



- (51) **International Patent Classification:**
F16G 13/04 (2006.01) *F16H 7/06* (2006.01)
F16H 55/30 (2006.01)
- (21) **International Application Number:**
PCT/US2014/064947
- (22) **International Filing Date:**
11 November 2014 (11.11.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/904,863 15 November 2013 (15.11.2013) US
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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,

[Continued on next page]

(54) **Title:** SPROCKET ASSEMBLY INCLUDING TEETH HAVING AN ENLARGED PROFILE

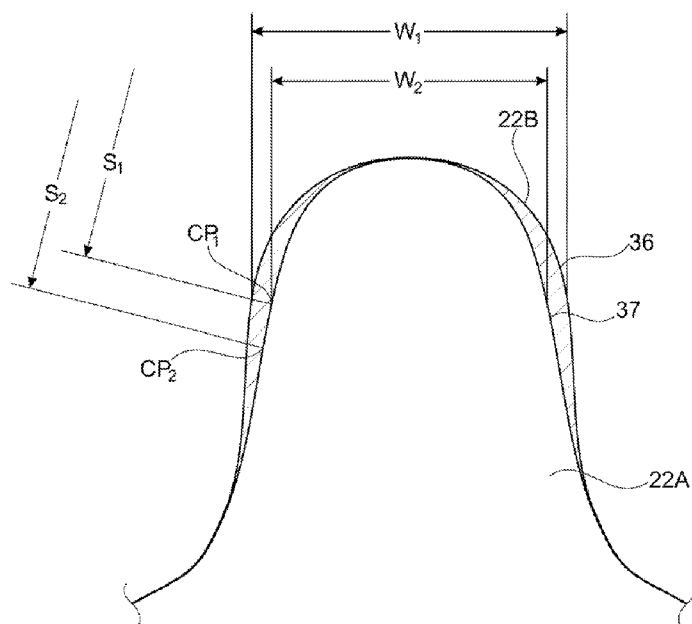


Fig. 6

(57) **Abstract:** A chain and sprocket drive system that includes an inverted tooth chain assembly configured to mesh with a laminated sprocket assembly is provided. The inverted tooth chain assembly includes a plurality of rows of links. The laminated sprocket assembly includes a plurality of plates, each of the plates including a plurality of teeth that are aligned with adjacent teeth. Each tooth has an engaging flank and a disengaging flank. The engaging flank of the teeth on one of the plurality of plates has an enlarged profile in a radially outwardly extending direction in comparison to corresponding ones of the teeth of an adjacent one of the plates, such that a first contact position of a link of the chain assembly carried thereon is located radially outward from a second contact position of the link with the corresponding teeth of the adjacent one of the plurality of plates.



DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, **Published:**

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).

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

SPROCKET ASSEMBLY INCLUDING TEETH HAVING AN ENLARGED PROFILE

[0001] INCORPORATION BY REFERENCE

[0002] The following documents are incorporated herein by reference as if fully set forth: U.S. Provisional Patent Application No. 61/904,863, filed November 15, 2013.

[0003] FIELD OF INVENTION

[0004] This application is generally related to a sprocket assembly and is more particularly related to an improved laminated sprocket assembly.

[0005] BACKGROUND

[0006] In the field of automotive engines, sprockets are used in connection with timing chains and timing drives, and for various other purposes. Teeth or other driving surfaces are formed around the periphery of the sprockets to carry a chain or drive assembly having pockets in which the teeth of the sprocket are engaged. During operation, the sprocket teeth mesh with chain, and the contact of the advancing teeth engaging the chain links creates noise. In known sprocket and chain drive systems, contact between the links and sprocket teeth occurs along a common contact line. It would be desirable to reduce the noise caused by meshing of the sprocket and chain assemblies while still providing the required load carrying capabilities.

[0007] SUMMARY

[0008] A chain and sprocket drive system that alters the contact positions between chain and sprocket assemblies is provided. The drive system includes an inverted tooth chain assembly configured to mesh with a sprocket assembly. The inverted tooth chain assembly includes a plurality of rows of links. The drive system also includes a laminated sprocket assembly including a plurality of plates, each of the plates including a plurality of teeth. The teeth of adjacent plates are aligned with one another. Each of the teeth

have an engaging flank, a disengaging flank, a tip interconnecting the engaging flank and the disengaging flank, and a root located between adjacent teeth of the plurality of teeth. The engaging flank of the teeth on one of the plurality of plates has an enlarged profile in a radially outwardly extending direction in comparison to corresponding ones of the teeth of an adjacent one of the plates, such that a first contact position with a link of the chain assembly carried thereon is located radially outward from a second contact position of the link with the corresponding teeth of the adjacent one of the plurality of plates. The enlarged profile of the teeth causes staggering among contact positions of the chain assembly as it meshes with the sprocket assembly.

