of the planet gear, improves bearing and gear fatigue life, and improves running accuracy, which can reduce noise and vibration during operation.

The planetary gear assembly may include a spacer positioned between the taper roller bearings and a locking fastener (e.g. lock nut) that fixes the position of the taper roller bearings with respect to the sleeve.

5 The planet gear may be a spur gear. Alternatively, the planet gear may be a helical gear. The use of accurately preloaded bearings, as is possible in the planetary gear assembly of the present invention, means that helical planet gears of a relatively high helix angle (e.g. greater than or equal to 10°) may be used. Helical gears can improve power density and noise and/or vibration performance in operation.

An oil feed may be provided through the pin and the sleeve.

10 The bearing arrangement may comprise one, two, four, six or any other suitable number of bearings.

The carrier may comprise a plurality of planet gears. Each of the planet gears may be mounted to the carrier using a pin, sleeve and bearing arrangement.

15 A second aspect of the invention provides a planetary gear assembly for engagement with a sun gear and an annulus in a planetary gearbox, the planetary gear assembly comprising: a planet gear for engaging with a sun gear and an annulus of a planetary gearbox; a carrier for supporting the planet gear within a planetary gearbox, the carrier comprising two mounting portions one at each axial extent of the planet gear; a pin mounted to the two mounting portions of the carrier and about which the planet gear is
20 arranged such that the pin defines an axis of rotation of the planet gear; a sleeve arranged around the pin; and a bearing arrangement mounting the planet gear to the pin via the sleeve; wherein the bearing arrangement comprises one or more caged bearings.

25 The planetary gear assembly of the second aspect may have one or more features of the planetary gear assembly of the first aspect.

A third aspect of the invention provides a planetary gearbox comprising: a sun gear; a planetary gear assembly according to the first or second aspect, the planet gear of the planetary gear assembly being engaged with the sun gear; and an annulus surrounding

the sun gear and the planet gear of the planetary gear assembly and engaged with the planet gear.

A fourth aspect of the invention provides a method of assembly of a planetary gear assembly for engagement with a sun gear and an annulus in a planetary gearbox; the method comprising: (i) forming a pre-assembled module by providing a sleeve, bearing arrangement and planet gear, and mounting the planet gear to the sleeve via the bearing arrangement; (ii) providing a carrier for supporting the planet gear within a planetary gearbox, the carrier defining two opposing mounting portions; (iii) positioning the pre-assembled module between the two mounting portions of the carrier; (iv) positioning a pin to extend through the sleeve, wherein the pin has an outer diameter greater than an inner diameter of the sleeve and the pin is positioned to extend through the sleeve using differential expansion; and (v) mounting the pin to the mounting portions of the carrier.

The steps (i) to (iv) of the method of the fourth aspect are performed sequentially. In exemplary embodiments, steps (iv) and (v) are performed, at least partially, simultaneously.

The method may comprise clamping an axial end of the pin to the carrier against axial and/or rotational movement.

Each mounting portion may comprise an aperture. The method may comprise positioning the pre-assembled module between the two mounting portions of the carrier. The pin may be positioned to extend through the apertures of the mounting portions of the carrier. The diameter of the pin may be greater than the diameter of the aperture, and the pin may be positioned to extend through the apertures using differential expansion.

The method may comprise the step of selecting the diameter of the pin and the inner diameter of the sleeve to apply a pre-determined preload to the bearing.

The bearing may be a taper bearing, and the method may comprise the step of setting a preload on the taper bearing before the pre-assembled module is positioned in the carrier. The preload selected may be lower than the preload required for optimal

operation to account for a preload applied due to differential expansion between the pin and the sleeve.

The method of differential expansion may be freeze fitting.

The bearing arrangement may comprise one or more cylindrical bearings, and the method may comprise selecting an inner diameter of the sleeve and a diameter of the pin to achieve a desired radial preload on the one or more cylindrical bearings.

The planetary gear assembly may be a planetary gear assembly of the first aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a detailed cross section view of a planet assembly mounted in a planetary gearbox;

Figure 2 shows a detailed cross section of an axial end of the planet assembly of Figure 1; and

Figure 3 shows a detailed cross section view of an alternative planet assembly mounted in a planetary gearbox.

