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(71) Applicant *(for all designated States except US):* **TUBE INVESTMENTS OF INDIA LIMITED** [IN/IN]; Dare House, 2, (Old. No. 234), N.S.C. Bose Road, Chennai 600 001 (IN).

(72) Inventors; and

(75) Inventors/Applicants *(for US only):* **SRINIVAS, Krishna** [IN/IN]; 102 Karpagam Avenue, R.A. Puram, Chennai 600 028 (IN). **DASARI, N** [IN/IN]; H.no: D 305, AKS Serenity, Aishwarya Nagar, Ayanambakkam, Chennai 600 095 (IN). **NARAYANAN, K Sathia** [IN/IN]; Flat 4A, Amruthanjali, 14,P T Rajan Road, K K Nagar, Chennai 600 078 (IN). **GOVINDARAGHAVAN, Ramesh** [IN/IN]; 2b, 16th cross street, Lenin Nagar, Ambattur, Chennai 600 053 (IN).

(74) Agents: **BARNABAS, Anand** et al; De Penning & De Penning, 120, Velachery Main Road, Guindy, Chennai 600 032 (IN).

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[Continued on nextpage]

(54) Title: SPROCKET

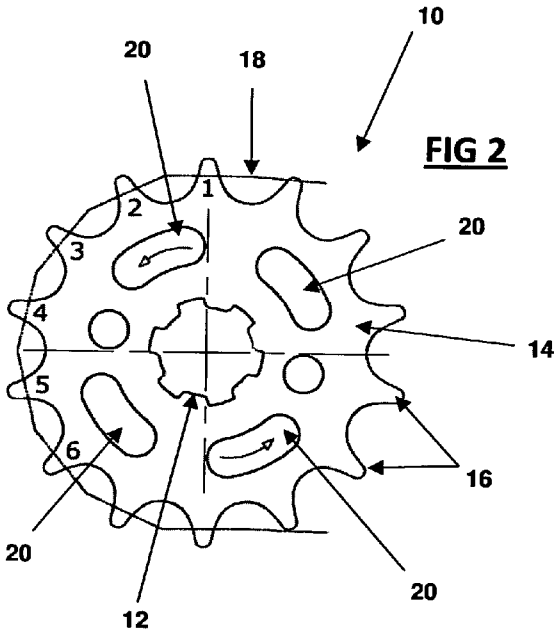

FIG 2

(57) Abstract: The invention relates to a sprocket (10) comprising a hub portion (12) and an annular ring portion (14) having tooth portions (16) on its outer peripheral side. The invention in particular provides material relieved portions (20) between the ring and the hub portions in such a way that the area between the relief provided is configured to be loaded in bending at all times when the sprocket is in power transmission mode. This produces optimal torsional elastic stiffness in the section between the annular ring portion and the hub portion. This stiffness is lesser than the bending stiffness of the individual teeth and a clearly distinguishable back-and- forth rotational cushioning movement of the hub portion with respect to the annular ring portion is produced. This reduces the peak impulse load intensity on the sprocket tooth thereby resulting in reducing the wear and damage on the tooth, which in turn increases sprocket life.

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SPROCKET

Field of Invention

The invention relates to a mechanical power transmission device, in particular to a sprocket used in transmitting power to drive a chain driven system using a chain-sprocket mechanism.

Background of the Invention

In bicycles and motorcycles, a mechanism having a pair of sprockets and a chain laid between are generally used as a drive force transmission system. A sprocket is a profiled wheel with teeth that meshes with the chain track. The life of a sprocket is partially determined by the damaging effect of the high impact force of the sprocket tooth surface in contact with the mating surface of the chain during power transmission in a chain-sprocket mechanism. In particular, this effect is more pronounced on smaller sprockets with lower number of teeth since the number of high impulses is more per given time on the smaller sprocket and the force is higher on the sprocket with smaller radius. This leads to higher damage effect rate at the smaller sprocket tooth, which determines the life of the sprocket as well as the life of the chain-sprocket system.

In a chain-sprocket system, usually the smaller of the sprockets wears out at a faster rate than the larger sprocket and the chain since the smaller sprocket, has lower number of teeth and experiences higher impulses per given time. When the small sprocket gets worn out and is due to be replaced the entire chain-sprocket assembly is required to be replaced since an old chain cannot be accurately fitted onto a new sprocket. This results in expensive maintenance for the user

who is also forced to forego the optimum use of the larger sprocket and the chain. In order to avoid this problem it is required that the life of the smaller sprocket be more or less equal to the life of the larger sprocket and the chain so that the above-mentioned problem can be avoided.

U.S. Patent No. 5,980,407 discloses a rotary member in the form of a sprocket or a brake disc for transmitting a drive force or brake force. The rotary member has weight reduction openings disposed between an inner ring portion and an outer ring portion. Arms are formed between the weight reduction openings and are offset circumferentially to prevent warpage. The arms allow an elastic deformation of the outer ring portion relative to the inner ring portion when the chain/brake shoe engages the rotary member, but do not provide tooth elasticity.

