



(43) International Publication Date
21 January 2016 (21.01.2016)

(51) International Patent Classification:
F16H 48/40 (2012.01)

(21) International Application Number:
PCT/US2014/072088

(22) International Filing Date:
23 December 2014 (23.12.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2034/DEL/2014 18 July 2014 (18.07.2014) IN

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: DIFFERENTIAL ASSEMBLY WITH HELICAL PINION GEAR HAVING PROTUBERANCE

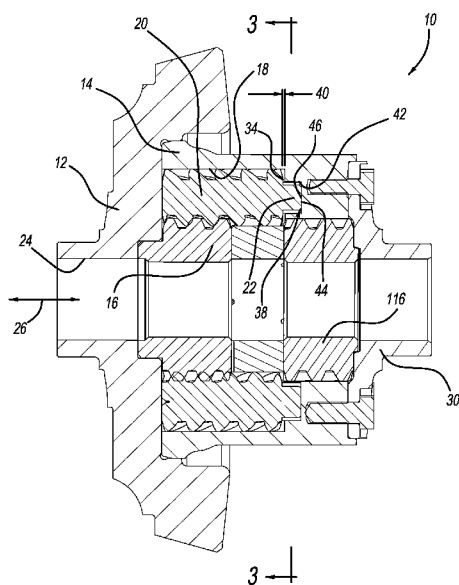


FIG-2

(57) Abstract: A differential assembly can include a housing, a helical pinion gear, and at least one protuberance. The housing can define a pocket with a blind end. The housing can have a central axis and the pocket can be spaced from the central axis. The helical pinion gear can be positioned in the pocket. The at least one protuberance can extend from an end of the helical pinion gear along the central axis. The at least one protuberance can contact the blind end of the pocket. The at least one protuberance can be guided at the blind end of the pocket, such as with a rectangular or v-shaped arrangement.

DIFFERENTIAL ASSEMBLY WITH HELICAL PINION GEAR HAVING PROTUBERANCE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of IN Patent Application No. 2034/DEL/2014 filed on July 18, 2014. The disclosure of the above application is incorporated herein by reference.

FIELD

[0002] The present disclosure relates generally to a differential assembly for distributing rotary power and more particularly to a differential assembly having helical pinion gears.

BACKGROUND

[0003] A differential assembly includes pinion gears and side gears. The pinion gears can be helical. Each helical pinion gear is in mesh with an adjacent pinion gear and also with one of the side gears. The helical pinion gears are enclosed within pockets in a differential housing. The ends of the helical pinion gears receive the most wear due to movement during engagement. During torque transmission, when a vehicle is moving in a straight line, the side gears and the helical pinion gears rotate together about a central axis of the differential housing. When a vehicle is moving along a curved path, one wheel must move faster than the other wheel. The helical pinion gears then not only rotate about the central axis of the differential housing, but also rotate about their own individual center axes inside the housing pockets. The resistive torque on one of the wheels will cause the pinion gears to move radially outward and rub against the housing pocket. During turning of the vehicle at high load, the helical pinion gears in mesh exert very high radial loads on each other, leading to sticking, binding, and noise.

[0004] The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named Inventors, to the extent it is described in this background section, as well as aspects of the description that

may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

SUMMARY

[0005] A differential assembly can include a housing, a helical pinion gear, and at least one protuberance. The housing can define a pocket with a blind end. The housing can have a central axis, and the pocket can be spaced from the central axis. The helical pinion gear can be positioned in the pocket. The at least one protuberance can extend from an end of the helical pinion gear along the central axis. The at least one protuberance can contact the blind end of the pocket.

[0006] According to additional features, the at least one protuberance can have a circular cross-section with a diameter less than a diameter of the helical pinion gear. The diameter of the at least one protuberance can be substantially constant along at least a portion of the central axis. The at least one protuberance can terminate in a substantially flat surface slidably engaged with the blind end.

[0007] According to other features, the helical pinion gear and the at least one protuberance can be integrally-formed with respect to one another. The at least one protuberance can be spherical. The blind end of the pocket can include a slot receiving the at least one protuberance. The slot can be substantially rectangular in cross-section. The slot can extend in a radial direction relative to the central axis. The slot can surround the at least one protuberance. The slot can be v-shaped.

[0008] In other features, the at least one protuberance can include a plurality of protuberances. A first protuberance can extend from a first end of the helical pinion gear and contact the blind end of the pocket. A second protuberance can extend from a second end of the helical pinion gear opposite of the first end.

[0009] A method can include defining a pocket with a housing having a central axis, wherein the pocket is radially spaced from the central axis. The method can also include positioning a helical pinion gear in the pocket. The method can also include extending at least one protuberance from an end of the helical pinion gear along the central axis and contacting a blind end of the pocket.