DETAILED DESCRIPTION OF EMBODIMENT(S)

Referring to Figure 1, a planetary gearbox is indicated generally at 10. The planetary gearbox includes a sun gear 12, a planetary gear assembly 14 and an annulus 16. The planetary gear assembly 14 includes a planet gear 18. In the present embodiment, the planetary gear assembly includes three planet gears (only one shown), but in alternative embodiments any suitable number of planet gears may be used. The annulus 16 surrounds the sun gear 12, and both the sun gear and the annulus rotate about an axis A defined by a central longitudinal axis of the sun gear. The planet gear 18 is arranged between the sun gear and the annulus and engages with the sun gear 12 and the annulus 16 via meshing teeth. The planet gear 18 rotates about an axis B that

is defined by a central longitudinal axis of the planet gear and is substantially parallel to the axis A.

The planet gear 18 is supported within the gearbox 10 via a carrier 20. A pin 22 is mounted to the carrier 20 and extends along the axis of rotation B of the planet gear 18. A sleeve 24 surrounds the pin 22, and the planet gear 18 is mounted to the pin 22 via a bearing arrangement 26.

The carrier 20 is a one-piece carrier of the type known in the art, and that straddles the planet gear 18, such that the carrier 20 has two opposing mounting portions 28 that define a slot 19 in which the planet gear 18 is received. The mounting portions 28 each include an aperture 30. The pin 22 is received in the apertures 30 and extends therebetween. The apertures 30 and the axial ends of the pin 22 are dimensioned such that the fit between the pin 22 and the carrier 20 is an interference fit.

The pin 22 and apertures 30 have a circular cross section.

The pin 22 is stepped to have a larger diameter section 32 at one axial end, a mid diameter section 34 in a central region of the pin and a narrower diameter section 36 at the other axial end of the pin 22. The step from the larger diameter section 32 to the mid diameter section 34 is substantially aligned with an inner axial face 21 (but in alternative embodiments may be spaced from the axial face 21) of the carrier 20 in the region of the respective mounting portion 28. The step from the mid diameter section 34 to the narrower diameter section 36 is substantially aligned with the other inner axial face 23 of the carrier 20 in the region of the respective mounting portion 28.

A clamp plate 38 and fastener 40 are provided at an axial end of the pin 22 that has the narrower diameter section 36. The clamp plate and fastener are shown in more detail in Figure 2. The clamp plate 38 extends over an end of the pin 22 and overlaps an outer axial face of the carrier 20. The fastener 40 fastens the clamp plate 38 in position to axially and rotationally retain the pin 22 with respect to the carrier. In the present embodiment the fastener is a cap bolt, but in alternative embodiments any suitable type of fastener may be used. For example, in alternative embodiments the fastener may include an anti-rotation feature, for example a lock nut, or a ring nut around a projection from the body of the pin. In the present embodiment, the fastener

40 bolts to the pin 22, but in alternative embodiments the fastener may bolt to the carrier 20.

Advantageously, positive axial and rotational retention of the planet pin using the clamp plate 38 and the fastener 40 reduces the risk of fretting at the inner axial faces
5 21, 23 of the carrier adjacent the sleeve 24.

The fit between the sleeve 24 and the pin 22 is an interference fit. The interference fit between the sleeve 24 and the pin 22 further reduces fretting between the carrier and pin, and also at the sleeve-pin interface. As will be described later, the interference fit also provides a pre-load on the bearing arrangement 26.

10 The sleeve 24 includes a flange 42 positioned at an end of the sleeve nearest the clamp plate 38 and fastener 40. The flange 42 abuts against the respective inner axial face of the carrier 20 and also against an axial face of the bearing 26b. An end of the sleeve 24 opposite the flange 42 abuts against the step of the pin from the larger diameter section 32 to the narrower diameter section 34. A portion of the sleeve 24 is adjacent
15 to but not in contact with the respective axial face 21 of the carrier 20.

The arrangement of the described planet gear assembly 14, means that less accurate machining is required in respect of the overall slot width, surface finish or alignment tolerance of the carrier boss surface at 21 compared to planet gear assemblies of the prior art. This is because the clamp plate 38 and fastener 40 restrict axial movement
20 of the pin, so there is no need to rely on the faces of the slot to do this, which means that the slot does not need to be as accurately dimensioned as the slots of the prior art. For example, there is no requirement for precision control between the sleeve 24 and the carrier 20 at the end of the sleeve 24 that is opposite the flange 42. Further, the machining process is simplified because axial location features for locating the pin 22
25 with respect to the carrier 20 are at one end (the end having the clamp plate 38 and fastener 40), so it is possible to more easily machine the carrier a single setting.

