(12) UK Patent Application (19) GB (11) 2 386 652 (13) A

(43) Date of A Publication 24.09.2003

(21) Application No 0206301.4

(22) Date of Filing 16.03.2002

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(51) INT CL^7
F16H 57/02 , F16C 23/06 25/06 , F16H 48/08

(52) UK CL (Edition V)
F2D DH DLA D501 D516
F2A AD16 A7D3 A7D5 A7EX A7E2 A7E3

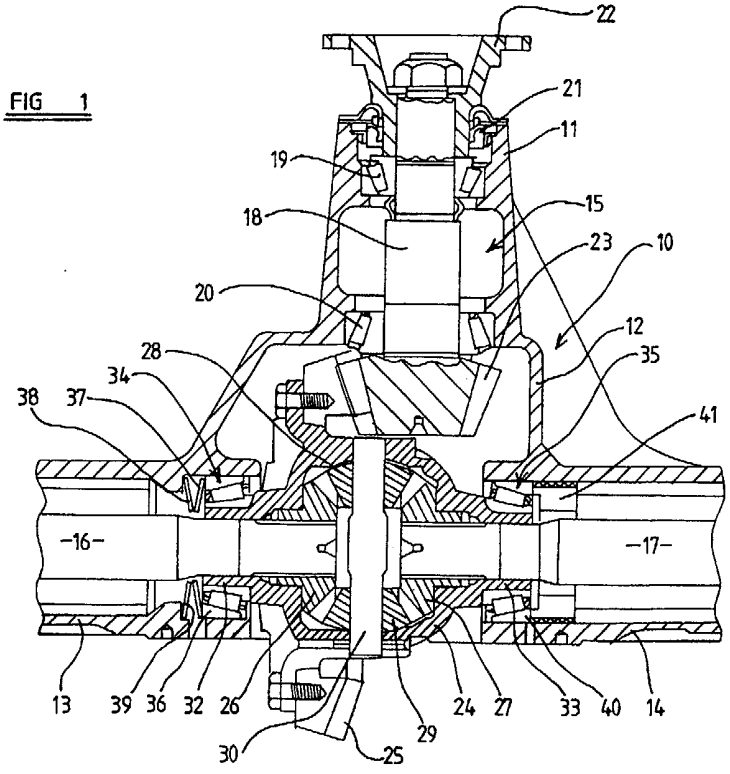
(56) Documents Cited
WO 2002/019502 A1 **US 6318201 B1**
US 5624345 A

(58) Field of Search
UK CL (Edition V) **F2A, F2D**
INT CL^7 **F16C, F16H**
Other: **EPODOC, JAPIO, WPI; INTERNET**

(54) Abstract Title
Differential with bearing pre-load provided by Belleville springs

(57) A differential comprises a housing 10 and a differential carrier 24 supported in the by two taper roller bearings 34, 35 spaced lengthwise along an axis of the housing 10. An outer race 36 of the bearing 34 abuts an outer diameter of a Belleville spring 37 having an inner diameter that abuts a further Belleville spring 38 in a back-to-back relationship. The other bearing 35 has an outer race 40 which is engaged by ring 41 having an male screw thread engaged with female screw thread provided in the housing 10. When the ring 41 is tightened against the outer race 40 the differential carrier 24 is moved thereby deforming the Belleville springs 37, 38. When a correct position of the carrier 24 has been reached the ring 41 is locked and the deformation of the Belleville springs 27, 38 provide a pre-load to the bearings 34, 35 which is maintained even when the housing is subjected to forces when it is installed in a vehicle.

