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(71) Applicant *(for all designated States except US)*: ENGINEERING SCIENCE & TECHNOLOGY PTY LTD [AU/AU]; 23 Colleen Grove, Mangerton, NSW 2500 (AU).

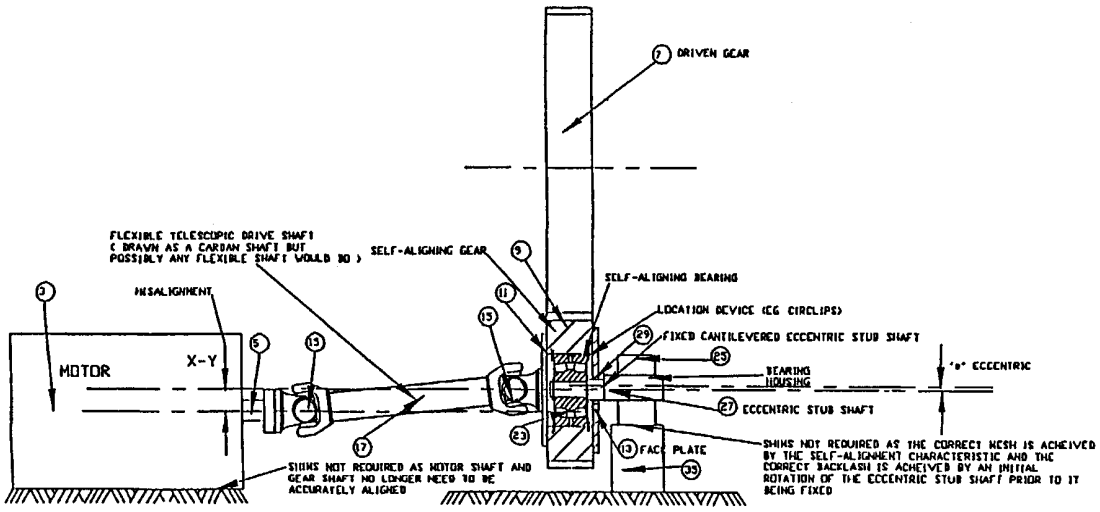
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: DAVEY, Robert, John [AU/AU]; 23 Colleen Grove, Mangerton, NSW 2500 (AU).

(74) Agent: GRIFFITH HACK; 509 St Kilda Road, Melbourne, VIC 3004 (AU).

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(54) Title: A DRIVE GEAR ASSEMBLY



(57) Abstract

A drive gear assembly is disclosed. The drive gear assembly includes a drive gear (9) that is adapted to mesh with a driven gear (7), the drive gear and the driven gear each having an axis about which the gears can rotate. A self–aligning bearing (23) supports one of the drive gear or the driven gear and allows it to rotate, typically with a rocking or wobbling motion, around a centre of the bearing so that the drive gear can self–align with respect to the driven gear or vice versa. At least one flexible coupling (15) is coupled to the drive gear and, in use of the drive gear assembly, is also coupled directly or indirectly to the drive shaft (5) of a motor (3) so that power from the motor can be transferred to the driven gear. The flexible coupling or couplings allow the axis of the drive gear to be positioned out of alignment with the axis of the drive shaft. An assembly (25, 27) supports the self–aligning bearing and allows the self–aligning bearing to be moved relative to the axis of the drive shaft.

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A DRIVE GEAR ASSEMBLY

The present invention relates to a drive gear assembly that can transfer drive from a motor, such as an electric motor, to a mechanical system, such as a grinding mill.

Many mechanical systems are driven by motors (eg. electric motors). In order to utilise the power available from a motor it is necessary to transfer the power from the motor to a mechanical system coupled to the motor. Typically, power transfer is achieved by connecting a drive shaft of a motor to a drive gear assembly which includes a drive gear, such as a pinion, and meshing the drive gear with a driven gear, such as a gear wheel, that is connected in some way to the mechanical system.

In practice, it is important that the motor, the mechanical system, and the mechanical components that couple together the motor and the mechanical system each be properly aligned so that the gear teeth of the drive gear and the gear teeth of the driven gear mesh to within fine tolerances. Failure to do this often results in excessive wear of the gear teeth, leading in the worst cases to failure of the gears as a result of breakage of the teeth. In addition, misalignment of gear teeth can also result in significant vibration which often produces other adverse outcomes, such as fatigue loads on various components of the mechanical system.

In the case of spur gears, in order to be properly aligned it is necessary that the gear teeth of the drive gear be parallel with the gear teeth of the driven gear. More generally, it is necessary for the axes of rotation of the drive gear and the driven gear to be

parallel to their axis of generation. It is also desirable that the backlash of the gears be an optimum for the particular gears. If the gears are set with a backlash of zero, ie. positioned such that the teeth mesh fully and are hard up against one another to the fullest extent, the gears generally will not rotate.

In order to achieve proper alignment it is also necessary that the motor drive shaft and the drive gear be aligned.

One known approach for achieving proper alignment is to physically move the motor and/or the drive gear assembly to accurately align the motor shaft and the drive gear assembly in order to achieve close tolerance meshing of the gear teeth.

In this approach the task of providing fine tolerances in the meshing gear teeth is largely achieved by "trial and error" adjustment of the position of the motor and the drive gear assembly. It is often a difficult and time consuming task. This is especially true with large motors and heavy drive gears.