The sleeve 24 and the pin 22 include an oil feed hole 46 which can be used to supply oil lubrication to the bearing arrangement 26.

The bearing arrangement 26 includes two caged bearings. Caged bearing is a term
30 known in the art, so will not be explained further here. Caged bearings advantageously

generally run with lower power losses and at higher speeds than alternative uncaged rollers. Further, caged bearings are easier to assembly, give higher operating speed capability and improve power efficiency compared to uncaged rolling element bearings.

- 5 In the present embodiment, the bearing arrangement 26 includes two taper roller bearings 26a, 26b. The taper roller bearings 26a, 26b are positioned in opposition and taper outwardly so as to have a greater diameter towards each respective axial end of the pin 22. This arrangement of bearings 26a, 26b is known in the art as an “O-layout”. The inner radial face 27 of the planet gear 28 is angled to match the profile
10 of the taper roller bearings 26a, 26b.

A spacer 40 separates the two taper roller bearings 26a, 26b. The axial length of the spacer can be selected for optimal axial clearance or preload of the bearings 26a, 26b. A lock nut 44 is provided at an axial end of the bearing arrangement 26 opposite the flange 42, to fix the spacer and bearings 26a, 26b relative to the sleeve with the
15 desired axial clearance and/or preload. The lock nut 44 may be a standard ring nut.

The spacer and lock nut advantageously can be used to improve the control of clearance and/or preload on the taper roller bearings 26a, 26b. Further, the use of the sleeve 24 with a flange 42, spacer 40, and lock nut 44 means that the preload on the bearings can be controlled without accurate control of the carrier slot 19 width.
20 Further advantageously, the sleeve, spacer and lock nut arrangement can be easily be disassembled for maintenance.

The gear teeth of the planet gear 18 that mesh with the annulus and the sun are in this embodiment spur gear teeth, but in alternative embodiments the gear teeth may be helical gear teeth. The use and accurate pre-loading of the taper bearings facilitates
25 the use of helical gears of a relatively high helix angle (for example 10° or more). Such helical gears can improve power density and noise/vibration performance.

To assemble the gearbox 10, firstly the planet gear assembly 14 is assembled. To assemble the planet gear assembly 14, firstly a pre-assembled module is assembled by mounting the planet gear 18 to the sleeve 24 via the bearing arrangement 26. The
30 required clearance and/or preload is then set before mounting the pre-assembled

module to the carrier 20. The pre-assembled module is retained using the lock nut 44, which advantageously fixes the bearings 26a, 26b and spacer 40 in position with respect to the sleeve 24, without the need for heat application (e.g. as would be the case with attachment methods such as welding), which would otherwise make setting
5 the preload on the bearing more difficult.

The pre-assembled module is then positioned in the carrier slot 19. The pin 22 is dimensioned to have a greater diameter than the diameter of the apertures 30 in the carrier and greater than the inner diameter of the sleeve 24. The pin 22 is inserted through the apertures 30 of the carrier 20 and through the sleeve 24 by freeze fitting.
10 In alternative embodiments any suitable differential expansion method may be used, for example heat fitting or hydraulic expansion methods.

The radial expansion of the pin 22 when it equalises thermally exerts a radial load on the bearing arrangement 26. The axial clearance and/or preload set on the bearing arrangement 26 before insertion of the pin 22 through the pre-assembled module and
15 carrier is adjusted to account for the radial load exerted on the bearing arrangement 26 by expansion of the pin 22, so that the final “as mounted” clearance and/or preload on the bearing arrangement 26 is correct.

Once the pin 22 is freeze fitted in the carrier 20 and sleeve 24, the clamp plate 38 is positioned adjacent the axial face of the narrower diameter section 36 of the pin 22
20 overlapping the carrier 20. The clamp plate 38 is then clamped in place using the fastener 40 to axially and rotationally retain the pin with respect to the carrier to, during operation, reduce fretting and rotational creep.

The carrier 20 is then positioned so that the planet gear 18 engages with the annulus 16 and the sun gear 12.