[0009] A laminated sprocket assembly configured to mesh with an inverted tooth chain assembly including a plurality of links is also provided. The laminated sprocket assembly includes a plurality of plates, each of the plates including a plurality of teeth. The teeth of adjacent plates are aligned with one another. Each of the teeth have an engaging flank, a disengaging flank, a tip interconnecting the engaging flank and the disengaging flank, and a root located between adjacent teeth of the plurality of teeth. The engaging flank of the teeth on one of the plurality of plates has an enlarged profile in a radially outwardly extending direction in comparison to corresponding ones of the teeth of an adjacent one of the plates. The enlarged profile causes a first contact position with a link of a chain assembly carried thereon to be located radially outward from a second contact position of the link with the corresponding teeth of the adjacent one of the plurality of plates.

[0010] Preferred arrangements with one or more features of the invention are described below and in the claims.

[0011] BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The foregoing Summary as well as the following Detailed Description will be best understood when read in conjunction with the appended drawings. In the Drawings:

[0013] Figure 1 is a front plan view of an exemplary chain and sprocket

drive system.

[0014] Figure 2 is a perspective view of chain and sprocket drive system of Figure 1.

[0015] Figure 3 is a perspective view of a laminated sprocket assembly.

[0016] Figure 4 is a magnified view showing two contact positions of a chain assembly with a laminated sprocket assembly.

[0017] Figure 5A is a magnified view showing a link of the chain assembly contacting a plate with an enlarged tooth profile.

[0018] Figure 5B is a magnified view showing a link of the chain assembly contacting a plate with a conventional tooth profile.

[0019] Figure 6 shows a comparison of teeth with differing profiles according to one embodiment.

[0020] Figure 7 shows comparison of teeth with differing profiles according to another embodiment.

[0021] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Certain terminology is used in the following description for convenience only and is not limiting. The words “inner,” “outer,” “inwardly,” and “outwardly” refer to directions towards and away from the parts referenced in the drawings. A reference to a list of items that are cited as “at least one of a, b, or c” (where a, b, and c represent the items being listed) means any single one of the items a, b, or c, or combinations thereof. The terminology includes the words specifically noted above, derivatives thereof, and words of similar import.

[0023] FIGS. 1 and 2 show an embodiment of a chain and laminated sprocket drive system 1. The chain assembly 10 preferably is an inverted tooth chain with a plurality of rows of links 12. Guide plates 14 are provided on axial ends of the inverted tooth chain. The inverted tooth chain includes outer links 16 and inner links 18 between the guide plates 14. The inverted tooth chain includes chain pins 19, and the plurality of rows of links 12 articulate relative to adjacent rows of links about a respective chain pin. In

one embodiment, the outer links 16 and inner links 18 have a uniform profile.

[0024] As shown in FIG. 3, the sprocket assembly 20 is a laminated sprocket including a plurality of plates 22A-C. Each of the plates 22A-C includes a plurality of teeth 24, and the teeth of adjacent plates 22A-C are aligned with one another. Each tooth includes an engaging flank 26 and a disengaging flank 28. The flanks 26, 28 engage the links of the chain assembly 10 during meshing. Each tooth includes a tip 30 that interconnects the engaging flank 26 and the disengaging flank 28, and a root 32 located between adjacent teeth.

[0025] As shown in FIGS. 4, 5A, 5B and 6, the engaging flank 34 of the teeth on one of the plurality of plates 22B has an enlarged profile 36 in a radially outwardly extending direction in comparison to corresponding teeth of an adjacent one of the plates 22A, 22C. In a preferred embodiment, teeth on an inner plate 22B include the enlarged profile 36. One of ordinary skill in the art recognizes that teeth 24 on any one or multiple ones of the plurality of plates 22A-C can include the enlarged profile 36. As shown in FIG. 4, the teeth 24 with the enlarged profile 36 cause a first contact position CP_1 with a link of the chain assembly 10 carried thereon to be located radially outwardly from a second contact position CP_2 of the link with the corresponding teeth of the adjacent one of the plurality of plates 22A, 22C. The corresponding teeth 24 of the adjacent one of the plurality of plates 22A, 22C have a conventional tooth profile. As shown in FIGS. 5A and 5B, a distance S_1 between a center of a first chain pin 40 of the chain assembly 10 and the first contact position CP_1 is less than a distance S_2 between a center of a second chain pin 42 and the second contact position CP_2 . A chain pitch P is defined as the distance between centers of adjacent chain pins. In this embodiment, the chain pitch P is defined as the distance between a center of the first chain pin 40 and a center of the second chain pin 42. In a preferred embodiment, a distance between the first contact position CP_1 and the second contact position CP_2 is approximately 10% - 40% of the chain pitch P . Preferably, the difference in the distances S_1 and S_2 is approximately 10% - 40% of the chain pitch P .