The problem in large measure arises because small movements in the location of the motor or the drive gear assembly can have a significant impact on the alignment. Therefore, great care and judgement is required in order to achieve alignment with minimum effort. By way of example, large motors and grinding mills with large girth gears and pinions can take several days to align.

The task is further complicated by the fact that in many situations excellent alignment of a drive gear assembly in the "cold" or "unloaded" condition does not correspond to satisfactory alignment when the mechanical system is loaded. This is due to distortion of the drive

gear assembly under load and other factors. As a consequence, further adjustment of the alignment of the motor and/or the drive gear assembly is often required to achieve satisfactory meshing of the gear teeth under load.

An alternative known approach for achieving proper alignment is based on:

(a) supporting a drive gear on a spherical bearing so that the drive gear can self-align with respect to the driven gear by rotating about a centre of the bearing, typically with a rocking or wobbling motion; and

(b) transferring power to the drive gear from a motor drive shaft via a central geared coupling.

Two known self-aligning drive gear assemblies in accordance with this approach are manufactured by Krupp-Polysius and Hofmann Engineering.

The above-described self aligning drive gear assemblies have a number of disadvantages.

Firstly, the minimum size of the drive gears is dictated by the size of the internal geared couplings and this often results in significantly larger drive gears than are otherwise required.

Furthermore, the particular form of the spherical bearings that can be used in the gear assemblies is generally not a standard off-the-shelf item and, moreover, generally have limited thrust capacity in their current configuration.

Furthermore, misalignment of the drive gears and the driven gears that can be accommodated is limited to the allowable angular misalignment of the internal geared couplings and usually this is relatively small.

Furthermore, it is still necessary to align the drive gears to the motor drive shafts.

An object of the present invention is to provide an improved self-aligning drive gear assembly.

According to the present invention there is provided a drive gear assembly which includes:

(a) a drive gear that is adapted to mesh with a driven gear, the drive gear and the driven gear each having an axis about which the gears can rotate;

(b) a self-aligning bearing that supports one of the drive gear or the driven gear and allows it to rotate, typically with a rocking or wobbling motion, around a centre of the bearing so that the drive gear can self-align with respect to the driven gear or vice versa;

(c) at least one flexible coupling that is coupled to the drive gear and, in use of the drive gear assembly, is also coupled directly or indirectly to the drive shaft of a motor so that power from the motor can be transferred to the driven gear, which flexible coupling or couplings allow the axis of the drive gear to be positioned out of alignment with the axis of the drive shaft; and

(d) an assembly that supports the self-aligning bearing and allows the self-aligning bearing to be moved relative to the axis of the drive shaft.

Preferably the self-aligning bearing assembly allows the self-aligning bearing to be moved laterally and/or radially relative to the axis of the drive shaft.

It is preferred that the self-aligning bearing supports the drive gear whereby in use of the drive gear assembly:

(a) the drive gear rotates, typically with a rocking or wobbling motion, on the self-aligning bearing and aligns the axis of the drive gear with the axis of the driven gear; and

(b) the self-aligning bearing support assembly and the flexible coupling or couplings allow lateral movement of the axis of the drive gear relative to the axis of the driven gear so as to position the drive gear so that it meshes correctly, eg at a selected backlash, with the driven gear.

Preferably the self-aligning bearing is located so that the geometric centre of the bearing coincides with the point at which the moments of the operating force systems that act on the drive gear and the driven gear are in equilibrium.

Preferably the drive gear assembly includes a pair of flexible couplings.

Preferably one of the pair of flexible couplings is coupled to the drive gear and the other of the pair is coupled to the drive shaft.

Preferably, the drive gear assembly includes a telescopic shaft that connects together the flexible couplings.

The flexible couplings may be any suitable form of power transmitting coupling that can accept angular misalignment, such as universal joints, constant velocity joints, hookes joints, gear couplings, rubber bush couplings or flexible diaphragm couplings. In fact, any form of power transmitting coupling may be used.

The drive gear and the driven gear may be any suitable gears.

By way of example, the drive gear and the driven gear may be gear wheels or friction wheels.

The most common embodiment of the invention has the drive gear as a pinion.

The driven gear may form part of any suitable system. By way of example, the mechanical system may be a pinion drive to a grinding mill girth gear.

Preferably the support assembly for the self-aligning bearing includes:

(a) a shaft that supports the self-aligning bearing; and

(b) a housing that supports the shaft for movement relative to the axis of the drive shaft.

Preferably the shaft includes an eccentric lobe which is received in the housing whereby rotation of the shaft in the housing displaces laterally the shaft and the self-aligning bearing carried by the shaft.

According to the present invention there is also provided a motor-driven mechanical system which includes the above-described drive gear assembly.

The present invention is described further by way of example with reference to Figures 1 to 6 which show the general arrangement of each of 6 embodiments of a drive gear assembly in accordance with the present invention;

The embodiments of the drive gear assembly shown in the drawings are arranged to transfer power from a motor 3 to a driven gear 7 of a mechanical system (not shown).

With reference to Figure 1, the drive gear assembly (which is drawn without a gear case but may be with a gear case) shown in the figure includes:

(a) a drive gear 9 in the form of a spur gear that has a central bore and external teeth (not shown) that are adapted to mesh with teeth (not shown) on the driven gear 7; and

(b) face plates 11 and 13 that are connected to opposite ends of the drive gear 9, with the face plate 13 having a central hole 29.

