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(54) **Title**: SYNCHRONOUS BELT SPROCKET AND SYSTEM

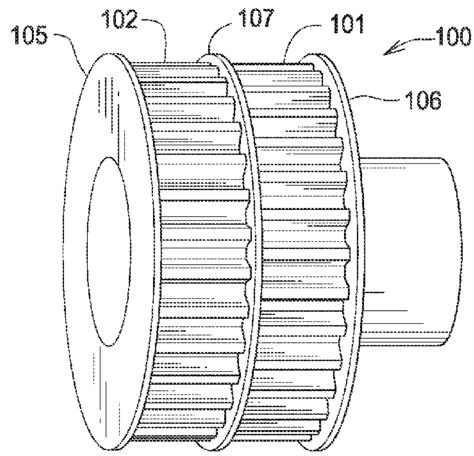

FIG.8

(57) Abstract: A sprocket system comprising a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1), the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth, a tooth of said first teeth aligned with a radius (A) of said first sprocket, a tooth of said second teeth offset a distance (x) from said radius (A), wherein (x) is greater than zero, a second sprocket (200), and a toothed belt (300) entrained between the first sprocket and the second sprocket.

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TITLE

Synchronous Belt Sprocket and System

TECHNICAL FIELD

[0001] The invention relates to a synchronous belt sprocket and system and more particularly to a synchronous belt sprocket system having a sprocket comprising a plurality of first transverse teeth and adjacent second transverse teeth.

BACKGROUND

[0002] Sprocket and belt combinations are well known and there are many different types of belts and many different combinations of belts and sprockets. The belt application typically determines the belt construction, while the belt construction is a factor in the sprocket construction. If the inner face of the belt is comprised of teeth, then the outer face of the drive sprocket, which contacts the inner face of the belt, is conventionally formed with grooves corresponding to the tooth profile of the belt. For synchronous drive belts wherein the teeth extend laterally across the width of the belt, the corresponding sprockets are provided with flanges to prevent the belt from tracking off of the sprocket. For drive belts with self-tracking tooth profiles, the sprockets do not require flanges to restrain the axial movement of the belt.

[0003] In operation a toothed belt system will generate noise. This is primarily due to engagement or meshing between the teeth of the belt and the groves of the sprocket. Motor noise is discounted as a given. The belt noise can be objectionable depending on the intensity and the associated service in which the system is being used.

[0004] Representative of the art is US application no. 20020119854 which discloses a drive system comprising a driver pulley, a driven pulley, and a belt. The belt has a pulley engaging surface comprised of a plurality of transversely extending self-tracking teeth. The driven pulley has a non-grooved, crownless belt engaging surface. The material forming the pulley engaging surface of the belt having a relatively low coefficient of friction, and the material forming the belt engaging surface of the driven pulley having a relatively high coefficient of friction.

[0005] What is needed is a sprocket system using a sprocket having a plurality of first transverse teeth and adjacent second transverse teeth thereby reducing operating system noise. The present invention meets this need.

SUMMARY OF THE EMBODIMENTS

[0006] The primary aspect of the invention is to provide a sprocket system using a sprocket having a plurality of first transverse teeth and adjacent second transverse teeth thereby reducing operating system noise.

[0007] Other aspects of the invention will be pointed out or made obvious by the following description of the invention and the accompanying drawings.

[0008] The invention comprises a sprocket system comprising a first sprocket comprising a plurality of transverse first teeth extending parallel to an axis of rotation (A-A) and having a first pitch (P1), the first sprocket further comprising a plurality of transverse second teeth having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth, a tooth of said first teeth aligned with a radius (R) of said first sprocket, a tooth of said second teeth offset a distance (x) from said radius (R), wherein (x) is greater than zero, a second sprocket, and a toothed belt entrained between the first sprocket and the second sprocket.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Fig. 1 is a perspective view of the inventive system.

[0010] Fig. 2 is a side view of a sprocket.

[0011] Fig. 3 is a top view of a sprocket.

[0012] Fig. 4 is a perspective view of a sprocket.

[0013] Fig. 5 is a graph of an overall dB comparison between different belt systems.

[0014] Fig. 6 is a chart of the parameters for the tested systems.

[0015] Fig. 7 is a perspective view of an inventive sprocket.

[0016] Fig. 8 is a perspective view of an alternate embodiment.