[0010] According to additional features, extending the at least one protuberance can be further defined as reducing a contact area between the helical pinion gear and the housing by selecting a first diameter of the helical pinion gear greater than a second diameter of the at least one protuberance.

[0011] According to other features, the method can include guiding movement of the helical pinion gear through the at least one protuberance with a slot in the blind end. The method can include arranging the at least one protuberance and the slot to contact in only two planes. The at least one protuberance can be formed as spherical and the slot can be formed to be v-shaped. The guiding step can include extending the at least one protuberance through the slot.

[0012] In other features, the extending step can be further defined as reducing an extent of contact between the helical pinion gear and the housing by selecting positioning a first protuberance between a first end of the helical pinion gear and the housing and a second protuberance between a second end of the helical pinion gear opposite the first end and the housing.

[0013] A differential assembly can include a ring gear, a housing, a side gear, a helical pinion gear, and at least one protuberance. The housing can be fixed for rotation with the ring gear. The housing can define a pocket and a central aperture radially adjacent to one another relative to a central axis of the housing. The side gear can be positioned in the central aperture. The helical pinion gear can be positioned in the pocket and meshed with the side gear. The at least one protuberance can project from an end of the helical pinion gear and contact a blind end of the pocket.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0015] FIG. 1 is an exploded view of a differential assembly constructed in accordance to one example of the present disclosure;

[0016] FIG. 2 is a cross-section taken in a plane containing a central axis of the exemplary differential assembly shown in FIG. 1;

[0017] FIG. 3 is a cross-section taken along section lines 3 – 3 in FIG. 2;

[0018] FIG. 4 is a partial cross-section of a differential assembly constructed in accordance to another example of the present disclosure; and

[0019] FIG. 5 is a side view of a differential assembly constructed in accordance to another example of the present disclosure.

DETAILED DESCRIPTION

[0020] A plurality of different embodiments of the present disclosure is shown in the Figures of the application. Similar features are shown in the various embodiments of the present disclosure. Similar features across different embodiments have been numbered with a common reference numeral and have been differentiated by an alphabetic suffix. Similar features in a particular embodiment have been numbered with a common two-digit, base reference numeral and have been differentiated by a different leading numeral. Also, to enhance consistency, the structures in any particular drawing share the same alphabetic suffix even if a particular feature is shown in less than all embodiments. Similar features are structured similarly, operate similarly, and/or have the same function unless otherwise indicated by the drawings or this specification. Furthermore, particular features of one embodiment can replace corresponding features in another embodiment or can supplement other embodiments unless otherwise indicated by the drawings or this specification.

[0021] As set forth above, when a vehicle is moving on a curved path, the wheels on one side of the vehicle must move faster than the other wheels. In a differential assembly having helical pinion gears, the helical pinion gears rotate about the central axis of the differential housing and also about their own individual center axes inside housing pockets. Resistive torque experienced by one wheel will cause the pinion gears to move radially outward and rub against the housing pocket. If the vehicle is turning at relatively high load, the helical pinion gears in mesh will exert very high radial loads on each other, tending to urge the helical pinions along the central axis of the housing. Contact between the housing and the helical gear can lead to sticking, binding, and noise.

[0022] Helical pinions can be provided with one or more protuberances to reduce an area of contact with the housing. This reduces the extent of friction between the pinion and the housing and thus reduces wear. Further, the housing can include a structure that guides movement of the helical pinions inside the differential assembly. The protuberance can be directed in movement by a slot in the housing without affecting the torque split of the differential. This reduces the likelihood of random movement of the helical gears inside the housing pockets and thus also reduces the likelihood of sticking and binding between helical gears under heavy radial load due to the helical gearing.

[0023] Referring now to FIG. 1, a differential assembly 10 can include a ring gear 12, a housing 14, a first side gear 16, a second side gear 116, a plurality of helical pinion gears such as referenced at 20, 120, 220, 320, and a plurality of protuberances such as referenced at 22, 122. The ring gear 12 can be meshed with a drive pinion gear (not shown). Rotary power developed by an engine can be transmitted to the drive pinion gear and can thus cause rotation of the ring gear 12. It is noted that the gear teeth of the ring gear 12 are not illustrated to enhance the clarity of the other structures illustrated in FIG. 1.