The drive gear assembly further includes a self-aligning bearing in the form of a spherical bearing 23 that is located axially in the central bore of the drive gear 9 and supports the drive gear 9 for rotary movement, typically in the form of a rocking or wobbling motion,

around the center of the spherical bearing 23. For even tooth load across the active face width, the spherical bearing 23 is located so that the geometric centre of the spherical bearing 23 coincides with the point at which the moments of the operating force systems that act on the drive gear 9 and the driven gear 7 are in equilibrium. In some cases, the location of this point may be such that the spherical bearing 23 will have to be positioned beyond the extremities of the gear teeth.

The drive gear assembly further includes an assembly which supports the spherical bearing 23 and which is in the form of a stub shaft 27 mounted in a housing 25. One end of the stub shaft 27 extends through the central hole 29 in the face plate 13 of the drive gear 9 and carries the spherical bearing 23. The other end of the stub shaft 27 has an eccentric lobe which is located in the housing 25, whereby rotation of the stub shaft 27 in the housing 25 laterally displaces the stub shaft 27, the spherical bearing 23, and the drive gear 9 with respect to the driven gear 7. It is noted that the eccentric lobe may be located in the spherical bearing 23 instead of the housing 25.

The drive gear assembly further includes a pair of flexible joints 15 and a telescopic shaft 17 which connect together the joints 15. The left hand joint 15 is connected to a drive shaft 5 of the motor 3 and the right hand joint 15 is connected to the face plate 11 of the drive gear. This arrangement transfers power from the motor 3 to the drive gear 9. In addition, this arrangement drives the drive gear 9 causing it to rotate about the center of the spherical bearing 23 and allows lateral movement.

The above-described drive gear assembly makes it possible:

(a) to install the motor 3 and the stub shaft 27 with only approximately correct alignment (and without significant adjustment of the motor 3 and the stub shaft 27 beyond that required in the initial installation and/or rotation of the stub shaft 27); and

(b) for rotation, typically rocking or wobbling motion, and lateral movement of the drive gear 9 to permit self-alignment of the drive gear 9 (at an optimum backlash) that is required to produce fine tolerance meshing with the driven gear 7.

The embodiments of the drive gear assembly shown in Figures 2 to 6 are similar conceptually to the embodiment shown in Figure 1 and the same reference numerals are used to denote the same structural features.

In the embodiments shown in Figures 2 and 3 the support assembly for the spherical bearing 23 is in the form of a stub shaft 27 that is supported by an "E" bracket 31 that is mounted on a pedestal 35 on the left-hand side of the drive gear as viewed in the drawings. These embodiments are suited particularly for situations in which there are space constraints on the right-hand side of the drive gear.

In the embodiment shown in Figure 4 the support assembly for the spherical bearing 23 is in the form of a hollow shaft 33 supported in housings 37 on pedestals 35. The right-hand end of the hollow shaft 33 carries the spherical bearing 23. The hollow shaft 33 includes eccentric lobes 39 that are located in the housings 37, whereby rotation of the hollow shaft 33 laterally displaces the hollow shaft 33. As with the embodiment shown in

Figure 1 the eccentric lobes 37 may be located within the spherical bearing 23 instead of the bearing housings 37.

In addition, in the embodiment shown in Figure 4 the telescopic shaft 17 extends through the hollow shaft 33 and a reversed flexible joint 41 is coupled to the end of the telescopic shaft 17 and to the face plate 11 (now on the right-hand face of the drive gear 9 as viewed in Figure 4) of the drive gear and thereby transfers power from the motor 3 to the drive gear (ie. drive gear 9). This arrangement also accommodates lateral movement of the drive gear.

The embodiments shown in Figures 5 and 6 are characterised in that the self-aligning bearing is in the form of a constant velocity joint 43 which is modified to accept externally applied radial and axial forces. Accordingly the constant velocity joint 43 is mounted on a shaft 53 which is connected to the right-hand side flexible joint 15. The shaft 53 is supported for lateral movement by bearings (not shown) retained in housings 55 on pedestals 35.

The drive gear assembly described above in relation to Figures 1 to 6 has a number of advantages over the known self-aligning drive gear assemblies.

Firstly, the drive gear assembly makes it possible to quickly and easily align drive and driven gears with a required backlash for optimum performance.

Furthermore, the drive gear assembly makes it possible to achieve alignment to a high degree at initial set-up and to maintain the alignment during operation and this minimises wear on gear teeth. This is a particularly important advantage in many situations. For example, in the case of grinding mills, the pinion is generally a quite

small diameter gear, with generally less than 30 teeth, whilst the driven girth gear is essentially the diameter of the mill shell, which may result anywhere in the order of 200 to 400 teeth. The simple result of this geometry is that girth gears may be up to 8 to 10 times more expensive than pinions. The designer therefore strives to protect the girth gear at the expense of the pinion. Apart from attempting to achieve minimum wear as a result of the quality of the initial alignment, the designer also gives considerable thought to the metallurgy of the girth gear relative to the pinion. The pinion is of a somewhat harder material than the girth gear, the differential being premised on a consensus over wear, especially recognising that there will always be less than perfect alignment in a conventional mill situation. This is not the case with the present invention, where essentially perfect alignment is produced. As a result, the designer can contemplate metallurgy which produces harder girth gears and thus less wear in the gears and longer times between replacement, whilst not compromising the overriding imperative of preferentially protecting the more expensive girth gear.