[0026] As shown in FIG. 6, which is an exaggerated representation of the profiles of the teeth, the teeth having the enlarged profile 36 preferably have a width W_1 at the first contact position CP_1 that is approximately 0.01 mm to 0.1 mm wider than a width W_2 of the teeth of the adjacent one of the plurality of plates 22A, 22C at the first contact position CP_1 . The profiles of both the teeth having the enlarged profile 36 and the teeth having the conventional profile 37 converge at the respective roots 32.

[0027] FIG. 7 illustrates another embodiment of teeth of adjacent sprocket plates. The profiles shown in FIG. 7 are exaggerated to more clearly show the features of the profiles. In this embodiment, a tooth 50 on one of the plurality of plates 22B has an enlarged profile in a first region 60 of the engaging flank 26 located adjacent to the tooth tip 30, and a corresponding tooth 52 on an adjacent one of the plurality of plates 22A has a conventional profile in the first region 60. In a preferred embodiment, the tooth 50 on plate 22B has a width in the first region 60 that is approximately 0.01 mm to 0.1 mm wider than the tooth 52 on plate 22A in the first region 60. In a medial region 62 of the engaging flank 26, both teeth 50, 52 have the same profile, and the profiles of the teeth 50, 52 converge at the medial region 62. The tooth 52 on plate 22A has an enlarged profile in a second region 64 of the engaging flank 26 located adjacent to the root 32, and the tooth 50 on plate 22B has a smaller profile in the second region 64. The profiles of the teeth 50, 52 converge at the root 32. In a preferred embodiment, the tooth 50 on plate 22B has a width in the second region 62 that is approximately 0.01 mm to 0.1 mm wider than the tooth 52 on plate 22A in the second region 62. Because the enlarged profiles of the teeth 50, 52 are radially offset from each other, the links on the chain assembly mesh with the teeth 50, 52 at radially offset contact positions. A first contact position CP_1 of the tooth 50 on plate 22B is located radially outwardly from a second contact position CP_2 of the tooth 52 on plate 22A.

[0028] Having thus described various embodiments of the present chain and sprocket drive system in detail, it is to be appreciated and will be apparent to those skilled in the art that many physical changes, only a few of

which are exemplified in the detailed description above, could be made in the apparatus without altering the inventive concepts and principles embodied therein. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore to be embraced therein.

[0029]	Log to Reference Numbers
[0030]	1. Sprocket and Chain Drive System
[0031]	10. Chain Assembly
[0032]	12. Plurality of Rows of Links
[0033]	14. Guide Plates
[0034]	16. Outer Links
[0035]	18. Inner Links
[0036]	19. Chain Pins
[0037]	20. Sprocket Assembly
[0038]	22A-C. Sprocket Plates
[0039]	24. Sprocket Teeth
[0040]	26. Engaging Flank
[0041]	28. Disengaging Flank
[0042]	30. Tip
[0043]	32. Root
[0044]	34. Engaging Flank with Enlarged Profile
[0045]	36. Enlarged Profile
[0046]	37. Conventional Profile
[0047]	38. Link Engaged by Tooth with Enlarged Profile
[0048]	40. First Chain Pin
[0049]	42. Second Chain Pin
[0050]	50. Tooth on Plate 22B
[0051]	52. Tooth on Plate 22A
[0052]	60. First Region

- [0053] 62. Medial Region
- [0054] 64. Second Region
- [0055] CP_1 – First Contact Position
- [0056] CP_2 – Second Contact Position
- [0057] W_1 – Width of Tooth with Enlarged Profile at First Contact Position
- [0058] W_2 – Width of Tooth with Conventional Profile at First Contact Position
- [0059] S_1 – Distance between First Chain Pin Center and First Contact Position
- [0060] S_2 – Distance between Second Chain Pin Center and Second Contact Position