[0024] The housing 14 can be fixed for rotation with the ring gear 12. For example, the housing 14 and the ring gear 12 can be bolted together. The housing 14 can define a plurality of pockets, such as referenced at 118, 318 in FIG. 1. Each pocket can extend along a central axis 26 of the housing 14. Each pocket can extend less than fully through the housing 14. The housing 14 can also define a central aperture 24. The pocket 118 and the central aperture 24 can be radially adjacent to one another relative to the central axis 26. The ring gear 12 can close the pockets on a first side 28 of the housing 14 and a plate 30 can close the pockets, including pockets 118 and 318, on a second side 32 of the housing 14. The housing 14 can be fixed for rotation with the plate 30. For example, the housing 14 and the plate 30 can be bolted together.

[0025] Each helical pinion gear 20, 120, 220, 320 can be positioned in one of the pockets. For example, the helical pinion gear 120 can be positioned in the pocket 118. The helical pinion gear 320 can be positioned in the pocket 318. The first side gear 16 and the second side gear 116 can be positioned in the central aperture 24. Each helical pinion gear 20, 120, 220, 320 can be meshed with one of the side gears 16, 116. For

example, the helical pinion gears 20 and 220 can be meshed with the first side gear 16. The helical pinion gears 120 and 320 can be meshed with the second side gear 116. Each helical pinion gear 20, 120, 220, 320 can also be meshed with another helical pinion gear. For example, the helical pinion gear 20 can be meshed with the helical pinion gear 120. The helical pinion gear 220 can be meshed with the helical pinion gear 320.

[0026] In operation, the side gears 16, 116 and the helical pinion gears 20, 120, 220, 320 can rotate together about the central axis 26 of the housing 14 when the associated vehicle is moving in a straight line. Rotary power is transmitted to a first wheel through the first side gear 16 and transmitted to a second wheel opposite the first wheel through the second side gear 116. During straight line movement, the helical pinion gears 20, 120, 220, 320 are orbiting about the central axis 26 but are not rotating about their own, individual center axes inside their respective pockets. When the vehicle moves along a curved path, one of the wheels of the vehicle must move faster than the wheel on the opposite side of the vehicle. During vehicle movement along a curved path, the helical pinion gears 20, 120, 220, 320 not only rotate about the central axis 26, but also rotate about their own, individual center axes inside their respective pockets. Resistive torque on one of the wheels will cause the helical pinion gears 20, 120, 220, 320 to move radially outward and rub against the housing pocket. At relatively higher turning loads, the meshing between the helical pinion gears 20, 120, 220, 320 will also result in loads directed along the individual center axes of the helical pinion gears 20, 120, 220, 320. These loads will be transmitted through the ends of the helical pinion gears 20, 120, 220, 320 to the housing 14, the ring gear 12, and/or the plate 30. The transmission of these loads can lead to sticking, binding, and noise.

[0027] A protuberance can project from an end of one or more of the helical pinion gears. For example, the protuberance 22 can project from an end 34 of the helical pinion gear 20. The helical pinion gear 20 and the protuberance 22 can be integrally-formed with respect to one another. The protuberance 22 can reduce a contact area between the helical pinion gear 20 and the housing 14 since the diameter of the protuberance 22 can be less than a diameter of the helical pinion gear 20. The relatively smaller protuberance 22 can contact the housing 14 rather than the relatively larger end 34 of the helical pinion gear 20.

[0028] As best shown in FIG. 2, the helical pinion gear 20 and the protuberance 22 can be positioned in a pocket 18 defined by the housing 14. The protuberance 22 can contact a blind end 38 of the pocket 18. The end 38 of the pocket 18 is blind in that the helical pinion gear 20 cannot pass through the pocket 18. A gap, referenced at 40, can be defined between the end 34 and the blind end 38. The protuberance 22 can cause separation between the end 34 and the blind end 38.

[0029] Referring again to FIG. 1, the protuberance 122 can project from an end 136 of the helical pinion gear 120. The protuberance 122 can reduce a contact area between the helical pinion gear 120 and the plate 30 since the diameter of the protuberance 122 can be less than a diameter of the helical pinion gear 120. The relatively smaller protuberance 122 can contact the plate 30 rather than the relatively larger end 136 of the helical pinion gear 120.

[0030] As set forth above, resistive torque on one of the wheels can cause the helical pinion gears 20, 120, 220, 320 to move radially outward and rub against the pocket. One or more of the pockets can also include a slot 42 to guide radial movement of the helical pinion gear positioned in that pocket. For example, as shown in FIG. 2, the blind end 38 of the pocket 18 can include a slot 42 receiving the protuberance 22. The slot 42 can guide movement of the helical pinion gear 20 through the engagement with the protuberance 22.

[0031] Embodiments of the present disclosure can provide various approaches to reducing contact area and guiding the movement of helical pinion gears. FIGS. 1 – 3 disclose a first approach. The protuberance 22 can have a circular cross-section that can be substantially constant along at least a portion of the central axis 26. The protuberance 22 can terminate in a substantially flat surface 44 that can be slidably engaged with a surface 46 of the blind end 38.