Furthermore, as there is no requirement for an internal gear coupling the diameter of the drive gear 9 can be reduced.

Furthermore, the self-aligning bearing may be any conventional "one-piece" commercially available self-aligning bearing such as a spherical roller or self-aligning ball bearing or spherical plain bearing which has inherent thrust capacity that allows the drive gear assembly to be applied to both spur and helical gears, be they single or double external or internal gears. Accordingly, the drive gear assembly can be used in current gear systems.

Furthermore, misalignment is now limited to the

allowable angular misalignment of the spherical bearing and not to the allowable misalignment of an internal geared coupling and therefore significantly higher angular misalignments can be accommodated.

Furthermore, the motor does not require accurate alignment with the drive gear assembly.

Many modifications may be made to the preferred embodiment of the drive gear assembly described above without departing from the spirit and scope of the present invention.

CLAIMS:

1. A drive gear assembly which includes:

(a) a drive gear that is adapted to mesh with a driven gear, the drive gear and the driven gear each having an axis about which the gears can rotate;

(b) a self-aligning bearing that supports one of the drive gear or the driven gear and allows it to rotate, typically with a rocking or wobbling motion, around a centre of the bearing so that the drive gear can self-align with respect to the driven gear or vice versa;

(c) at least one flexible coupling that is coupled to the drive gear and, in use of the drive gear assembly, is also coupled directly or indirectly to the drive shaft of a motor so that power from the motor can be transferred to the driven gear, which flexible coupling or couplings allow the axis of the drive gear to be positioned out of alignment with the axis of the drive shaft; and

(d) an assembly that supports the self-aligning bearing and allows the self-aligning bearing to be moved relative to the axis of the drive shaft.

2. The drive gear assembly defined in claim 1 wherein the self-aligning bearing assembly allows the self-aligning bearing to be moved laterally and/or radially relative to the axis of the drive shaft.

3. The drive gear assembly defined in claim 1 or claim 2 wherein the self-aligning bearing supports the drive gear whereby in use of the drive gear assembly:

(a) the drive gear rotates, typically with a rocking or wobbling motion, on the self-aligning bearing and aligns the axis of the drive gear with the axis of the driven gear; and

(b) the self-aligning bearing support assembly and the flexible coupling or couplings allow movement of the axis of the drive gear relative to the axis of the driven gear so as to position the drive gear so that it meshes correctly, eg at a selected backlash, with the driven gear.

4. The drive gear assembly defined in any one of the preceding claims wherein the self-aligning bearing is located so that the geometric centre of the bearing coincides with the point at which the moments of the operating force systems that act on the drive gear and the driven gear are in equilibrium.

5. The drive gear assembly defined in any one of the preceding claims includes a pair of flexible couplings wherein one of the pair of flexible couplings is coupled to the drive gear and the other of the pair is coupled to the motor drive shaft (in use of the drive gear assembly).

6. The drive gear assembly defined in claim 5 further includes a telescopic shaft that connects together the flexible couplings.

7. The drive gear assembly defined in any one of the preceding claims wherein the flexible couplings include

universal joints, constant velocity joints, hookes joints, gear couplings, rubber bush couplings, and flexible diaphragm couplings.

8. The drive gear assembly defined in any one of the preceding claims wherein the support assembly for the self-aligning bearing includes:

(a) a shaft that supports the self-aligning bearing; and

(b) a housing that supports the shaft for movement relative to the axis of the drive shaft.

9. The drive gear assembly defined in claim 8 wherein the shaft includes an eccentric lobe which is received in the housing whereby rotation of the shaft in the housing displaces laterally the shaft and the self-aligning bearing carried by the shaft.