* * *

CLAIMS

What is claimed is:

1. A chain and sprocket drive system comprising:
 - an inverted tooth chain assembly configured to mesh with a sprocket assembly, the inverted tooth chain assembly including a plurality of rows of links,
 - a laminated sprocket assembly including a plurality of plates, each of the plates including a plurality of teeth, the teeth of adjacent plates being aligned with one another,
 - each of the teeth having an engaging flank, a disengaging flank, a tip interconnecting the engaging flank and the disengaging flank, and a root located between adjacent teeth of the plurality of teeth,
 - the engaging flank of the teeth on one of the plurality of plates has an enlarged profile in a radially outwardly extending direction in comparison to corresponding ones of the teeth of an adjacent one of the plates, such that a first contact position with a link of the chain assembly carried thereon is located radially outward from a second contact position of the link with the corresponding teeth of the adjacent one of the plurality of plates.
2. The chain and sprocket drive system of claim 1, wherein links of the plurality of rows of links have a uniform profile.
3. The chain and sprocket drive system of claim 1, wherein the laminated sprocket assembly includes an inner plate and two outer plates, and the inner plate includes the teeth having the enlarged profile.
4. The chain and sprocket drive system of claim 1, wherein the inverted tooth chain assembly includes chain pins, and the plurality of rows of links articulate relative to adjacent rows of links about the respective chain pin.

5. The chain and sprocket drive system of claim 4, wherein a distance between a center of a first chain pin and the first contact position is less than a distance between a center of a second chain pin and the second contact position.

6. The chain and sprocket drive system of claim 5, wherein a distance between the first contact position and the second contact position is approximately 10% - 40% of a chain pitch.

7. A laminated sprocket assembly configured to mesh with an inverted tooth chain assembly including a plurality of links, the laminated sprocket assembly comprising:

a plurality of plates, each of the plates including a plurality of teeth, the teeth of adjacent plates being aligned with one another,

each of the teeth having an engaging flank, a disengaging flank, a tip interconnecting the engaging flank and the disengaging flank, and a root located between adjacent teeth of the plurality of teeth,

the engaging flank of the teeth on one of the plurality of plates has an enlarged profile in a radially outwardly extending direction in comparison to corresponding teeth of an adjacent one of the plates, such that a first contact position with a link of a chain assembly carried thereon is located radially outward from a second contact position of the link with the corresponding teeth of the adjacent one of the plurality of plates.

8. The laminated sprocket assembly of claim 7, wherein the plurality of plates is comprised of an inner plate and two outer plates, and the inner plate includes the teeth having the enlarged profile.

9. The laminated sprocket assembly of claim 7, wherein a distance between the first contact position of the link and the second contact position of the link is approximately 10% - 40% of a chain pitch.

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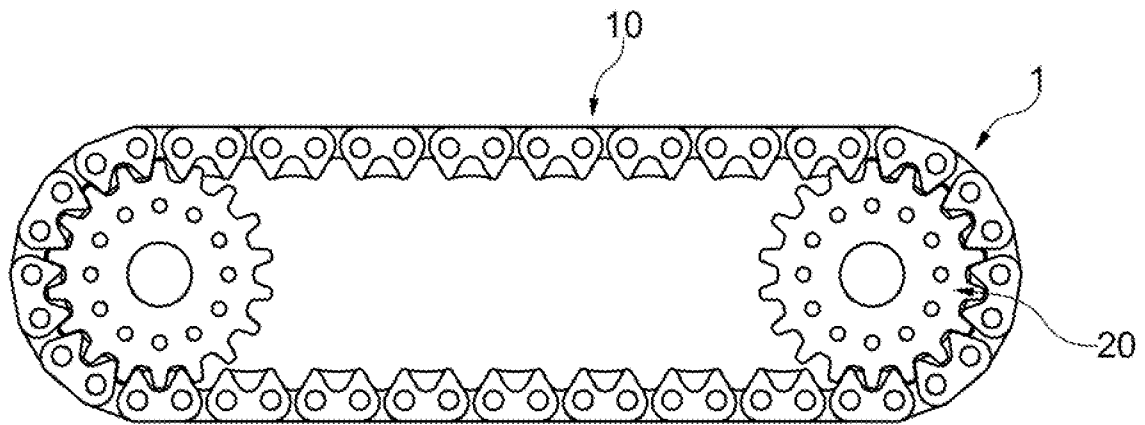