[0017] Fig. 9 is a chart depicting the sound pressure level of prior art and inventive belt systems for an 8mm pitch.

[0018] Fig. 10 is a chart depicting the sound pressure level of prior art and inventive belt systems for an 11mm pitch.

[0019] Fig. 11 is a schematic drawing of a test arrangement.

[0020] Figure 12 shows a pair of inventive sprockets with a single belt installed to determine the phase angle.

[0021] Fig. 13 is a pulse time marker chart.

DETAILED DESCRIPTION

[0022] Unless otherwise indicated, all numbers expressing dimensions and so forth used in the specification and claims are to be understood as being modified in all instances by the term “about”.

[0023] In this application and the claims, the use of the singular includes the plural unless specifically stated otherwise. In addition, use of “or” means “and/or” unless stated otherwise. Moreover, the use of the term “including”, as well as other forms, such as “includes” and “included”, is not limiting. Also, terms such as “element” or “component” encompass both elements and components comprising one unit and elements and components that comprise more than one unit unless specifically stated otherwise.

[0024] Fig. 1 is a perspective view of the inventive system. The system comprises a first sprocket 100 and a second sprocket 200. In a typical system first sprocket 100 would act as a driver sprocket and second sprocket 200 would act as a driven sprocket.

[0025] A first belt 300 is entrained about sprockets 100, 200. A second belt 400 is trained about sprockets 100, 200. First belt 300 and second belt 400 comprise toothed belts, each having teeth disposed on a longitudinal surface. First belt 300 comprises teeth 301. Second belt 400 comprises teeth 401.

[0026] Teeth 301 engage a toothed surface 101 on sprocket 100. Teeth 401 engage a toothed surface 102 on sprocket 100. Teeth 301 also engage a toothed surface 201 on sprocket 200. Teeth 401 also engage a toothed surface 202 on sprocket 200.

[0027] Sprocket 100 comprises a first toothed surface 101 comprising transverse teeth extending parallel to an axis of rotation A-A. Sprocket 100 further comprises a second toothed surface 102 disposed immediately adjacent the first toothed surface 101, Second teeth on toothed surface 102 are parallel to the first teeth on toothed surface 101.

[0028] Teeth 301 and teeth 401 may comprise any suitable shape or profile known in the art. Teeth on the toothed surfaces 101, 102, 201, 202 may comprise any cooperating profile suitable for engaging belt 300 and belt 400.

[0029] Sprocket 100 and sprocket 200 may be of equal or unequal diameters. Further, the diameter for toothed surface 101 may be equal or unequal to the diameter of adjacent toothed surface 102. Further, the diameter for toothed surface 201 may be equal or unequal to the diameter of adjacent toothed surface 202.

[0030] In operation it is preferable that each belt 300, 400 be made to track toward the outer portion of sprocket 100 and sprocket 200. The will reduce the possibility of the belts coming in contact or rubbing together. Methods relating to belt tracking control are known in the art.

[0031] Fig. 2 is a side view of a sprocket. Teeth on toothed surface 101 and 201 are spaced apart from each other by what is referred to as the "pitch", which is a distance (P1) between adjacent teeth. Teeth on toothed surfaces 102 and 202 are also spaced with a pitch (P2). Assuming a given toothed surface 101 is aligned with reference line "A" which aligns with a radius (R), the teeth on surface 102 are offset from the adjacent toothed surface 101 by a distance (x) which is a fraction of the pitch (P1) between 0 and 1. The offset may be adjusted/optimized during design in order to minimize or cancel noise generated by the belt engaging the sprocket, see Figure 12 and Figure 13. Belt pitches are typically 8mm, 9.525mm, 11mm, 14mm, 19 mm, 32mm, or some other value depending upon the requirements of the system.

[0032] In the preferred embodiment (x) is ½ the pitch (P1) for the given sprocket or belt. Hence, for the situation where the pitches of the adjacent toothed surfaces 101, 102 are equal, the teeth on surface 102 are disposed in alignment with the grooves 103 between teeth on surface 101. Distance (x) may be any value between zero and P1 or P2.

[0033] Pitch P1 and pitch P2 may or may not be equal depending upon system requirements.

[0034] In the preferred embodiment the pitch is equal for belt 300 and belt 400, and the offset (x) is ½ pitch. In an alternate embodiment, belt 300 and belt 400 may have different pitches, for example, belt 300 has a pitch of 8mm and belt 400 has a pitch of 10mm, or may have equal pitch but different offset (x).