U.S. publication No. 2008/0132367 discloses a sprocket with each teeth having elasticity by providing a plurality of openings proximate the sprocket teeth, thereby permitting redistribution of peak loads from a primary load-bearing tooth to adjoining tooth. One of the plurality of openings is arranged relative to one of the plurality of teeth in a one-to-one correspondence such that the opening is asymmetrically divided by a radial centreline of the tooth. A load strip is formed between the opening and the load-bearing flank and a second load strip is formed between the opening and the non-load-bearing flank.

Object of the Invention

The object of the invention is to reduce the sprocket tooth wear and damage by reducing the peak contact loads between the sprocket tooth and the chain

A further object of the invention is to provide an improved chain-sprocket system by reducing the impulse load on the sprocket tooth thereby improving the life of the sprocket.

Summary of the Invention

The invention provides a sprocket comprising a hub portion having an engagement hole through which the transmission shaft is capable of passing centrally, and an annular ring portion on its outer peripheral side. Tooth portions are formed in the outer circumferential portion of the annular ring portion. The invention in particular provides optimal torsional elastic stiffness in the section between the annular ring portion and the hub portion, which is lesser than the bending stiffness of the individual teeth. This is achieved by selectively relieving material between the ring and the hub portions in such a way that the area between the relief provided is configured to be loaded in bending at all times when the sprocket is in power transmission mode. The above construction produces a clearly distinguishable elastic back-and-forth rotational cushioning movement during power transmission of the hub portion with respect to the annular ring portion.

The embodiment described above generates an increased rotational elastic tangential displacement/deflection or *'give'* in the direction of the sprocket twist, which is opposite or in the direction of rotation of the sprocket. The term *'give'* as applied in this application refers to the reversible elastic movement of a tooth caused by energy absorbed by the respective tooth by moving in the direction of the force. This reduces the peak impulse load intensity on the sprocket tooth thereby resulting in reducing the wear and damage on the tooth owing to the greater time of engagement of teeth with the mating chain surfaces obtained through increased tooth displacement during engagement with successive links of the chain. According to this embodiment the individual tooth deflection remains unchanged, and is complemented by the rotational *give* of the sprocket. Also, the optimum torsional stiffness of the sprocket reduces the impulse load on the chain component surface, which is mating with the sprocket tooth. The weight of the sprocket is relatively low according to this embodiment.

In an optional embodiment, the sprocket wall thickness between the hub and the teeth is less, such that, the *'give'* in the direction of twist is comparatively under load. This design further reduces the peak impulse load intensity on the sprocket tooth thereby resulting in reducing the wear and damage on the tooth.

In a further optional embodiment, the sprocket produced with a plurality of pieces results in the *'give'* in the direction of twist being more than that in a single piece construction. In this embodiment, the sprocket hub portion and teeth are produced separately and are connected to each other by spokes or ribs. The ribs are joined at both ends by some fastening method.

In a preferred embodiment, the tooth can be individually and separately fitted onto the annular ring portion.

In a further embodiment, the material near and/or below the teeth on the annular ring portion is relieved such that the *'give'* in the direction of twist further reduces the peak impulse load intensity on the sprocket tooth and increases the strength and durability of the teeth. The sprocket according to this embodiment can be used in applications that require a uni-directional rotation of the sprocket.

In a further embodiment, the sprocket is provided with separate elastic elements such as helical springs that are inserted beneath the tooth profile such that the *'give'* in the direction of the twist can be increased. The elastic elements store energy, which they return, for the most part, to the mechanical system in the form of kinetic energy when the action of the load has stopped.

Statement of Invention

A sprocket comprising a hub portion; an annular ring portion; a plurality of tooth portions on the outer circumferential portion of the annular ring portion capable of

engaging with a chain; wherein material relieved portions are selectively provided between the annular ring portion and the hub portion so as to produce a relative elastic angular movement of the hub portion with respect to the annular ring portion in the period between two successive engagements of the tooth portions with the chain.

Brief Description of the Drawings

Referring now to the drawings wherein the showings are for the purpose of illustrating a possible embodiment of the invention only, and not for the purpose of limiting the same,

Figure 1 shows the conventional design of a sprocket and chain assembly,

Figure 2 shows the sprocket according to a first design of this invention,

Figure 3 shows the sprocket according to a second design of this invention,

Figure 4 shows the sprocket according to a third design of this invention,

Figure 5a shows the tooth load distribution plot in a sprocket,

Figure 5b shows the tooth deformation plot of a sprocket in the direction of sprocket twist,

Figure 6 shows the sprocket cross section according to a preferred embodiment,

Figure 7 shows the multi piece construction of a sprocket according to another embodiment of the invention, and

Figure 8 shows the sprocket according to a further embodiment of the invention.