Fig. 1

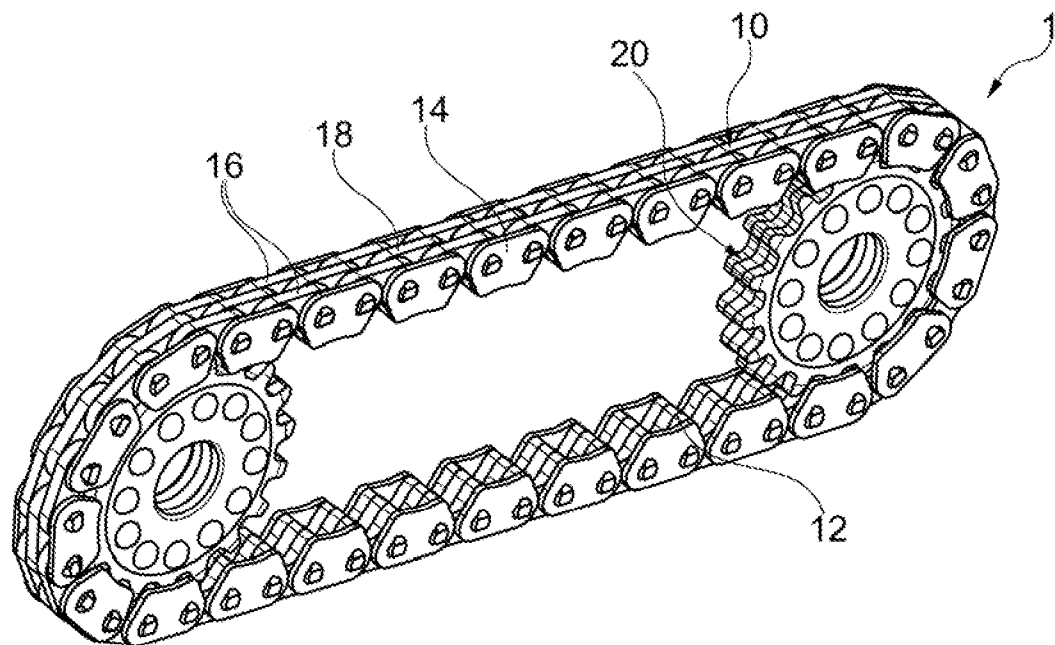


Fig. 2

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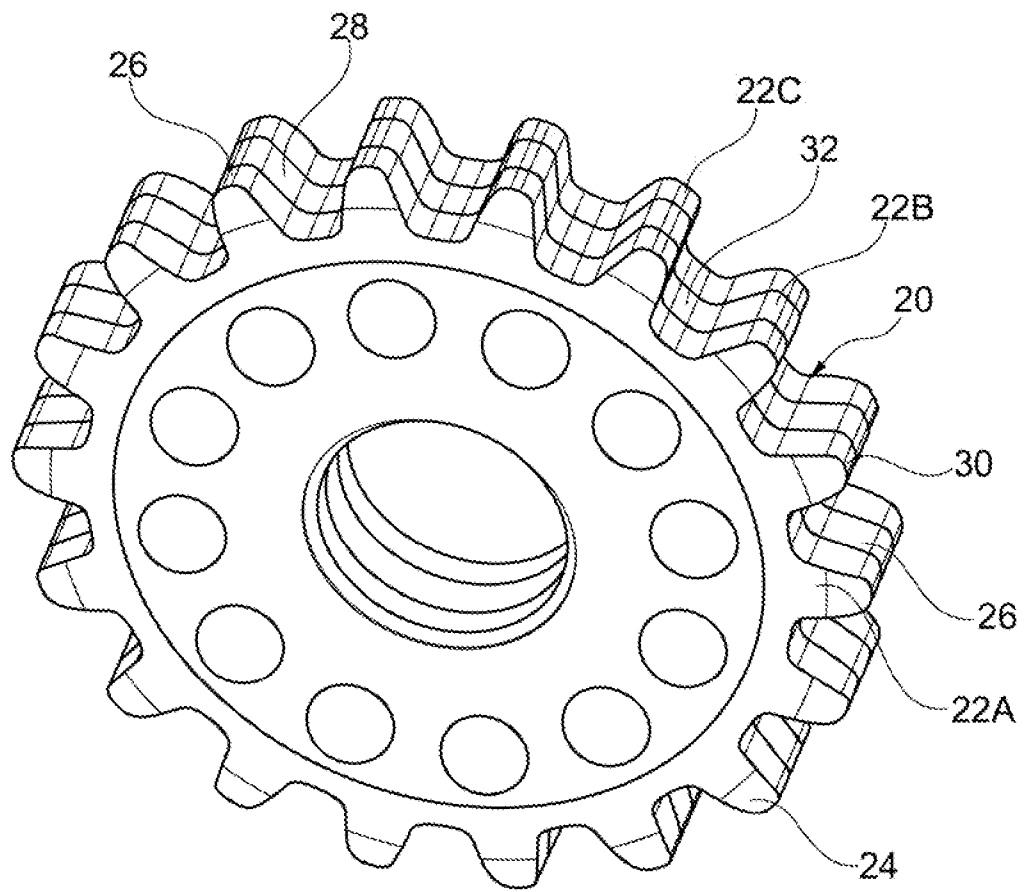