FIG 1



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

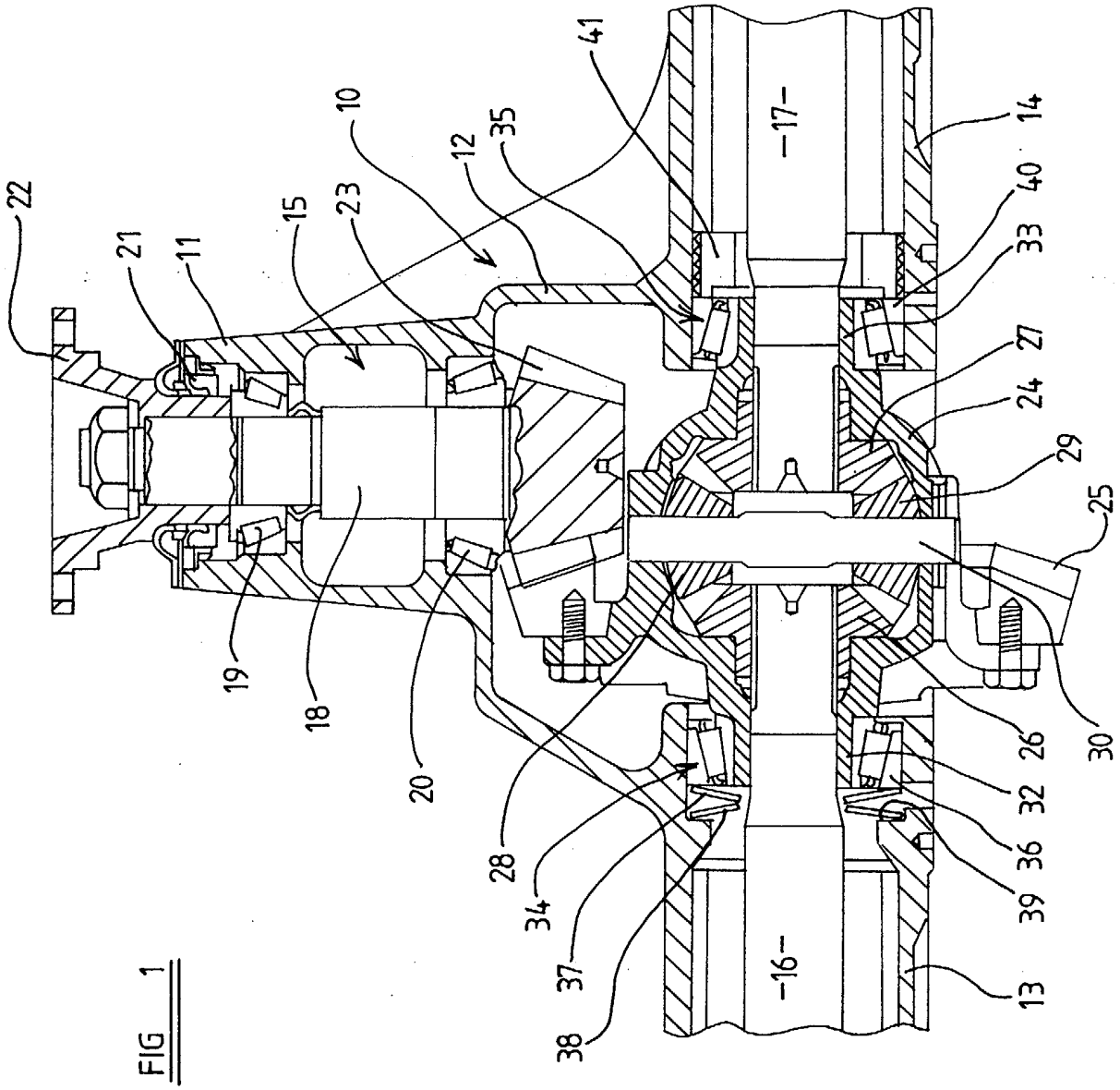
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FIG 1

Title: Differential Assembly for a Motor Vehicle

Description of Invention

This invention relates to a differential assembly for a motor vehicle. More particularly it relates to an arrangement providing for the correct setting and pre-loading of spaced bearings by which a differential carrier is supported for rotation within a housing of the differential.