Detailed Description of the Invention

A typical chain-sprocket design is illustrated in figure 1. The sprocket (10) comprises a hub portion (12) having an engagement hole (H) through which a transmission shaft *(not shown)* is capable of passing centrally. The sprocket also has an annular ring portion (14) on its outer peripheral side. Tooth portions (16) are formed in the outer circumferential portion of the annular ring portion (14). A roller chain (18) having links *(not shown)* meshable with the teeth (16) of the sprocket (10) is capable of sequentially engaging the teeth (16) on the sprocket (10) to transfer torque to a drive element *(not shown).* The arrow marked in figure 1 shows the direction of rotation of the sprocket. The tooth numbered 1 experiences the maximum load and the teeth numbered 2 to 6 experiences a lesser load compared to the load experienced by teeth number 1.

The preferred embodiment of the invention is illustrated in figure 2. According to this design, material relieved portions (20) are provided between the annular ring portion (14) and the hub portion (12) in such a way that the area between the material relieved portions (20) is configured to be loaded in bending continually when the sprocket (10) is in power transmission mode. This construction produces a clearly distinguishable back-and-forth rotational cushioning movement of the hub portion (12) with respect to the annular ring portion (14) in between the time when two successive teeth engage with the incoming chain links during power transmission. More specifically, the material relieved portions (20) are provided such that it increases the tooth *'give'* in the direction of sprocket twist, which is opposite to the direction of rotation of the sprocket (10), thereby reducing the peak impulse load intensity on the sprocket tooth (16) and the chain (18).

According to this invention, the portions (20) where material is removed should be preferably regular, but not interfering with the tooth rigidity. The load on the

arms in the relief must be relatively high, post relief so as to allow *'give'* in the sprocket, yet being within safe stress levels

The construction as described results in the torsional elastic stiffness of the section between the annular outer ring (14) and the hub portion (12) being lower than the bending stiffness of the individual teeth. This reduces the wear and/or damage on teeth since the duration of engagement of teeth with the mating chain surface is longer owing to the increased tooth displacement during engagement with successive links of the chain. It is to be noted that the individual tooth displacement remains unchanged.

Figures 3 and 4 are variants of the embodiment described with reference to figure 2. The design of figure 3 is different from the design of figure 2 in that the dimension of the material relieved portion (20) is greater and more optimized. And the design of figure 4 is different from the design of figure 2 and 3 in that the dimension of the material relieved portion (20) is greater and better optimized. The mechanics behind the fact that design of figure 4 shows more tooth *'give'* than the design of figure 2 and 3 is because the relief has been optimized for load deflection criteria, where the allowable load is still within safe limits, but produces a relatively small tangential displacement of the tooth (16) on chain entry, which improves meshing of the chain with sprocket, thereby reducing impact.

Figure 5a shows a typical sprocket tooth tangential load distribution plot for, typically, a sprocket with 14 teeth and a pitch circle diameter of 55mm. The table I below gives the numerical explanation of figure 5a. It is to be noted that 'design 1' refers to the embodiment described with reference to figure 2 and design 2 and design 3 refers to the embodiments described with reference to figures 3 and 4 respectively.

TABLE I

Sprocket tooth tangential load (kgf) data

Tooth no.	Conventional design *(kgf)*	Design 1 (fig 2) *(kgf)*	Design 2 (fig 3) *(kgf)*	Design 3 (fig 4) *(kgf)*
1	222	221.97	222.74	221.1
2	22.43	18.8	16.95	15.06
3	2.74	2.38	1.48	2.22
4	0.69	5.38	10.04	14.57
5	0.46	3.53	7.26	12.4
6	0.22	1.7	3.03	3.22

Figure 5a and the above table I shows that the maximum tooth load occurs in the top tooth adjacent to the chain tensile load. Also, the tooth load is mainly shared by the first 5 teeth of the sprocket. The load in teeth 2 to 6 is below 10% of the load in tooth 1. The variation of tooth loads between the conventional design and the designs 1 to 3 with material relieved portions according to the present invention is not very appreciable.

Figure 5b shows the sprocket tooth tangential deformation plot for, typically, a sprocket with 14 teeth and a pitch circle diameter of 55mm. The table II below gives the numerical explanation of figure 5b. As mentioned before, it is to be noted that 'design 1' refers to the embodiment described with reference to figure 2 and design 2 and design 3 refers to the embodiments described with reference to figures 3 and 4 respectively.