[0032] As set forth above, the protuberance 22 can extend through the slot 42 of the blind end 38. The slot 42 can be substantially rectangular in cross-section and extend in a radial direction relative to the central axis 26, as best shown in FIG. 3. The slot 42 can thus surround the protuberance 22.

[0033] Another embodiment of the present disclosure is shown in FIG. 4. The perspective of FIG. 4 is radially-inward. FIG. 4 discloses a helical pinion gear 20a

positioned in a pocket 18a. The pocket 18a can be defined by a housing 14a. The pocket 18a can terminate in a blind end 38a. The housing 14a can be centered on a central axis 26a. A protuberance 22a can extend from an end 34a of the helical pinion gear 20a. The blind end 38a includes a slot 42a.

[0034] The protuberance 22a can be spherical. The slot 42a can be v-shaped, having two opposing and intersecting walls 48a, 50a forming a concave corner facing an interior of the pocket 18a. The protuberance 22a can be thus arranged to contact the slot 42a in only two planes.

[0035] FIG. 5 discloses another embodiment of the present disclosure. The housing has been omitted from FIG. 5 to enhance the clarity of the remaining structures. FIG. 5 discloses a plurality of helical pinion gears 20b, 120b, 220b, side gears 16b and 116b, and a plate 30b.

[0036] Helical pinion gears 20b and 220b can include protuberances at both ends. The helical pinion gear 20b can include a first protuberance 22b positioned between a first end 34b and a housing and a second protuberance 422b positioned between a second end 36b and a plate 52b. The plate 52b can include a slot (not shown) for receiving the second protuberance 422b.