Usually a differential carrier, which contains differential gearing means driving two output elements extending from the differential carrier and providing a differential action between the output elements, is supported in a differential housing by two spaced anti-friction bearing assemblies which are able to take loads both axially and radially relative to an axis about which the differential carrier is rotatable. The input to the differential assembly typically is an input bevel pinion rotatable about an axis transverse to the rotational axis of the differential carrier (e.g. at right angles thereto) and meshing with a crown gear on the differential carrier. The bearings (which usually are taper roller bearing assemblies) which support the differential carrier have to be correctly set so as to establish the position in which the differential carrier is supported in the housing in the direction lengthwise of the axis about which the differential carrier is rotatable, to achieve correct meshing between the input pinion and the crown gear, essential for low noise operation, and a pre-load on the bearings so that they exert opposed axial forces on the differential carrier ensures a long service life despite bearing wear in use.

One known arrangement by which the bearings supporting the differential carrier in the housing can be set and pre-loaded is by engaging each bearing (the outer race thereof) by a respective ring having screw-threaded engagement with the housing. Appropriate adjustment of the two rings enables

the position of the differential carrier in the direction lengthwise of its rotational axis to be set, and the bearings pre-loaded. This has a disadvantage in that the bearing pre-load relies on the stiffness characteristics of the housing and measurements have shown that when the housing is bolted into its mounted position in a vehicle structure its effective stiffness is affected and hence bearing pre-load changed. Therefore the bearing pre-load in use may be different from that when the differential is built. Also, wear of the bearings causes a reduction in the axial pre-load thereon.

It has also been proposed in US-6318201 that one of the bearings of the differential carrier may be supported by a collapsible spacer which plastically deforms under axial loads, the other bearing being engaged by a ring having screw-threaded engagement with the differential housing. The collapsible spacer has a near-constant load/deflection characteristic, so that as the screwed ring is tightened to position the differential carrier correctly the bearing pre-load remains at a required value as the spacer collapses. This design has a disadvantage, however, in that if the screwed ring is screwed too far in during assembly and setting of the differential carrier position, the spacer loses its required stiffness at the required installation position and would have to be renewed.

It is therefore the object of the present invention to provide a differential assembly with a bearing adjustment and pre-load setting arrangement which overcomes or reduces these disadvantages.

According to the present invention, we provide a differential assembly for a motor vehicle, comprising:

a differential housing;

a differential carrier supported within said housing for rotation about an axis, by way of two anti-friction bearing assemblies spaced lengthwise of said axis;

spring means disposed between one of said bearing assemblies and said differential housing for exerting an axial force therebetween; and

screw-threaded adjustment means operatively disposed between the other of said bearing assemblies and said housing, the arrangement being such that as said threaded adjustment means is tightened said spring means is elastically deformed.

Preferably the spring means comprises at least one Belleville spring washer. A Belleville washer has the advantage that when it is deformed in the sense of being flattened out from its normal generally frusto-conical configuration, by the application of axial forces as between its inside and outside diameters, relatively small changes in its axial dimensions do not significantly change the force it exerts. When used in a differential assembly in accordance with the invention, the bearing pre-load force exerted by the Belleville washer(s) is relatively independent of the stiffness of the differential housing, and is not likely to be altered by installation of the differential assembly in a vehicle. Belleville washers retain their stiffness characteristics over a relatively wide range of deformation, and are more accommodating of the assembly procedure in that they are not likely to require renewal like the spacer disclosed in US-6318201.

Preferably the screw-threaded adjustment means comprises a screwed ring engaging with a correspondingly screw-threaded formation in the housing. Such a screw-threaded ring may simply abut the outer race of a taper roller bearing assembly provided at the other end of the differential carrier.

The invention will now be described by way of example with reference to the accompanying drawing, which is a diagrammatic horizontal section through part of a differential assembly in accordance with the invention.

Referring to the drawing, the illustrated part of a differential assembly comprises a housing indicated generally at 10, including a forward extension part 11, a main part 12, and two lateral extension parts 13, 14. The main part

12 of the housing accommodates a differential gearing assembly to be described hereafter, whilst the forward extension 11 of the housing accommodates an input element indicated generally at 15 and the lateral extensions 13, 14 respectively accommodate output elements in the form of half shafts 16, 17. The rear of housing part 12 is closed by a removable cover not shown.