10. A motor-driven mechanical system which includes the drive gear assembly defined in any one of the preceding claims.

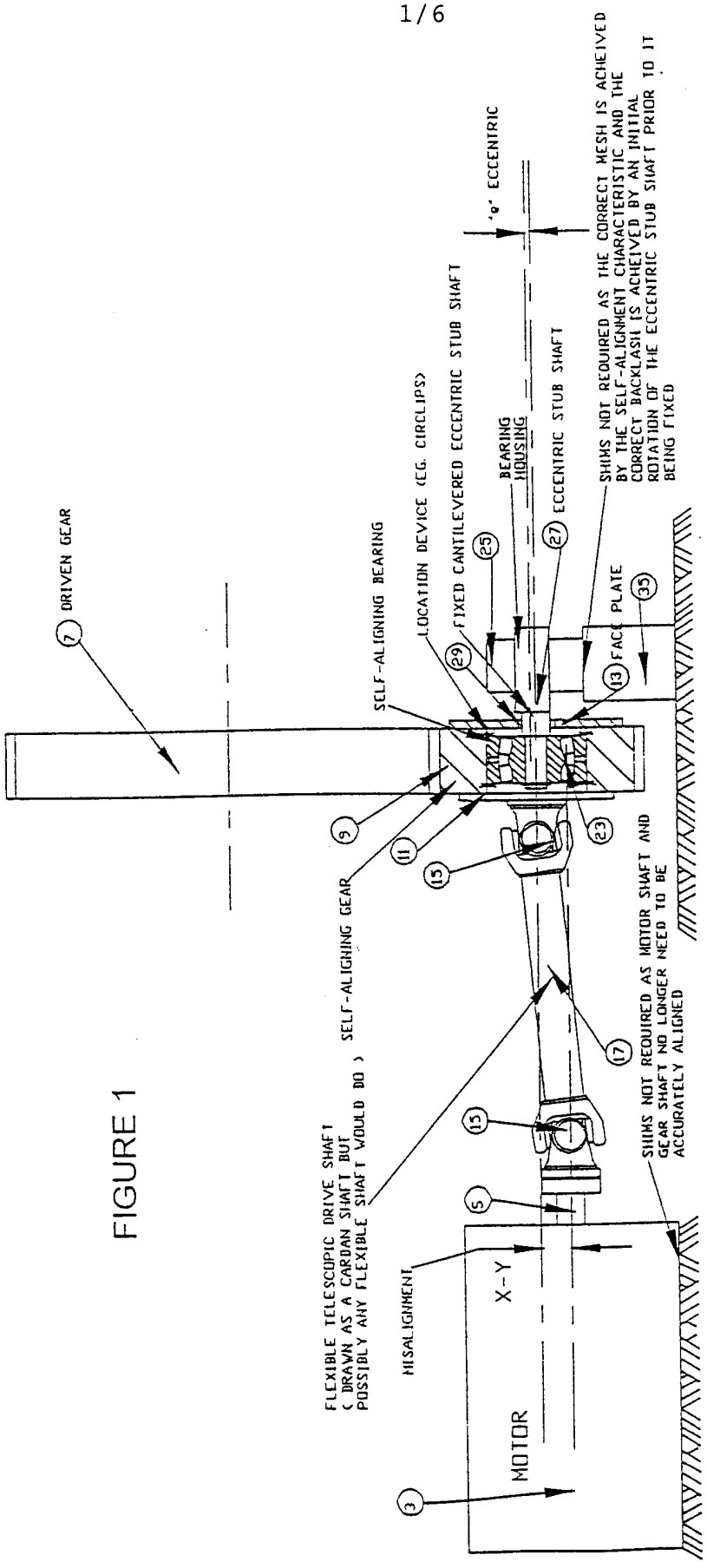

DRIVEN GEAR
SELF-ALIGNING BEARING
LOCATION DEVICE (EG. CIRCLIPS)
FIXED CANTILEVERED ECCENTRIC STUB SHAFT
BEARING HOUSING
ECCENTRIC STUB SHAFT
'e' ECCENTRIC
SHIMS NOT REQUIRED AS THE CORRECT MESH IS ACHEIVED BY THE SELF-ALIGNMENT CHARACTERISTIC AND THE CORRECT BACKLASH IS ACHEIVED BY AN INITIAL ROTATION OF THE ECCENTRIC STUB SHAFT PRIOR TO IT BEING FIXED
FACE PLATE
SELF-ALIGNING GEAR
FLEXIBLE TELESCOPIC DRIVE SHAFT
(DRAWN AS A CARDAN SHAFT BUT POSSIBLY ANY FLEXIBLE SHAFT WOULD DO)
SHIMS NOT REQUIRED AS MOTOR SHAFT AND GEAR SHAFT NO LONGER NEED TO BE ACCURATELY ALIGNED
MISALIGNMENT
X-Y
MOTOR
7
29
25
27
35
13
9
11
15
23
17
15
5
3