TABLE II

Sprocket tooth tangential elastic displacement (mm) data

Tooth no.	Conventional design *(mm)*	Design 1 (fig 2) *(mm)*	Design 2 (fig 3) *(mm)*	Design 3 (fig 4) *(mm)*
1	0.0270	0.0340	0.0580	0.0930
2	0.0130	0.0250	0.0420	0.0750
3	0.0130	0.0220	0.0360	0.0600
4	0.0086	0.0190	0.0290	0.0550
5	0.0073	0.0150	0.0280	0.0510
6	0.0063	0.0110	0.0230	0.0400

Figure 5b and the above table II shows that the maximum tooth deflection occurs in the top tooth in all the designs. However, the *'give'* in the direction of the twist or the tooth deformation in the direction of rotation of the sprocket is considerably higher in designs 1, 2 and 3 as compared with the conventional design. More specifically the *'give'* in the direction of the twist is appreciably higher in design 3 compared with designs 1 and 2. The reason for this is because the relief in design 3 has been optimized for load deflection criteria, where the allowable load is still within safe limits, but produces a relatively small tangential displacement of the tooth upon chain entry, which improves meshing of the chain with sprocket, thereby greatly reducing impact.

Figure 6 shows the cross sectional view of a sprocket according to a preferred embodiment of the invention. In this construction, the thin sprocket wall (22) between the hub portion (12) and the teeth (16) enables the *'give'* in the direction of the twist of the sprocket (10) under load to be more compared to the conventional sprocket.

In a further preferred construction as illustrated in figure 7 the sprocket (10) is constructed in a multi-piece manner. This construction enables the *'give'* in the direction of the twist of the sprocket (10) under load to be more compared with the single-piece construction of the sprocket. In this embodiment, the hub portion (12) and the teeth (16) are made separately and connected to each other by means of ribs (24). The ribs (24) are joined at both ends by a known process such as riveting, bolting, welding etc. Alternately, each tooth (16) may be fitted individually onto the corresponding openings on the annular ring portion (14).

In a further embodiment illustrated in figure 8, the material near the teeth (16) is relieved such that the *'give'* in the direction of twist is more. However, the sprocket according to this embodiment can be used in one direction of rotation only.

Providing the material relieved portions in the sprockets according to the above embodiments results in substantial improvement in tooth wear life. The improved sprocket configuration permits the roller chain to pass freely like in the normal operation of the chain drive. The wear of the roller in the chain is also minimized as a result of this construction of the sprocket, thus providing a long, trouble-free chain drive system while yet being simple and economical in construction.

Many modifications and other embodiments of the invention may come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims.

WE CLAIM

1. A sprocket comprising:

a hub portion;

an annular ring portion;

a plurality of tooth portions on the outer circumferential portion of the annular ring portion capable of engaging with a roller chain;

wherein material relieved portions are selectively provided between the annular ring portion and the hub portion so as to produce a relative elastic angular movement of the hub portion with respect to the annular ring portion in the period between two successive engagement of the tooth portions with the chain.

2. The sprocket as claimed in claim 1, wherein the relative rotational movement is a back-and-forth rotational cushioning movement.

3. The sprocket as claimed in claim 1, wherein an area between the material relieved portions is configured to be continually loaded in bending when the sprocket is transmitting power.

4. The sprocket as claimed in claim 1, wherein the material relieved portions are provided such that tooth 'g/Ve' increases in the direction of twist of sprocket during the two successive engagement of the tooth portions with the chain.

5. The sprocket as claimed in claim 1, comprising a thin wall portion between the hub portion and the tooth portion.

6. The sprocket as claimed in claim 1, wherein the hub portion and the annular ring portion are produced separately and connected to each other by ribs.