Fig. 3

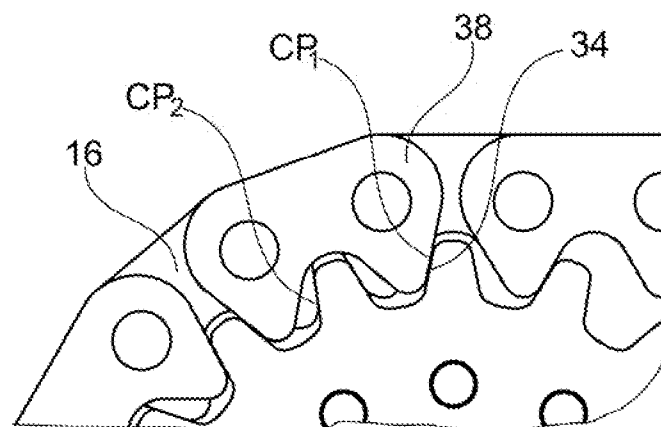


Fig. 4

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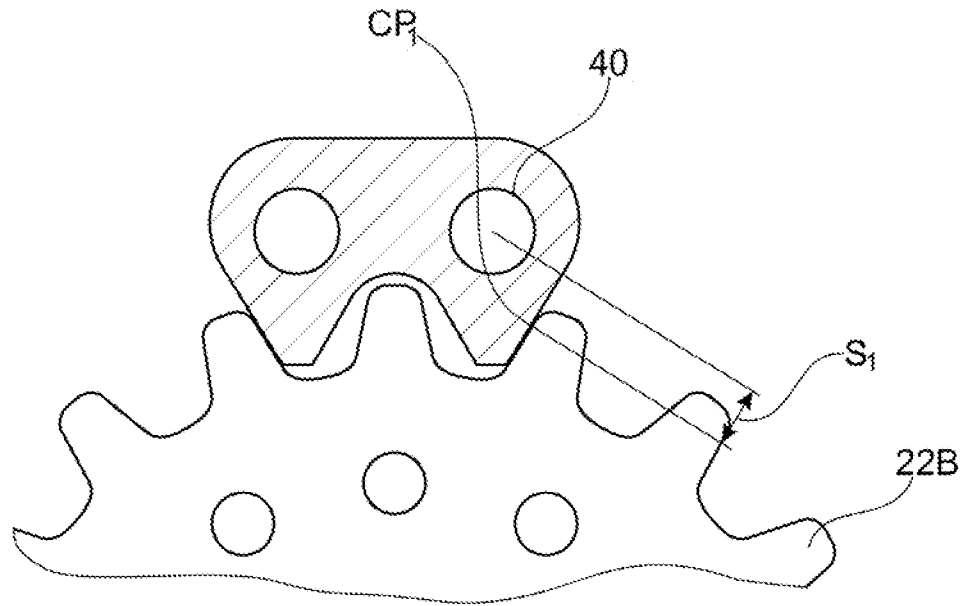