FIGURE 1

FIGURE 2

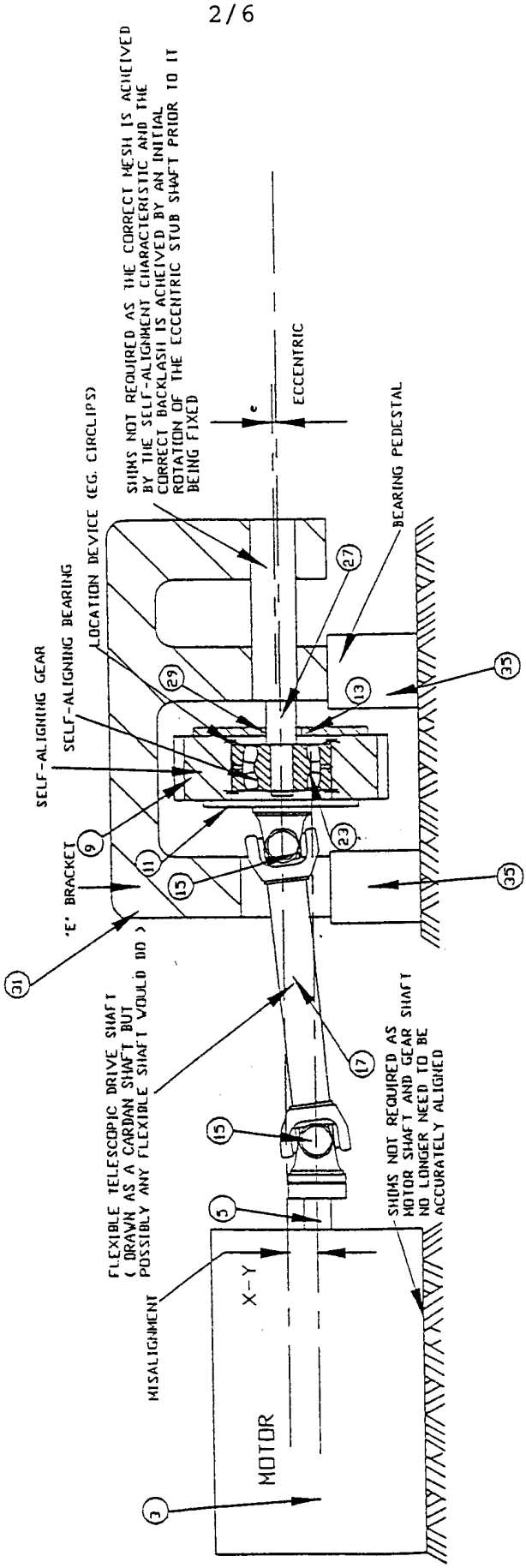

SHIMS NOT REQUIRED AS THE CORRECT MESH IS ACHIEVED BY THE SELF-ALIGNMENT CHARACTERISTIC AND THE CORRECT BACKLASH IS ACHIEVED BY AN INITIAL ROTATION OF THE ECCENTRIC STUB SHAFT PRIOR TO IT BEING FIXED
ECCENTRIC
e
BEARING PEDESTAL
LOCATION DEVICE (EG. CIRCLIPS)
SELF-ALIGNING BEARING
SELF-ALIGNING GEAR
'E' BRACKET
FLEXIBLE TELESCOPIC DRIVE SHAFT (DRAWN AS A CARDAN SHAFT BUT POSSIBLY ANY FLEXIBLE SHAFT WOULD DO)
SHIMS NOT REQUIRED AS MOTOR SHAFT AND GEAR SHAFT NO LONGER NEED TO BE ACCURATELY ALIGNED
MISALIGNMENT
X-Y
MOTOR
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9
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31
35

FIGURE 3

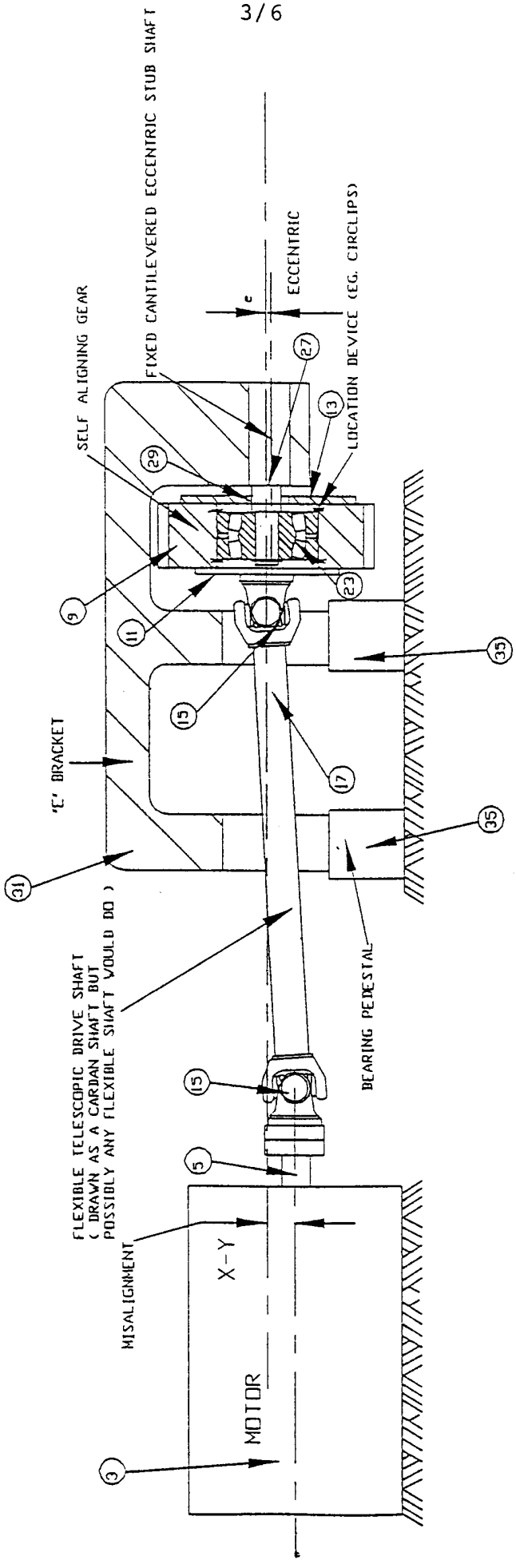

FIXED CANTILEVERED ECCENTRIC STUB SHAFT
SELF ALIGNING GEAR
ECCENTRIC
e
LOCATION DEVICE (EG. CIRCLIPS)
27
13
29
23
9
11
35
15
17
'L' BRACKET
31
35
FLEXIBLE TELESCOPIC DRIVE SHAFT
(DRAWN AS A CARDAN SHAFT BUT
POSSIBLY ANY FLEXIBLE SHAFT WOULD DO)
BEARING PEDESTAL
15
5
MISALIGNMENT
X-Y
MOTOR
3