7. A chain-sprocket assembly for a motorcycle comprising a sprocket as claimed in any one of the preceding claims.

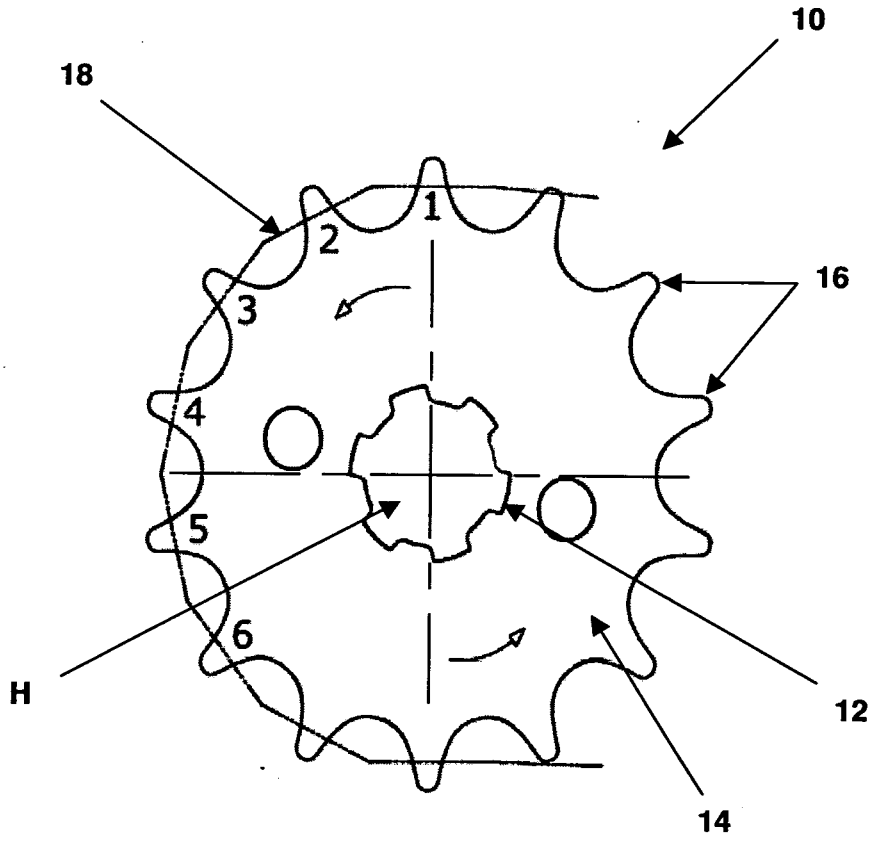

Fig 1

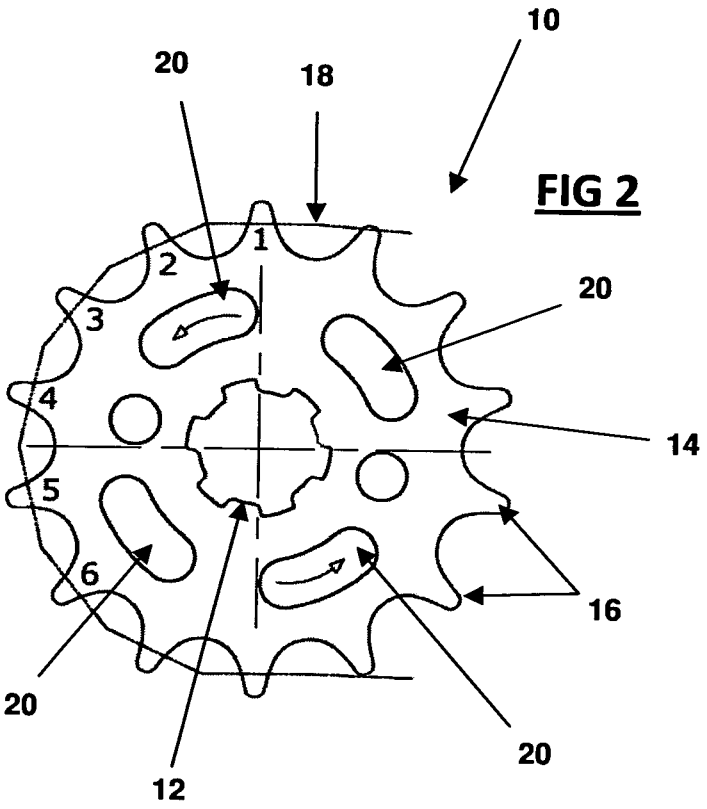

FIG 2

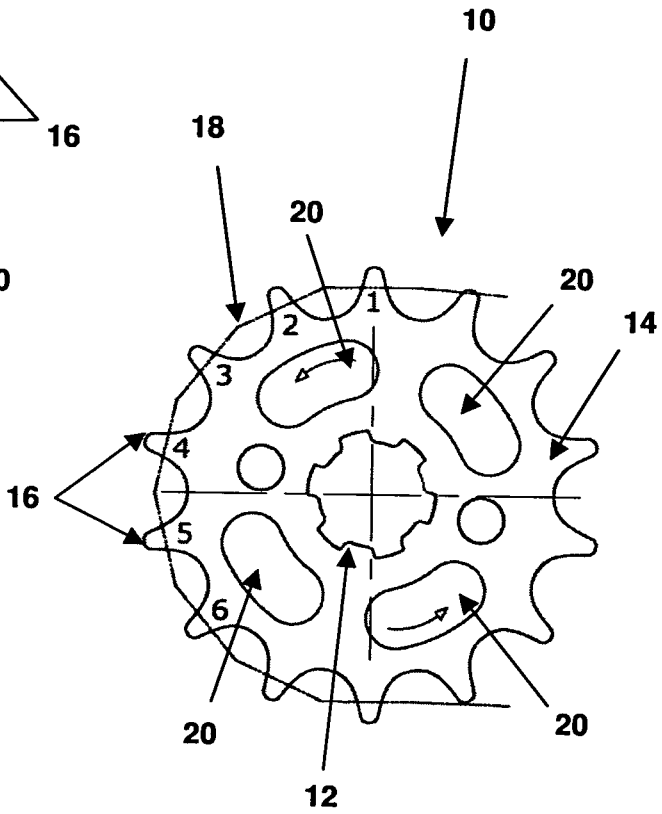

FIG 3

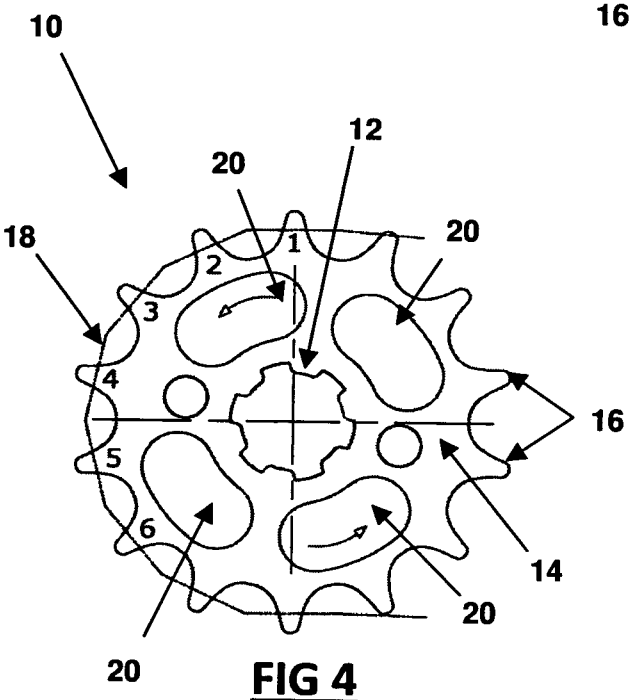

FIG 4

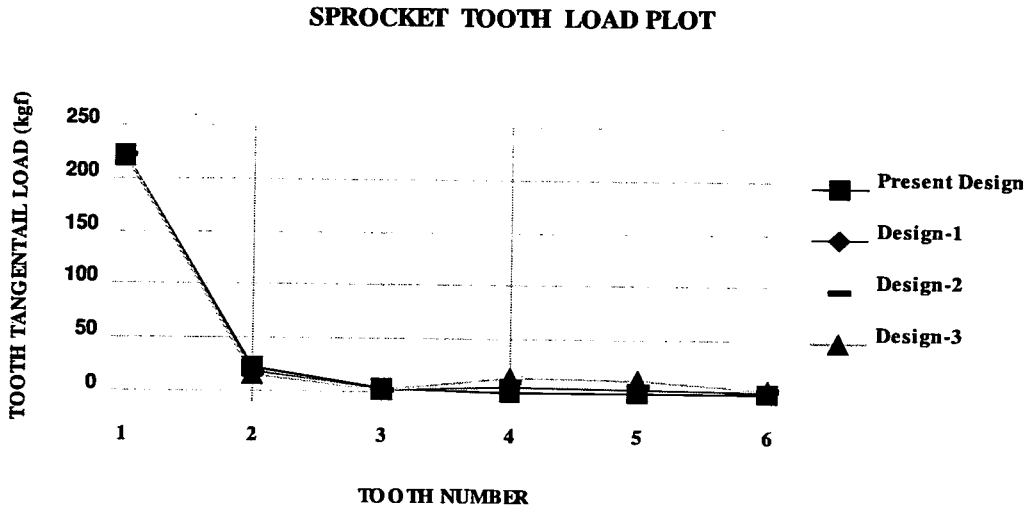