The input element 15 comprises a shaft 18 supported in the forward extension 11 of the housing 10 by a spaced pair of taper roller bearing assemblies 19, 20. Beyond the bearing assembly 19 the shaft 18 extends out of the housing extension 11 passing through an oil seal assembly 21, and carries a drive flange 22. The drive flange 22 provides for bolted connection to a shaft such as a motor vehicle propshaft by way of a universal joint. The opposite end of the shaft 18 is provided with a drive pinion 23.

The differential gearing assembly within the main part 12 of the housing 10 comprises a differential carrier 24. A crown gear 25 is bolted to the carrier 24 and meshes with the pinion 23. Respective bevel side gears 26, 27 are rotatably supported within the differential carrier 24 adjacent opposite ends thereof and these mesh with bevel differential gears 28, 29 carried on a pin 30 extending across the carrier 24. The side gears 26, 27 are splined respectively to the half shafts 16, 17. Thus the differential gearing provides for torque transmission from the input shaft 18 to the output half shafts 16, 17, whilst permitting differential rotation between the latter.

The differential carrier 24 is supported in the housing part 12 for rotation about an axis which is also the rotational axis of the side gears 26, 27 and the half shafts 16, 17 connected thereto. To this end spigot portions 32, 33 at opposite ends of the carrier 24 have supported thereon the inner races of respective taper roller bearing assemblies indicated generally at 34, 35, the outer races of the bearing assemblies being received in cylindrical receiving formations in the housing part 12. The outer race (36) of bearing assembly 34 abuts the outer diameter of a Belleville spring washer 37 whose inner diameter

abuts a further Belleville spring washer 38 in back-to-back relation with the washer 37. The outer diameter of washer 38 abuts a stop face 39 in the housing 12.

At the opposite end of the differential carrier 24, the outer race (40) of bearing assembly 35 is engaged by a ring 41 whose outer circumference is screw-threaded and engaged with a correspondingly screw-threaded interior part of the housing part 12/14.

In the process of assembly of the differential, screwing in of the ring 41, i.e. tightening it against the outer race 40 of the taper roller bearing assembly 35, moves the differential carrier as a whole to the left with reference to the drawing, deforming the Belleville spring washers 37, 38. When the correct position of the differential carrier has been reached for satisfactory meshing of bevel input gear 23 with crown gear 25, the ring 41 is locked to hold that position. The bearings for the differential carrier are pre-loaded by the force exerted by the Belleville spring washers 37, 38, which pre-load is maintained despite, for example, deformation of the housing 10 of the differential as a result of forces exerted thereon when it is installed in a motor vehicle.

In the present specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A differential assembly for a motor vehicle, comprising:

a differential housing;

a differential carrier supported within said housing for rotation about an axis, by way of two anti-friction bearing assemblies spaced lengthwise of said axis;

spring means disposed between one of said bearing assemblies and said differential housing; and

screw-threaded adjustment means operatively disposed between the other of said bearing assemblies and said housing, the arrangement being such that as said threaded adjustment means is tightened said spring means is elastically deformed.

2. A differential assembly according to Claim 1 wherein the spring means comprises at least one Belleville spring washer.

3. A differential assembly according to Claim 1 or Claim 2 wherein said screw-threaded adjustment means comprises a screwed ring engaging with a correspondingly screw-threaded formation in the housing.

4. A differential assembly according to any one of the preceding claims including an input element rotatable about an axis transverse to said axis and having a pinion engaging a crown gear on the differential carrier.

5. A differential assembly substantially as hereinbefore described with reference to the accompanying drawing.

6. Any novel feature or novel combination of features described herein and/or in the accompanying drawing.

Application No:	GB 0206301.4	**Examiner:**	Mike Mckinney
Claims searched:	1 to 5	**Date of search:**	9 July 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1 to 4	US 5624345	(GRAFT et al) see figs and threaded adjuster in line 22 col 3.
Y	1 to 4	US 6318201 B1	(YOSHIOKA) referred to on page 2 of specification.
Y	1 to 4	WO 02/19502 A1	(VALEO) see whole document.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

F2A, F2D

Worldwide search of patent documents classified in the following areas of the IPC[7]:

F16C, F16H

The following online and other databases have been used in the preparation of this search report:

EPODOC, JAPIO, WPI; INTERNET