[0037] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

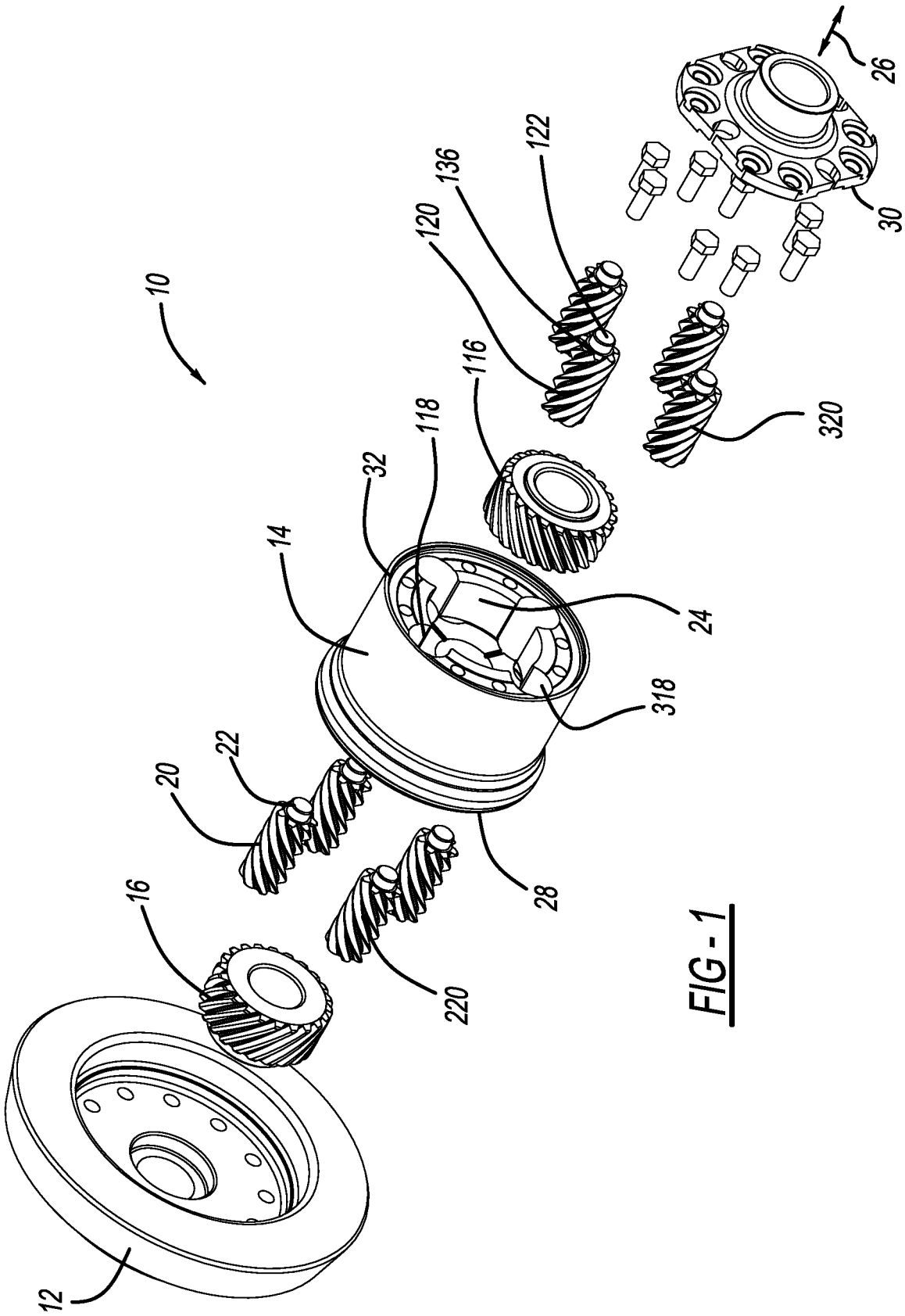
CLAIMS

What is claimed is:

1. A differential assembly comprising:
a housing defining a pocket with a blind end and having a central axis wherein the pocket is spaced from the central axis;
a helical pinion gear positioned in the pocket; and
at least one protuberance extending from an end of the helical pinion gear along the central axis and contacting the blind end of the pocket.
2. The differential assembly of claim 1 wherein the at least one protuberance has a circular cross-section with a diameter less than a diameter of the helical pinion gear.
3. The differential assembly of claim 2 wherein the diameter of the at least one protuberance is substantially constant along at least a portion of the central axis.
4. The differential assembly of claim 2 wherein the at least one protuberance terminates in a substantially flat surface slidably engaged with the blind end.
5. The differential assembly of claim 1 wherein the helical pinion gear and the at least one protuberance are integrally-formed with respect to one another.
6. The differential assembly of claim 1 wherein the at least one protuberance is spherical.
7. The differential assembly of claim 1 wherein the blind end of the pocket further comprises:
a slot receiving the at least one protuberance.
8. The differential assembly of claim 7 wherein the slot is substantially rectangular in cross-section.

9. The differential assembly of claim 7 wherein the slot extends in a radial direction relative to the central axis.
10. The differential assembly of claim 7 wherein the slot surrounds the at least one protuberance.
11. The differential assembly of claim 7 wherein the slot is v-shaped.
12. The differential assembly of claim 1 wherein the at least one protuberance further comprises:
 - a first protuberance extending from a first end of the helical pinion gear and contacting the blind end of the pocket; and
 - a second protuberance extending from a second end of the helical pinion gear opposite of the first end.
13. A method comprising:
 - defining a pocket with a housing having a central axis wherein the pocket is radially spaced from the central axis;
 - positioning a helical pinion gear in the pocket; and
 - extending at least one protuberance from an end of the helical pinion gear along the central axis and contacting a blind end of the pocket.
14. The method of claim 13 wherein the step of extending is further defined as:
 - reducing a contact area between the helical pinion gear and the housing by selecting a first diameter of the helical pinion gear greater than a second diameter of the at least one protuberance.
15. The method of claim 13 further comprising the step of:
 - guiding movement of the helical pinion gear through the at least one protuberance with a slot in the blind end.

16. The method of claim 15 wherein the guiding step further comprises the step of:
arranging the at least one protuberance and the slot to contact in only two planes.
17. The method of claim 16 wherein the guiding step further comprises the steps of:
forming the at least one protuberance as spherical; and
forming the slot to be v-shaped.
18. The method of claim 16 wherein the guiding step further comprises the steps of:
extending the at least one protuberance through the slot.
19. The method of claim 13 wherein the extending step is further defined as:
reducing an extent of contact between the helical pinion gear and the housing by
selecting positioning a first protuberance between a first end of the helical pinion gear
and the housing and a second protuberance between a second end of the helical pinion
gear opposite the first end and the housing.
20. A differential assembly comprising:
a ring gear;
a housing fixed for rotation with the ring gear, the housing defining a pocket and a
central aperture radially adjacent to one another relative to a central axis of the housing;
a side gear positioned in the central aperture;
a helical pinion gear positioned in the pocket and meshed with the side gear; and
at least one protuberance projecting from an end of the helical pinion gear and
contacting a blind end of the pocket.