Fig. 5A

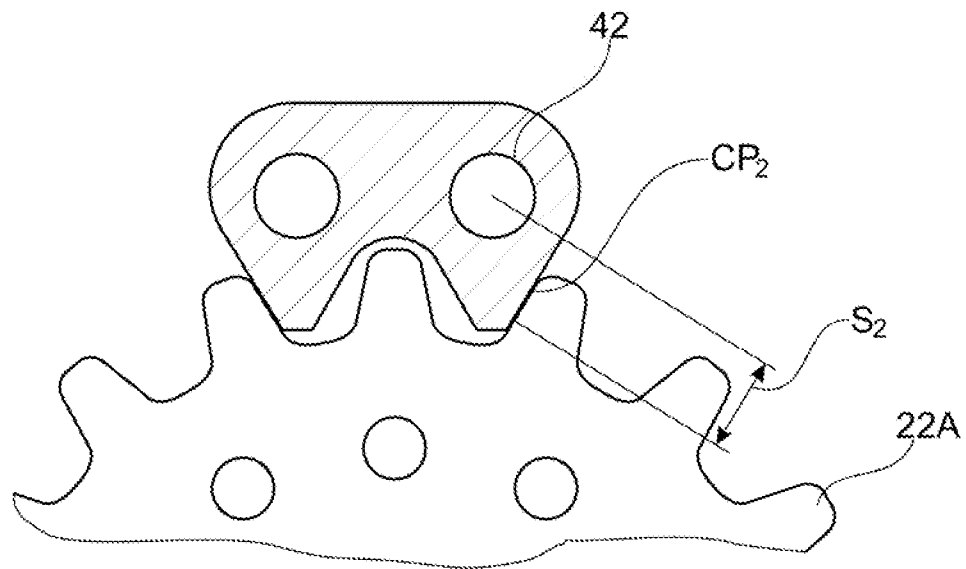


Fig. 5B

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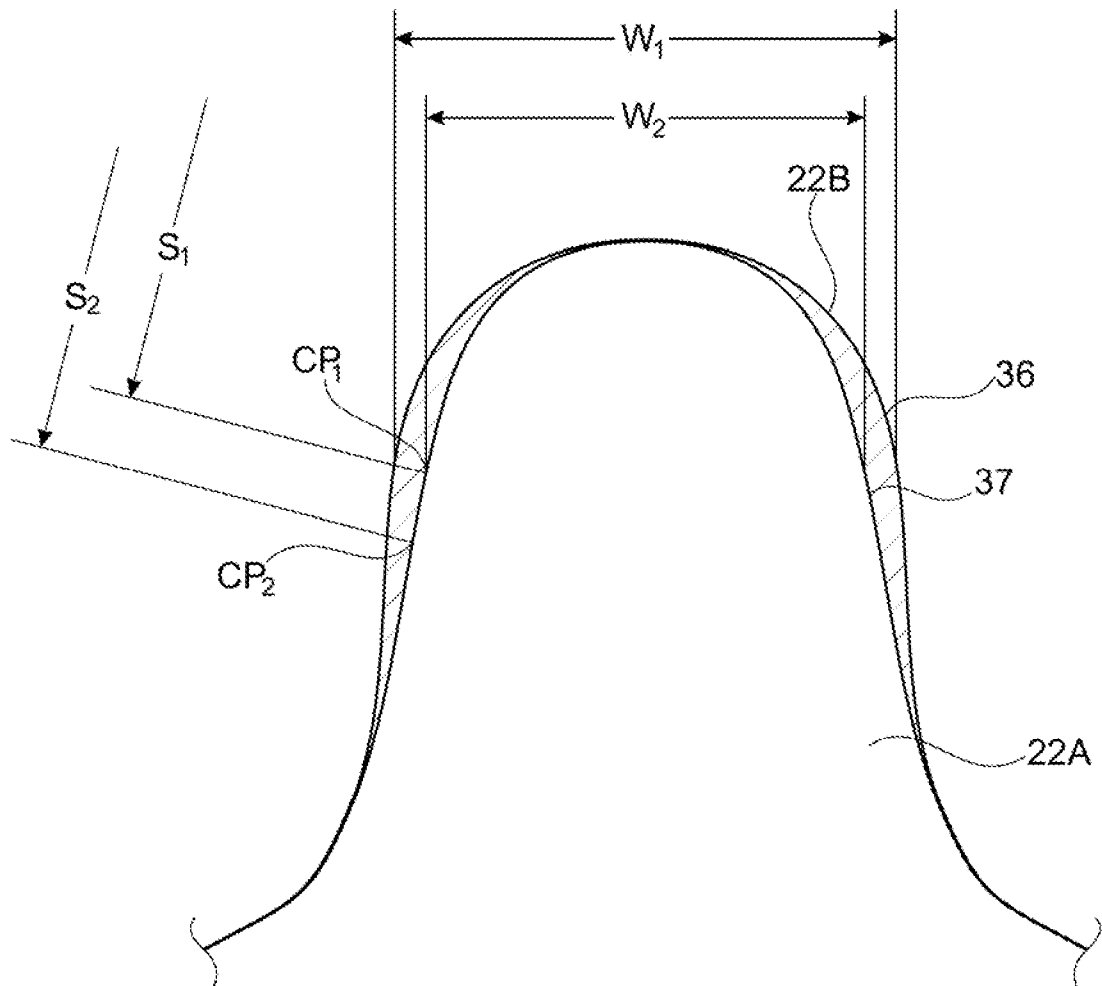