FIGURE 4

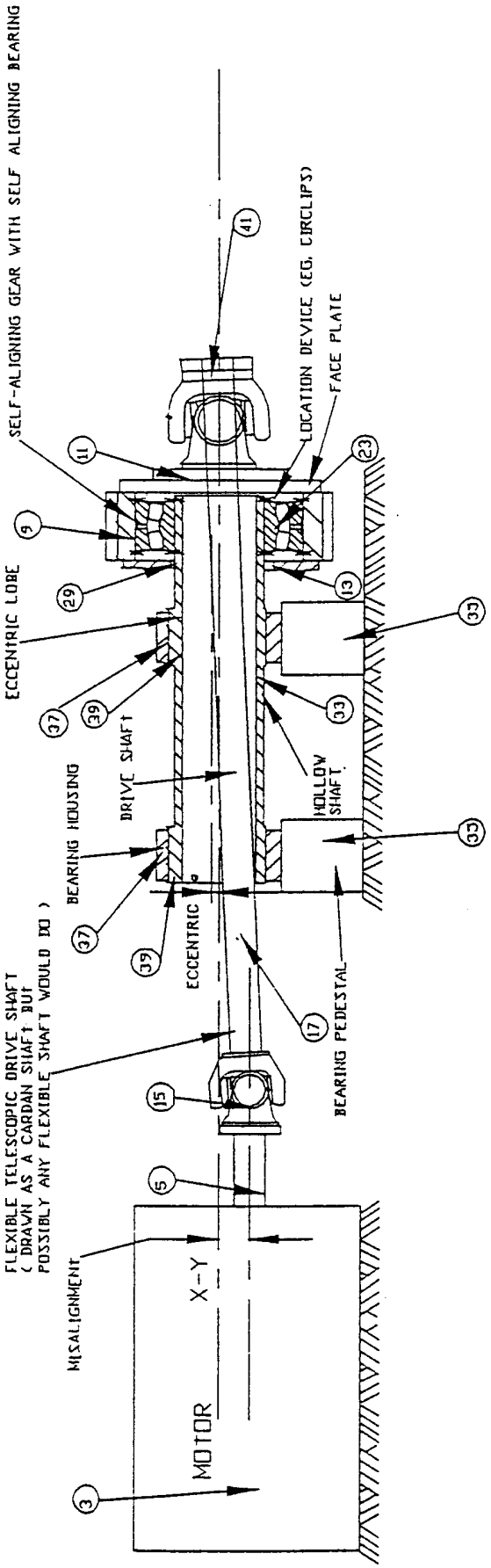

SELF-ALIGNING GEAR WITH SELF ALIGNING BEARING
LOCATION DEVICE (EG. CIRCLIPS)
FACE PLATE
ECCENTRIC LOBE
DRIVE SHAFT
HOLLOW SHAFT
BEARING HOUSING
ECCENTRIC
BEARING PEDESTAL
FLEXIBLE TELESCOPIC DRIVE SHAFT
(DRAWN AS A CARDAN SHAFT BUT
POSSIBLY ANY FLEXIBLE SHAFT WOULD DO)
MISALIGNMENT
X-Y
MOTOR
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37
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17
15
5
3