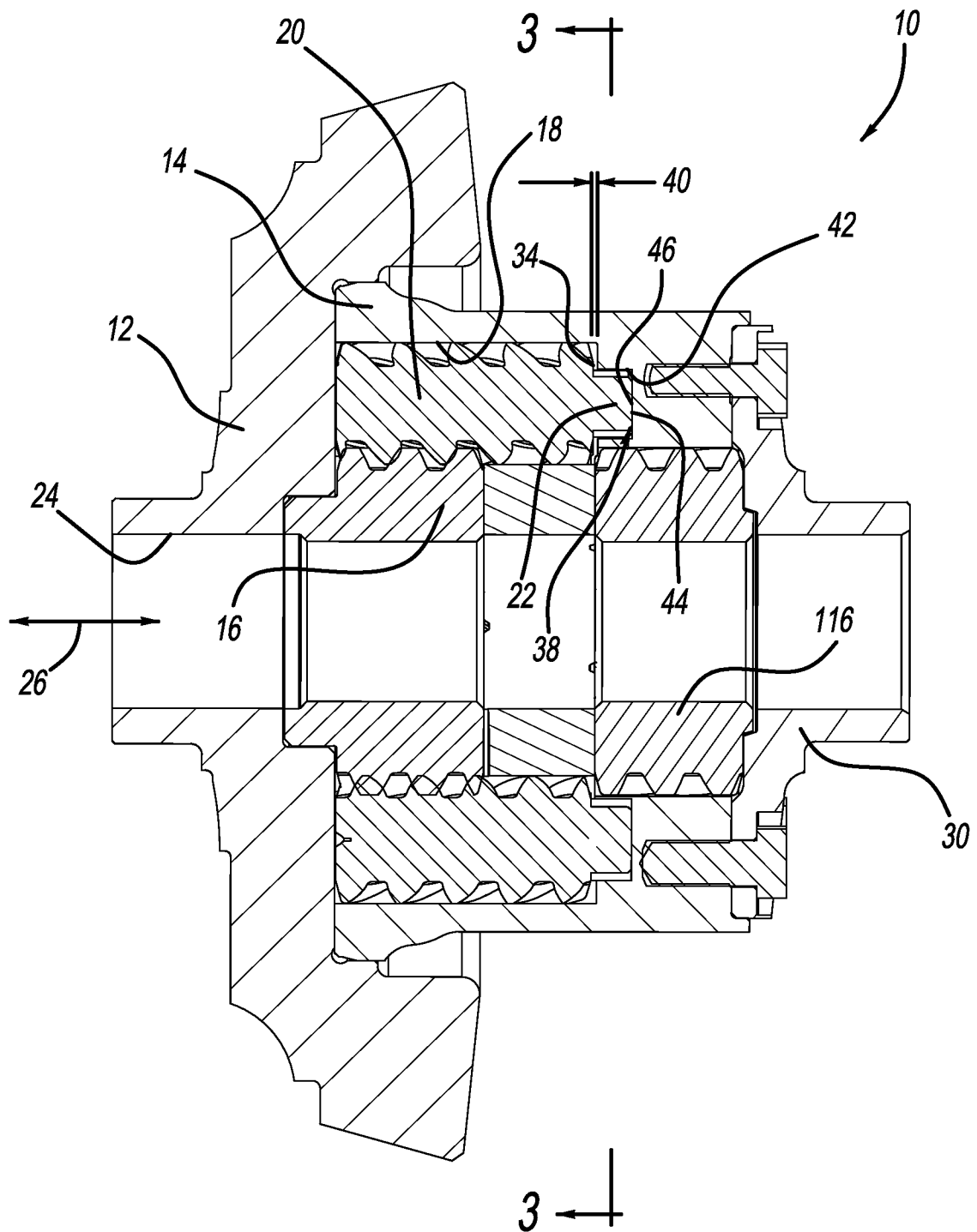


FIG - 2

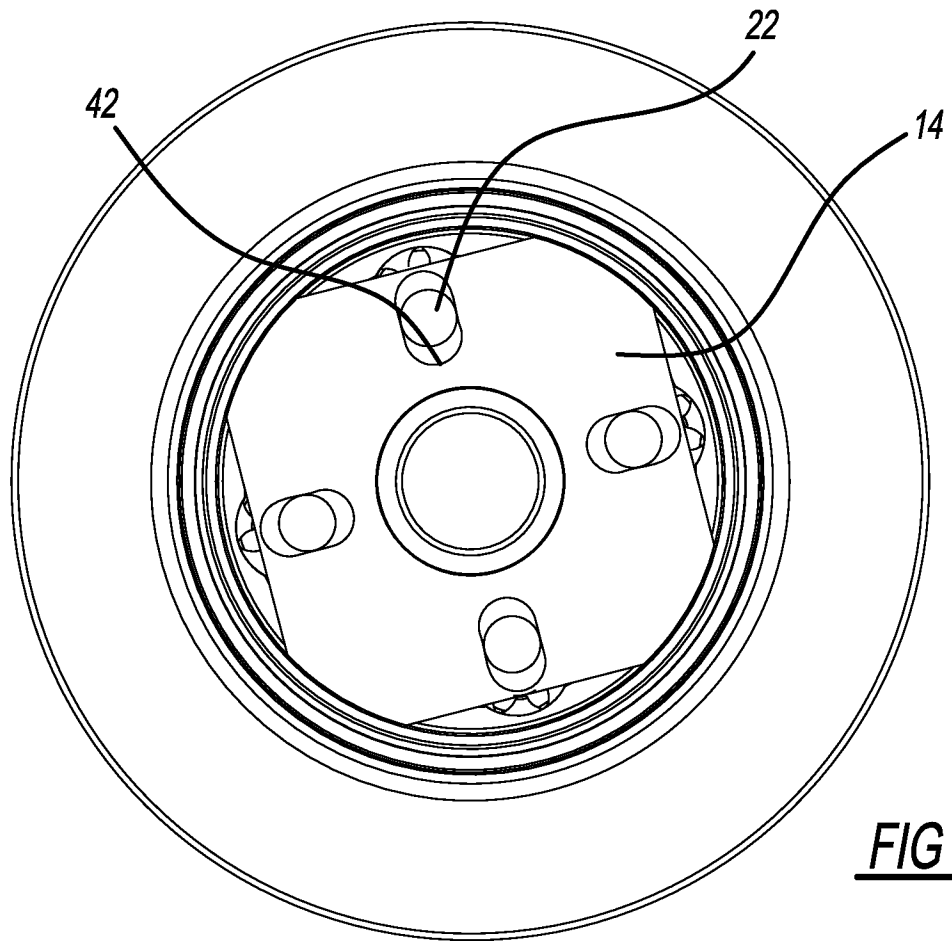


FIG - 3

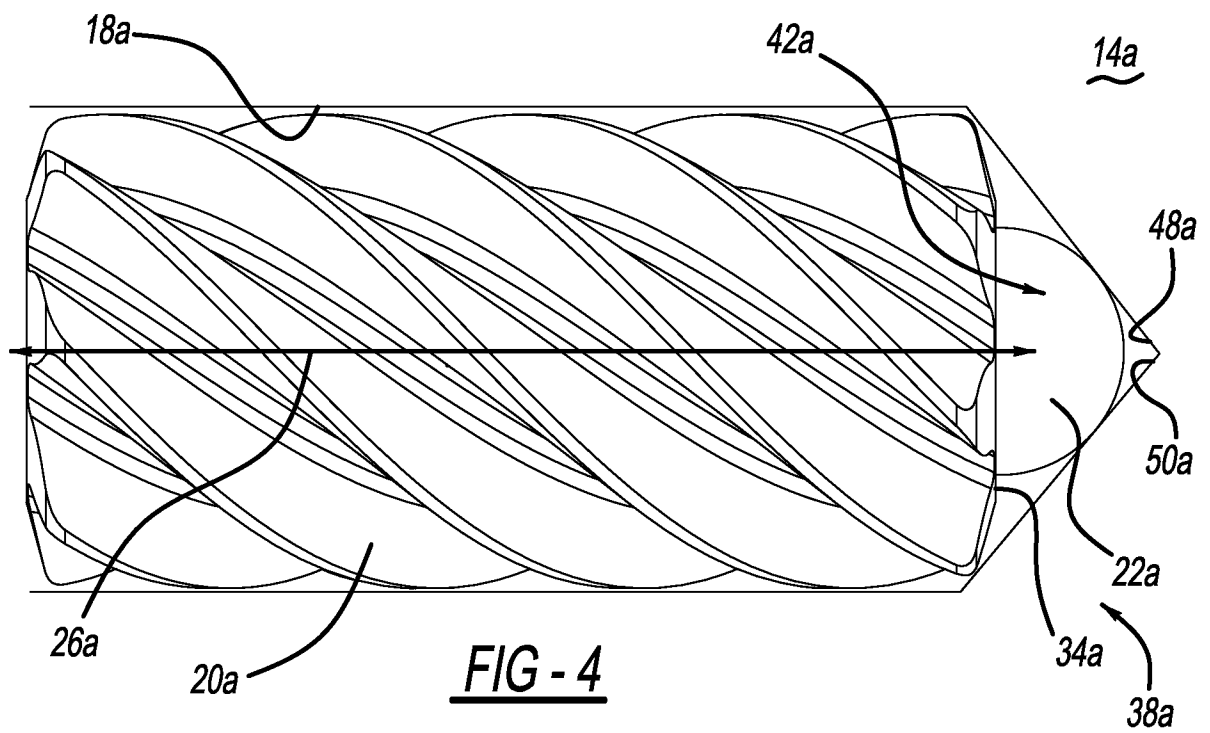


FIG - 4

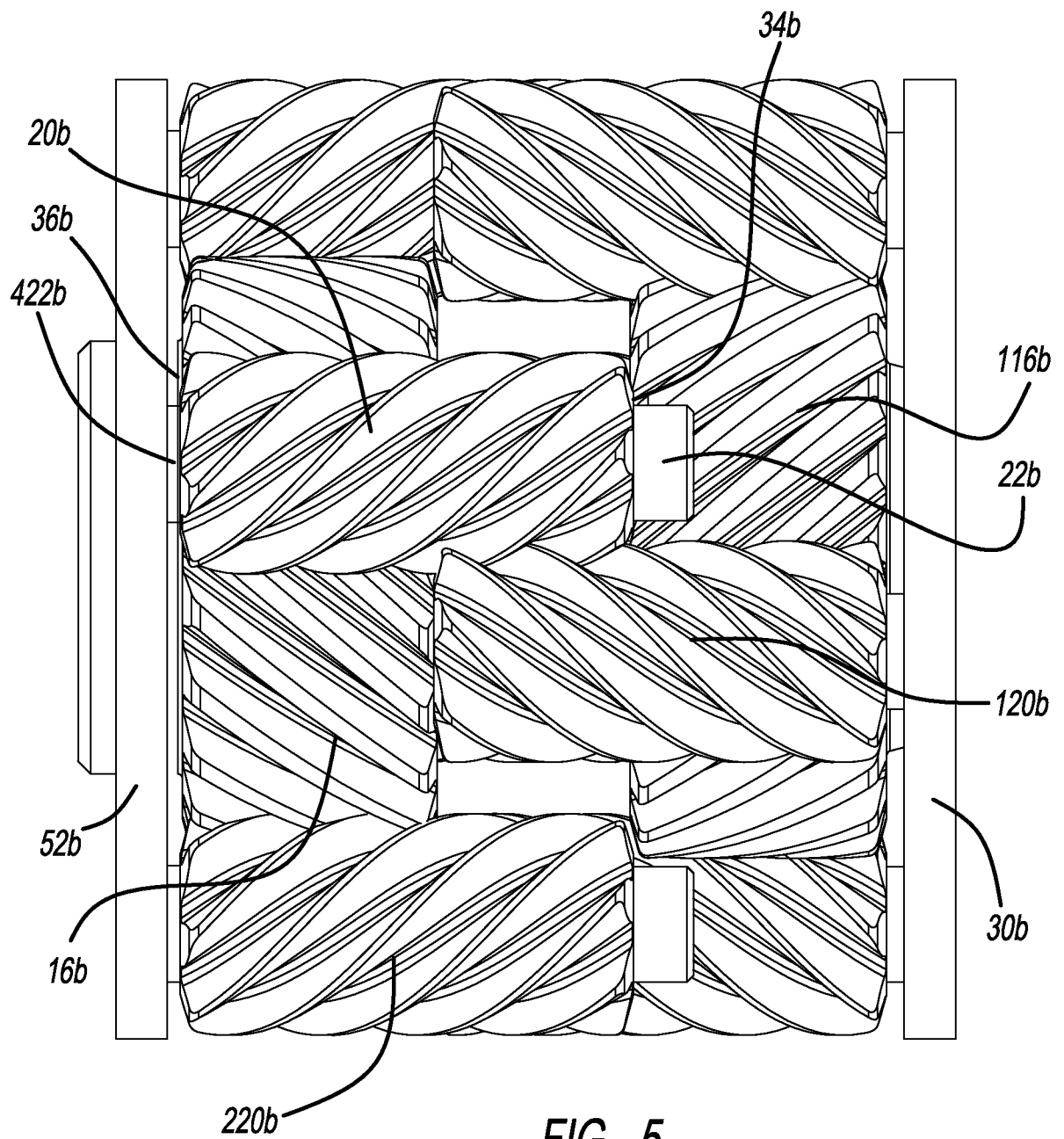


FIG - 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2014/072088

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H48/40
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	US 6 053 838 A (GAGE GARRETT W [US]) 25 April 2000 (2000-04-25) figures 1-12	1-20
A	----- US 2010/081535 A1 (GUTSMIEDL PETER [DE]) 1 April 2010 (2010-04-01) figures 1-14 -----	1-20



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See patent family annex.

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Date of the actual completion of the international search

21 September 2015

Date of mailing of the international search report

06/10/2015

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/072088

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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