25 Advantageously, setting the clearance and/or preload of the bearings 26a, 26b away from the carrier 20 simplifies assembly and improves accuracy and consistency of assembly. This is particularly advantageous for applications involving highly unsteady and potentially reversing loads, as found in renewable energy applications e.g. wind or tidal turbine gearboxes, but also in applications where the planetary gear

assembly operates at high speed with low loading, and also when assembled with a vertical axis of rotation where gravity induced loads on the bearings are low.

The ability to accurately preload the bearings can assure good control of planet alignment and improve gear fatigue life. The running accuracy can also be improved
5 which can be beneficial for noise and vibration reduction in operation.

The present invention permits taper bearings to be used in applications where cylindrical or spherical bearings may be conventionally used. Accurate setting of the preload on the taper bearings, as provided for by the described embodiment, improves life of the bearing arrangement through the avoidance or reduction of rolling element-
10 raceway sliding or skidding wear and damage, which can be seen with cylindrical or spherical bearing arrangements of the prior art which, in the prior art, must be assembled with a clearance.

Further advantageously, modular assembly of the gearbox, as provided by the described embodiment, eases gearbox manufacture, particularly when the gearbox is
15 large, for example gearboxes for wind or tidal turbines.

The planet gear assembly can be disassembled, e.g. for maintenance, using hydraulic injection techniques that utilise drillings or galleries applied between the pin and sleeve and the pin and carrier. For example, circumferential and/or spiral grooves may be provided on the outer surface of the pin, e.g. grooves may be provided on the a
20 larger diameter section 32, the mid diameter section 34 and the narrower diameter section 36 of the pin 22. Oil, for example hydraulic fluid, can be pumped to the grooves through the injection port 50 to expand the sleeve and/or carrier so as to remove the pin. The provision of a spiral groove enables a wider application of release pressure than a circumferential groove.

25 Referring now to Figure 3, an alternative gearbox is indicated generally at 110. The gearbox 110 is similar to the previously described gearbox 10, and similar features are given similar reference numerals, but with a prefix "1". Only the differences will be described here.

The planetary gear assembly 114 of the gearbox 110 differs from the planetary gear assembly 14 of the gearbox 10 in that the bearing arrangement 126 includes cylindrical roller bearings 126a, 126b instead of taper roller bearings.

Advantageously, when assembling the gearbox 110, the planet gear 118, bearings 126a, 126b and sleeve 124 are assembled to form the pre-assembled module. The radial clearance of the components of the pre-assembled module is set such that when the pin 122 is freeze fitted into the sleeve 124 and apertures 130 of the carrier 120, expansion of the pin 122 applies a controlled radial displacement to the cylindrical bearings 126a, 126b.

In planet gear assemblies of the prior art, it is not generally possible to apply pre-load to cylindrical bearings. Pre-loading of taper bearings is possible with arrangements of the prior art, because pre-loading can be applied axially. However, with cylindrical bearings, application of a load in an axial direction will not apply a radial pre-load.

Use of cylindrical bearings with a pre-load additionally permits multiple rows of bearings to be used because of increased control of load distribution on each of the bearings. Multiple rows of bearings can increase planet gear capacity, power and torque density, which can reduce gearbox size and cost.

Although the invention has been described above with reference to one or more preferred embodiments, it will be appreciated that various changes or modifications may be made without departing from the scope of the invention as defined in the appended claims.

For example, spherical bearings may be used instead of cylindrical or taper roller bearings. Spherical bearings would generally be used in low speed, steady load conditions.

The presently described embodiments have shown two taper bearings or two cylindrical bearings. However, in alternative embodiments any suitable number of bearings may be used.