FIGURE 5

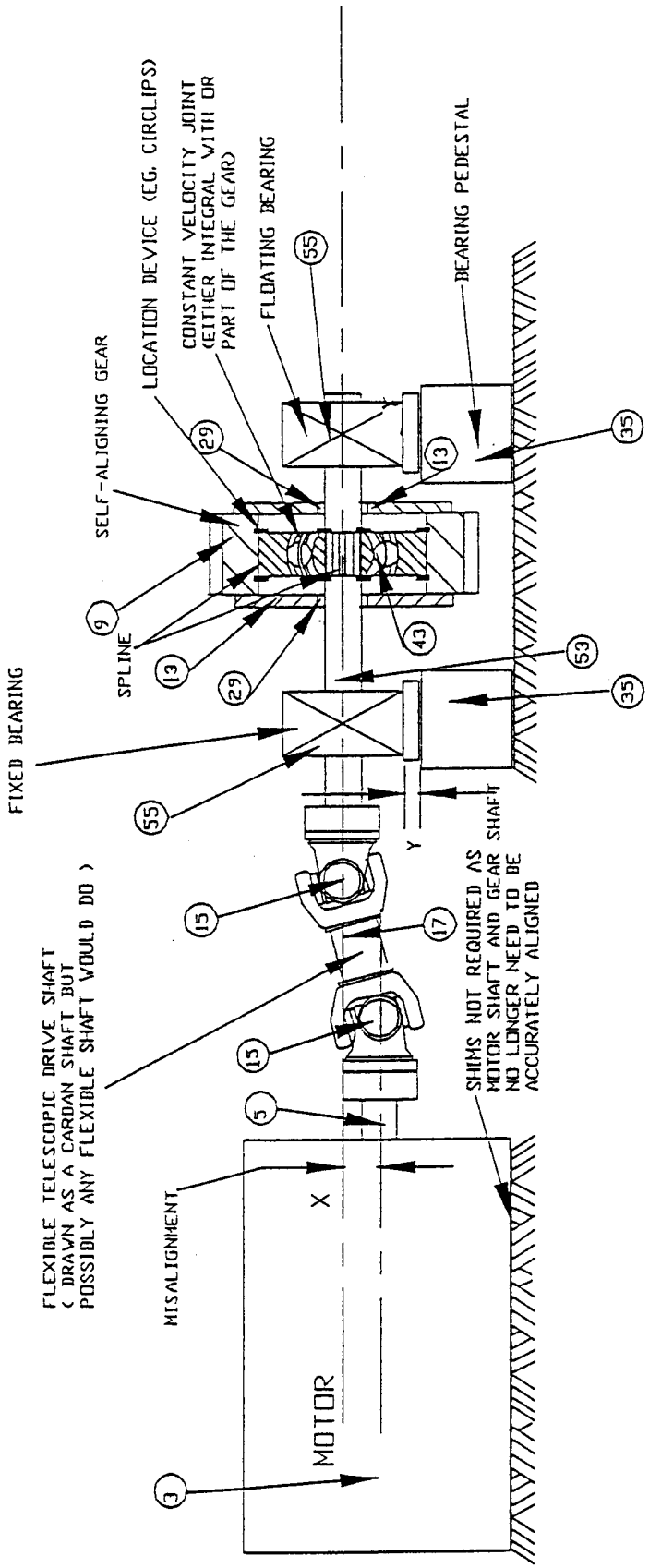
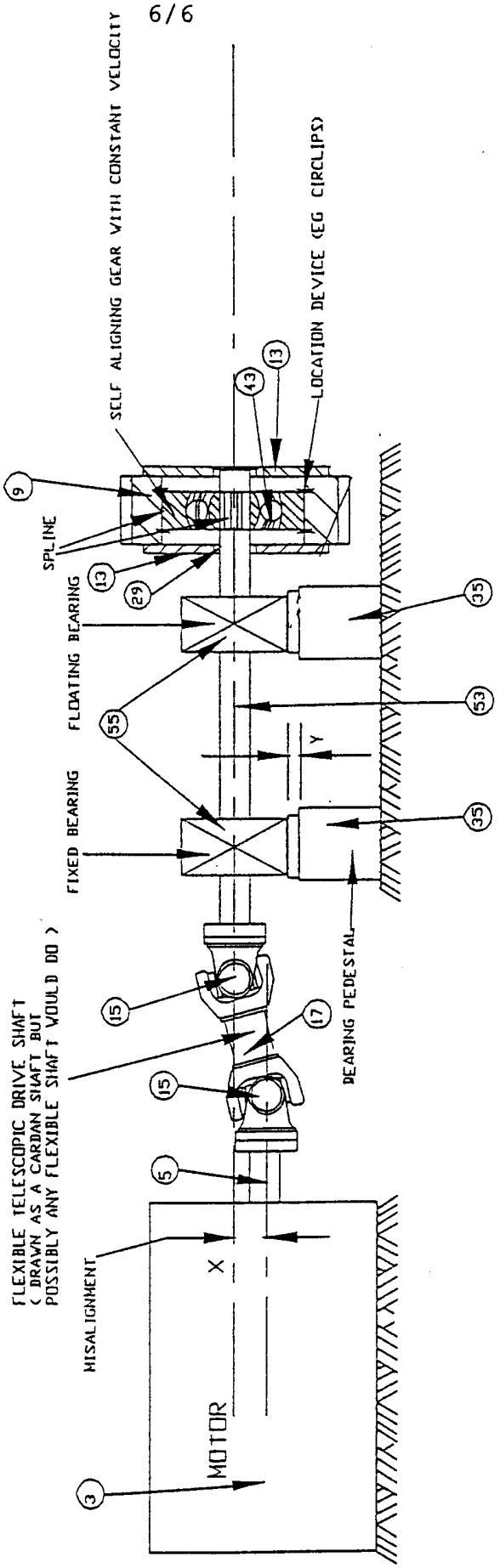

FIXED BEARING
SELF-ALIGNING GEAR
LOCATION DEVICE (EG. CIRCLIPS)
CONSTANT VELOCITY JOINT (EITHER INTEGRAL WITH OR PART OF THE GEAR)
FLOATING BEARING
BEARING PEDESTAL
SPLINE
FLEXIBLE TELESCOPIC DRIVE SHAFT (DRAWN AS A CARDAN SHAFT BUT POSSIBLY ANY FLEXIBLE SHAFT WOULD DO)
MISALIGNMENT
SHIMS NOT REQUIRED AS MOTOR SHAFT AND GEAR SHAFT NO LONGER NEED TO BE ACCURATELY ALIGNED
MOTOR
X
Y
55
29
9
13
43
53
35
15
17
5
3

FIGURE 6


SELF ALIGNING GEAR WITH CONSTANT VELOCITY
LOCATION DEVICE (EG CIRCLIPS)
SPLINE
FLOATING BEARING
FIXED BEARING
BEARING PEDESTAL
FLEXIBLE TELESCOPIC DRIVE SHAFT
(DRAWN AS A CARDAN SHAFT BUT
POSSIBLY ANY FLEXIBLE SHAFT WOULD DO)
MISALIGNMENT
MOTOR
X
Y
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU00/00332

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F16H 1/26, 35/06, 57/12

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 1/-, 35/-, 57/-, 55/-

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)
WPAT with keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 4328477 A (DORSTENER MASCHFAB AG) 10 March 1994 whole document	
A	US 4896837 A (KRUPP POLYSIUS AG) 30 January 1990 whole document	

☐ Further documents are listed in the continuation of Box C ☒ 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

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Date of the actual completion of the international search	Date of mailing of the international search report
4 May 2000	23 MAY 2000
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **KURT TOBLER** Telephone No : (02) 6283 2469

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU00/00332

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	4896837 A	EP	324930 A	DE	3801728 A

END OF ANNEX