SPROCKET TOOTH LOAD PLOT
TOOTH TANGENTAIL LOAD (kgf)
250
200
150
100
50
0
1
2
3
4
5
6
TOOTH NUMBER
Present Design
Design-1
Design-2
Design-3

FIG 5a

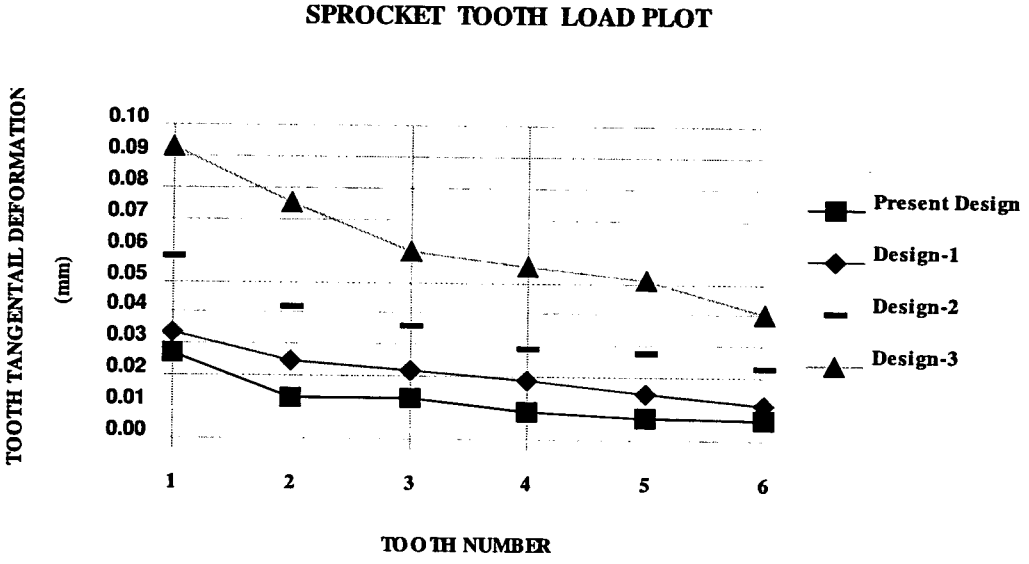
SPROCKET TOOTH LOAD PLOT
TOOTH TANGENTAIL DEFORMATION (mm)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1
2
3
4
5
6
TOOTH NUMBER
Present Design
Design-1
Design-2
Design-3