Claims

1. A planetary gear assembly for engagement with a sun gear and an annulus in a planetary gearbox, the planetary gear assembly comprising:
 - a planet gear for engaging with a sun gear and an annulus of a planetary gearbox;
 - a carrier for supporting the planet gear within a planetary gearbox, the carrier comprising two mounting portions one at each axial extent of the planet gear;
 - a pin mounted to the two mounting portions of the carrier and about which the planet gear is arranged such that the pin defines an axis of rotation of the planet gear;
 - a sleeve arranged around the pin; and
 - a bearing arrangement mounting the planet gear to the pin via the sleeve;
- wherein the fit between the sleeve and the pin is an interference fit.
2. The planetary gear assembly according to claim 1, wherein the two mounting portions each comprise an aperture, and the pin extends through the apertures, and wherein the fit between the pin and the apertures of the mounting portions of the carrier is an interference fit.
3. The planetary gear assembly according to claim 1 or 2, wherein the bearing arrangement comprises one or more caged bearings.
4. The planetary gear assembly according to any one of the previous claims comprising a clamping arrangement at an axial end of the pin axially and rotationally fixing the pin with respect to the carrier.
5. The planetary gear assembly according to claim 4, wherein the clamping arrangement includes a clamp plate positioned at said axial end of the pin and overlapping an axial face of the pin and the carrier, and a fastener that fixes the clamp plate with respect to the pin and the carrier.

6. The planetary gear assembly according to claim 5, wherein the fastener fastens to the pin.
7. The planetary gear assembly according to any one of claims 4 to 6, wherein the sleeve comprises a flange at an end nearest to the clamping arrangement.
- 5 8. The planetary gear assembly according to claim 7, wherein the flange abuts against an axial face of the carrier.
9. The planetary gear assembly according to any one of claims 4 to 8, wherein the pin comprises a stepped portion at an end furthest from the clamping arrangement, such that the stepped portion defines a section of wider diameter positioned in one of the apertures of the mounting portion of the carrier, and a section of narrower diameter along which the sleeve is positioned.
- 10 10. The planetary gear assembly according to claim 9, wherein the sleeve is arranged to be adjacent an axial face of the carrier at a position furthest from the clamping arrangement.
- 15 11. The planetary gear assembly according to any one of the previous claims, wherein the bearing arrangement comprises one or more cylindrical bearings.
12. The planetary gear assembly according to any one of claims 1 to 10, wherein the bearing arrangement comprises two taper roller bearings arranged to have opposing tapers.
- 20 13. The planetary gear assembly according to claim 12, wherein the planetary gear assembly comprises an arrangement that fixes the position of the taper roller bearings relative to the sleeve and the planet gear for setting a desired clearance or preload.
- 25 14. The planetary gear assembly according to claim 13, wherein the planetary gear assembly includes a spacer positioned between the taper roller bearings and a locking fastener that fixes the position of the taper roller bearings with respect to the sleeve.

15. The planetary gear assembly according to any one of the previous claims, wherein the planet gear is a helical gear.
16. The planetary gear assembly according to any one of the previous claims, wherein an oil feed is provided through the pin and the sleeve.
- 5 17. A planetary gearbox comprising:
- a sun gear;
 - a planetary gear assembly according to any one of the previous claims, the planet gear of the planetary gear assembly being engaged with the sun gear; and
- 10 an annulus surrounding the sun gear and the planet gear of the planetary gear assembly and engaged with the planet gear.
18. A method of assembly of a planetary gear assembly for engagement with a sun gear and an annulus in a planetary gearbox; the method comprising:
- (i) forming a pre-assembled module by providing a sleeve, bearing
- 15 arrangement and planet gear, and mounting the planet gear to the sleeve via the bearing arrangement;
- (ii) providing a carrier for supporting the planet gear within a planetary gearbox, the carrier defining two opposing mounting portions;
 - (iii) positioning the pre-assembled module between the two mounting
- 20 portions of the carrier;
- (iv) positioning a pin to extend through the sleeve, wherein the pin has an outer diameter greater than an inner diameter of the sleeve and the pin is positioned to extend through the sleeve using differential expansion; and
 - (v) mounting the pin to the mounting portions of the carrier.
- 25 19. The method according to claim 18, wherein each of the two mounting portions comprises an aperture, and the method comprises positioning the pin to extend through the apertures of the mounting portions.
20. The method according to claim 19, wherein the apertures have a diameter smaller than the diameter of the pin, and the step of mounting the pin to the

mounting portions of the carrier comprises positioning the pin to extend through the apertures using differential expansion.

21. The method according to any one of claims 18 to 20, comprising the step of selecting the diameter of the pin and the inner diameter of the sleeve to apply a pre-determined preload to the bearing.
22. The method according to any one of claims 18 to 21, wherein the bearing arrangement comprises two taper bearings, and the method comprises the step of setting a preload on the taper bearings before the pre-assembled module is positioned in the carrier.
23. The method according to any one of claims 18 to 21, wherein the bearing arrangement comprises one or more cylindrical bearings, and the method comprises the step of selecting the inner diameter of the sleeve and the outer diameter of the pin so as to apply the required pre-load to the cylindrical bearings.
24. The method according to any one of claims 18 to 23, wherein the method of differential expansion is freeze fitting.