Fig. 6

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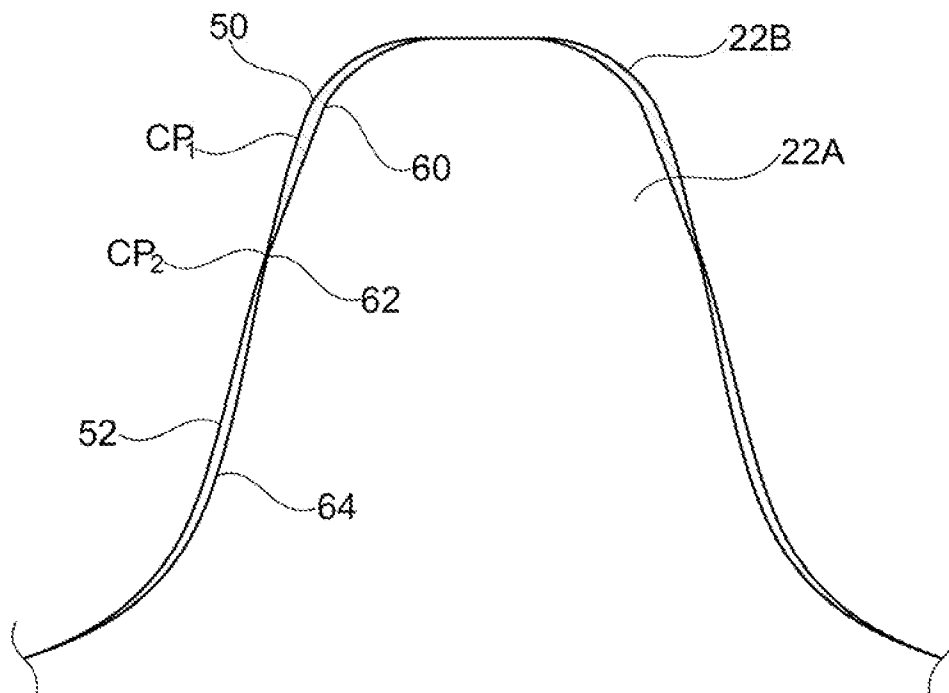


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/064947**A. CLASSIFICATION OF SUBJECT MATTER****F16G 13/04(2006.01)i, F16H 55/30(2006.01)i, F16H 7/06(2006.01)i**

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)

F16G 13/04; F16G 13/02; F16G 1/28; F16H 55/30; F16H 7/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: sprocket, teeth, enlarge, profile, chain, plate, flank and link

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006-0068959 A1 (YOUNG et al.) 30 March 2006 See abstract, paragraphs [0021]-[0029], claim 1 and figures 1-6.	1-9
A	US 2008-0070732 A1 (LEDVINA, TIMOTHY J.) 20 March 2008 See abstract, paragraphs [0006], [0047]-[0050], claim 1 and figures 1-9.	1-9
A	US 2003-0027675 A1 (SUZUKI et al.) 06 February 2003 See abstract, paragraphs [0048]-[0060] and figures 1-9.	1-9
A	US 6416436 B1 (KANEHIRA et al.) 09 July 2002 See abstract, column 3, line 48 - column 5, line 67, claim 1 and figures 1-4.	1-9
A	US 2007-0155564 A1 (LEDVINA et al.) 05 July 2007 See abstract, paragraphs [0044]-[0076] and figures 3-9.	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

17 February 2015 (17.02.2015)

Date of mailing of the international search report

23 February 2015 (23.02.2015)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/064947

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006-0068959 A1	30/03/2006	AU 2005-289916 A1 AU 2005-289916 B2 EP 1802893 A1 JP 05000520 B2 JP 2008-514877 A US 7789783 B2 WO 2006-036603 A1	06/04/2006 30/06/2011 04/07/2007 15/08/2012 08/05/2008 07/09/2010 06/04/2006
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