FIG 5b

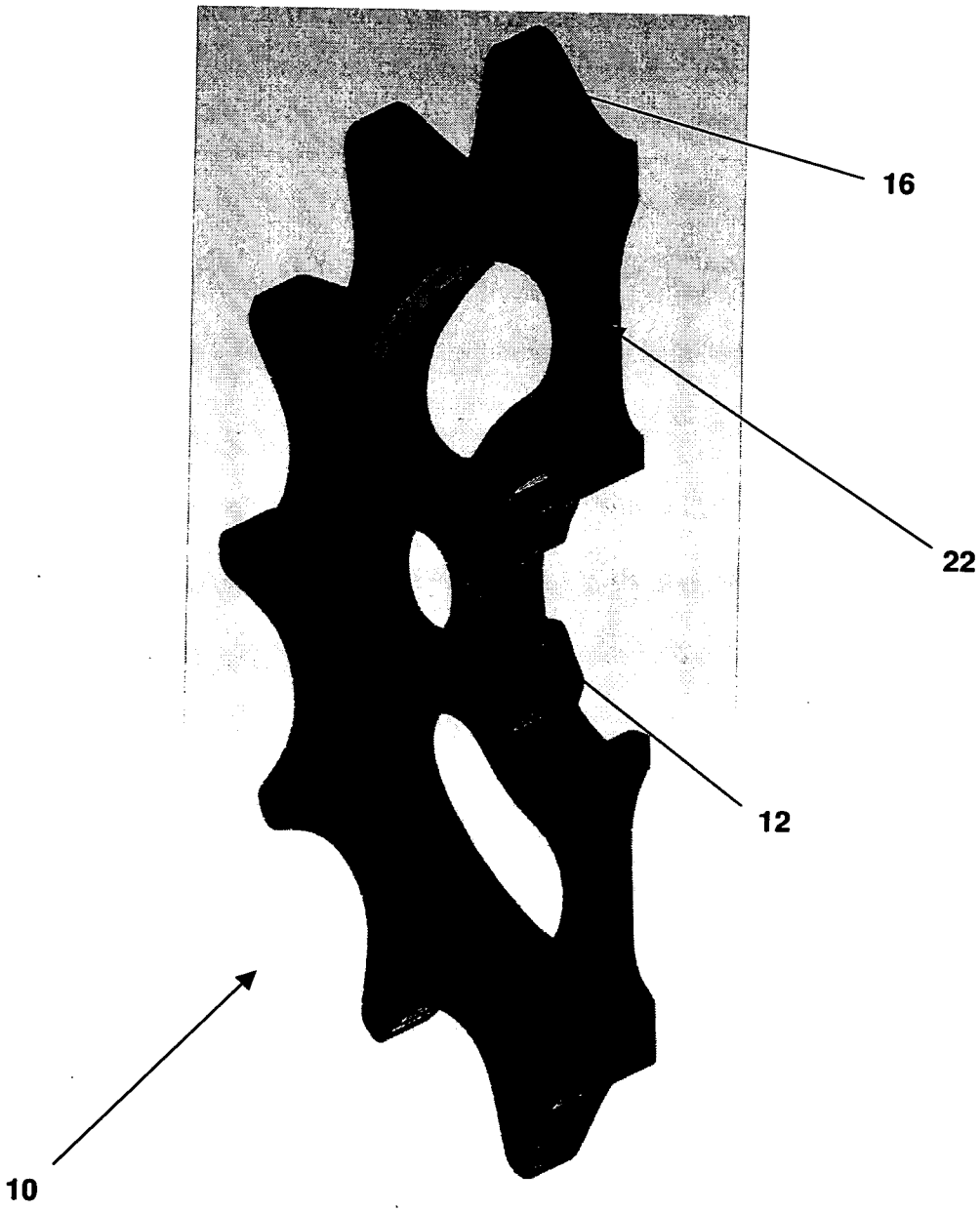

FIG 6

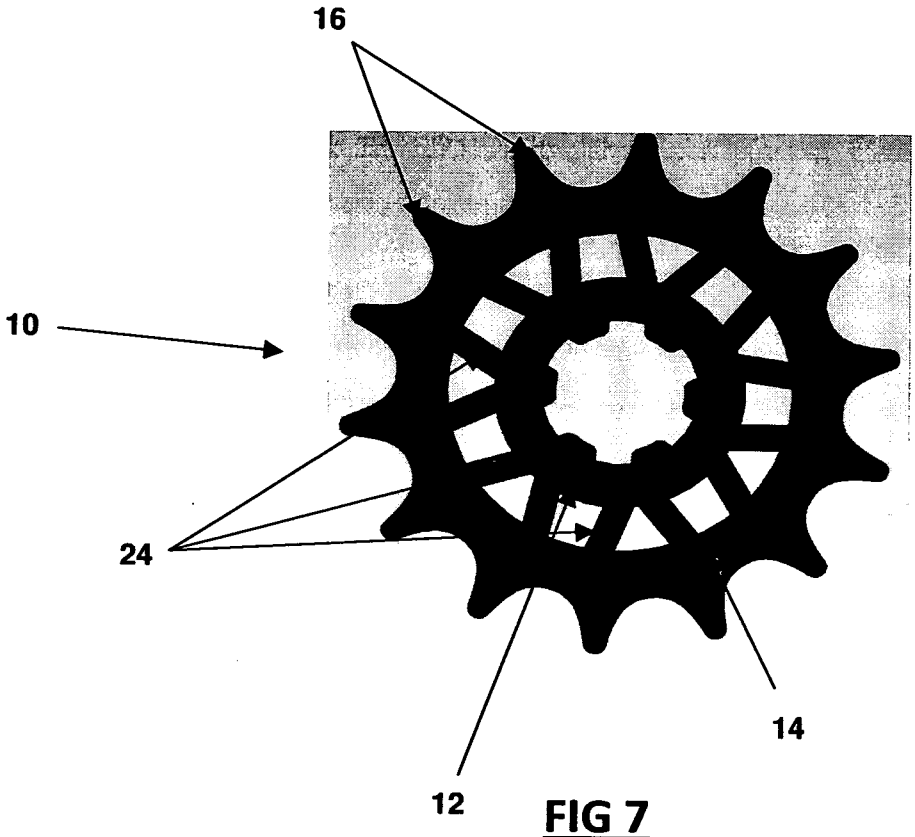

FIG 7

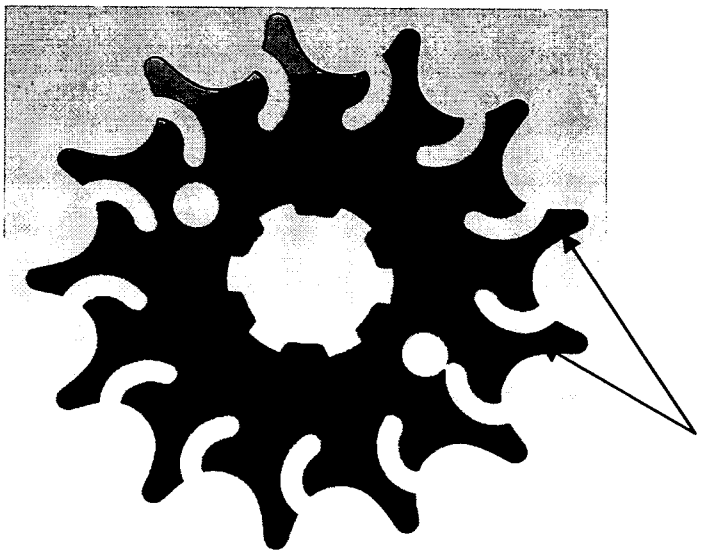

FIG 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2011/000291

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H55/14 F16H55/30
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 B62M

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 practical, 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	DE 10 2007 049880 Al (SCHAEFFLER KG [DE]) 23 April 2009 (2009-04-23) paragraphs [0022] - [0027] ; figures 1,2	1-4,7
X	DE 10 2004 015954 Al (INA SCHAEFFLER KG [DE]) 10 November 2005 (2005-11-10) paragraphs [0017] , [0018] ; figures 1-6	1-5 ,7
X	US 5 324 238 A (KARP STEFAN [GB]) 28 June 1994 (1994-06-28) the whole document	1-4,6
X	US 5 980 407 A (TAKAM0RI N0RIHIK0 [JP] ET AL) 9 November 1999 (1999-11-09) cited in the application column 4, line 37 - column 5, line 22 pages 1-3	1-4,7

-/- .

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2011	27/10/2011

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2011/000291

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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