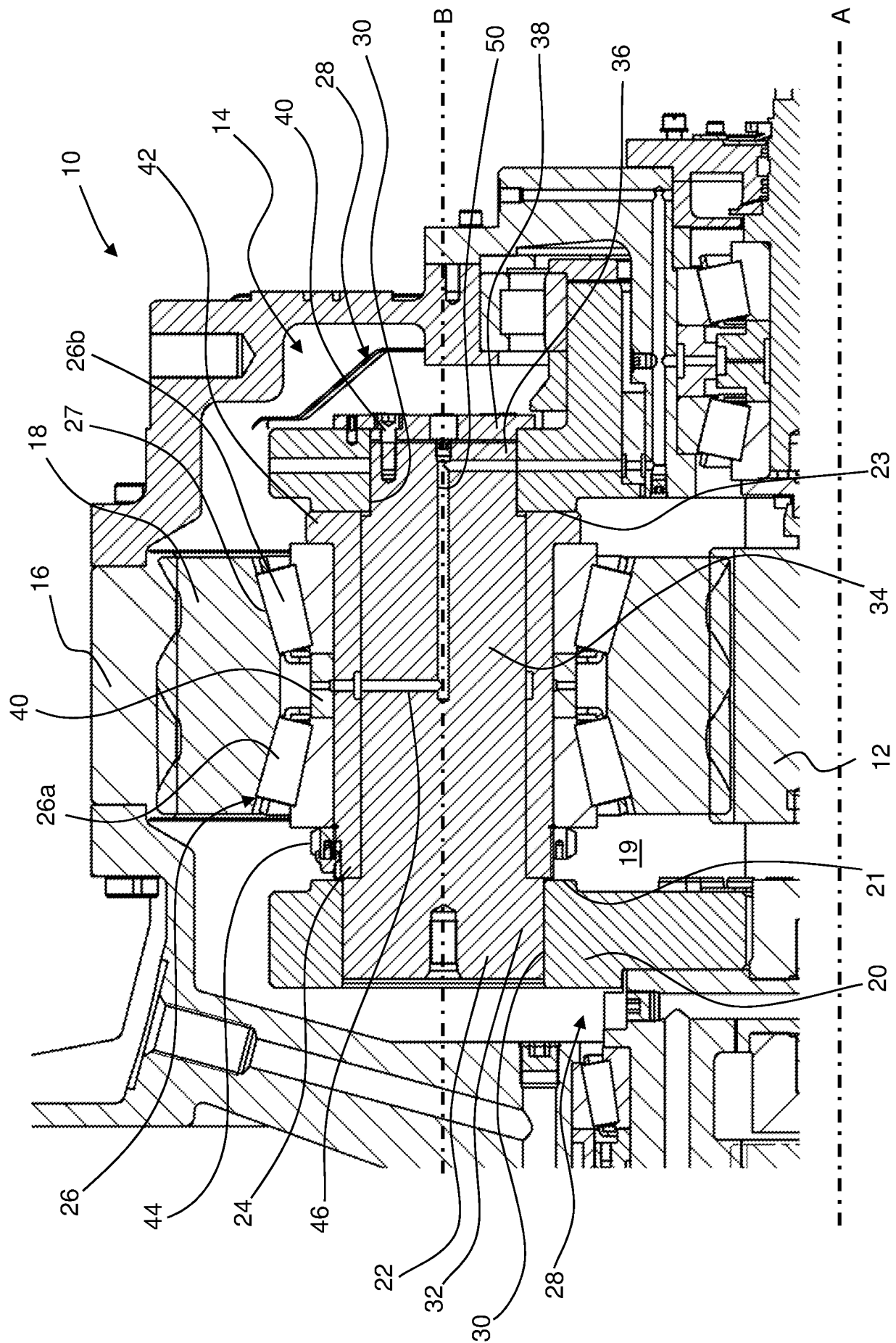


FIG. 1

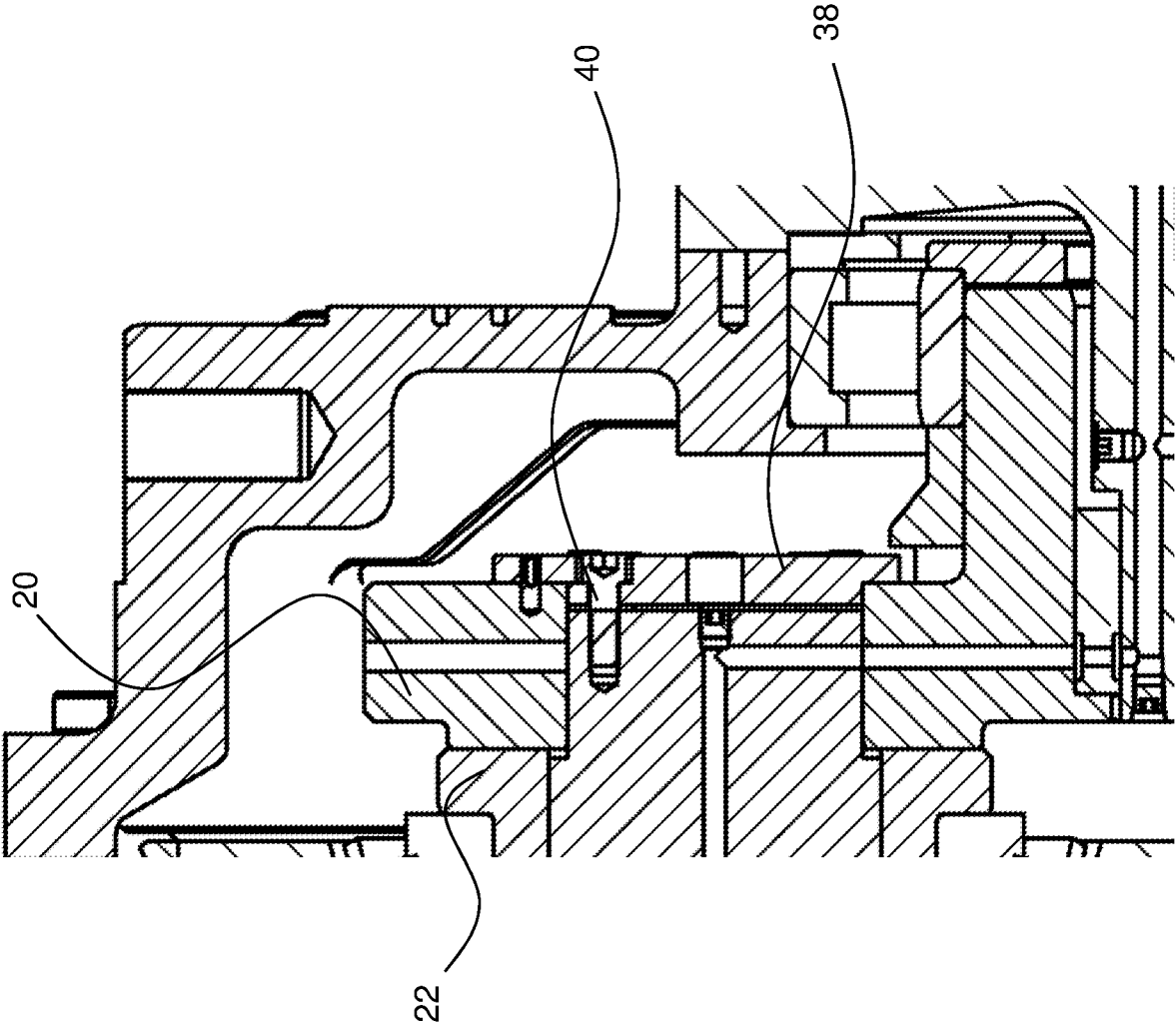
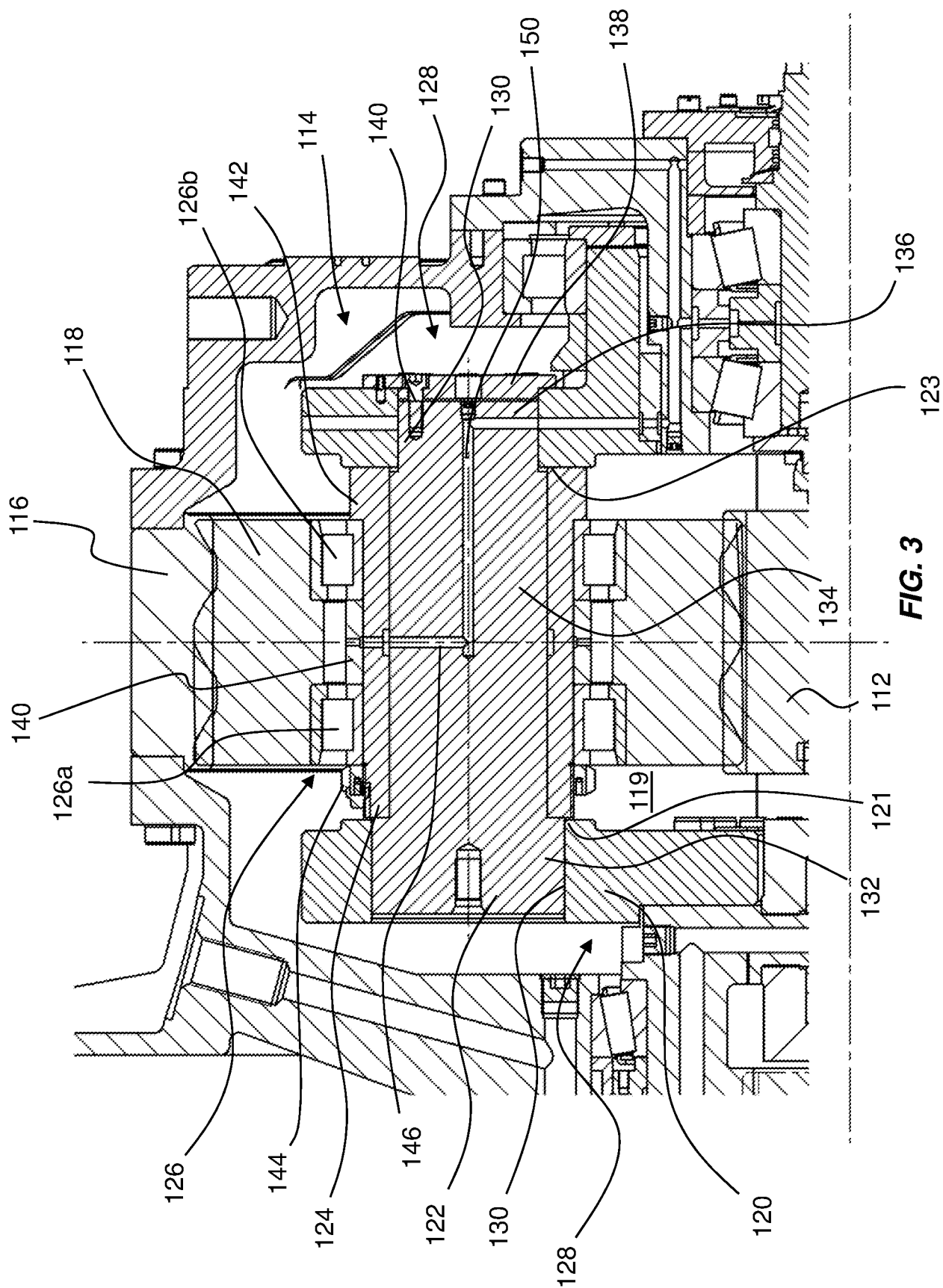


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/051516

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H57/08 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

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.
X A	WO 2013/043822 A2 (TIMKEN CO [US]) 28 March 2013 (2013-03-28) figures 1,2	1-3, 11-15,17 4-10,16, 18-24
X,P	----- WO 2014/057468 A1 (DANIELI OFF MECC [IT]) 17 April 2014 (2014-04-17) figure 5	1,17,18
A	----- DE 10 2011 077960 A1 (ZAHNRADFABRIK FRIEDRICHSHAFEN [DE]) 27 December 2012 (2012-12-27) the whole document	1,17,18
A	----- EP 0 054 852 A1 (NISSAN MOTOR [JP]) 30 June 1982 (1982-06-30) abstract; figures 2,8 ----- -/-	1,17,18



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

24 July 2014

Date of mailing of the international search report

08/08/2014

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Revilla, Xavier

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2014/051516

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2014/051516

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