[0035] Fig. 3 is a top view of a sprocket. Teeth on surface 101 are disposed adjacent teeth on surface 102. Sprocket 100 comprises adjacent rows of teeth on surface 101 and surface 102 on an outer belt engaging surface. Each sprocket rotates about an axis of rotation A-A.

[0036] Fig. 4 is a perspective view of a sprocket. Each toothed surface may comprise an equal or unequal diameter D.

[0037] An advantage of the inventive system is the significant reduction in drive noise. The system typically produces a 6 dB noise reduction over a comparable single belt system. Fig. 5 is a graph of an overall dB comparison between single belt systems, dual belt systems using the inventive system, and a single belt system using a belt with helix teeth. Bars A, C, D, and F represent the noise from single belt systems. Bar B is a dual belt system using single belt sprockets. Bar E represents the sound pressure levels for an inventive system, also using two belts. Bar G is for a single belt helix pitch system. Bar H is the electric motor only. The inventive system represented by bar (E) is quieter that all of the single belt systems.

[0038] Parameters for the tested systems are shown in Fig. 6.

[0039] Fig. 7 is a perspective view of an inventive sprocket. Flanges 105 and 106 retain each belt 400, 300 respectively on sprocket 100. Flanges 105 and 106 are situated on the outboard portions of sprocket 100.

[0040] Fig. 8 is a perspective view of an alternate embodiment. Radially extending middle flange 107 is disposed between transverse tooth section 101 and transverse tooth section 102. Flange 107 prevents belt 300 from contacting belt 400 during operation. Middle flange 107 also serves as a parting line for the manufacturing process which is commonly described as sinter metal. In the sinter metal process the two halves of the mold insert connect at the middle flange 107 to ensure a smooth transition between tooth and flange. As described in Figure 7, flanges 105 and 106 retain each belt 400, 300 respectively on sprocket 100. Flanges 105 and 106 are situated on the outboard portions of sprocket 100.

[0041] Fig. 9 is a chart depicting the sound pressure level of the tooth meshing order of prior art and inventive belt systems for an 8mm pitch belt over a given speed range. The sound pressure level for the system labeled as “dual phase” indicates a significant decrease for system noise across the speed range using the inventive sprocket (dual phase) compared to the prior art (pitch single and helical tooth).

[0042] The sound level of the system can be measured using a test system. Figure 11 is a schematic drawing of a test system arrangement. An electric motor 800 is attached to a driver differential 801. Driver differential 801 is attached to an inventive driver sprocket 100a. A second inventive driven sprocket 100b is attached to driven differential 802. Belts 300, 400 are trained between the first inventive sprocket 100a and second inventive sprocket 100b as described elsewhere in this specification, for example, in Figure 1. The system tested in this Figure 11 uses a sprocket as described in Figure 8, which includes a flange 107. Driven differential 802 is attached to a first generator 803 and second generator 804, which provide load for the system.

[0043] Each of the belts used in the system noise measurement tests are as follows:

[0044] 8mm pitch, 30 mm width

[0045] 11mm pitch, 20 mm width

[0046] The driver sprocket and driven sprocket each comprise 40 teeth for portion 101 and portion 102 for the 8mm pitch system. For the 11mm system the driver sprocket and driven sprocket each comprise 31 teeth for portion 101 and portion 102.

[0047] For the test system:

[0048] $\omega 1 : \omega 2 = 1:2.46$

[0049] $\omega 2 = \omega 3$

[0050] $\omega 3 : \omega 4 = 2.46:1$

[0051] $\omega 3 : \omega 6 = 2.46:1$

[0052] The belt noise measurement is made with the input shaft torque at 100 N-m and an input shaft speed of 5000 RPM.

[0053] Microphone 805 is mounted at a distance of 10 cm above the driven sprocket 100b. Microphone 805 is the ICP type condenser microphone by PCB, or other suitable equivalent.

[0054] Fig. 10 is a chart depicting the sound pressure level of the tooth meshing order of prior art and inventive belt systems for an 11mm pitch belt system. As is the case for the 8mm system, the sound pressure level for the 11mm pitch dual belt system is also significantly reduced across the speed range when compared to a single toothed belt installation.

[0055] Figure 12 shows a pair of inventive sprockets with a single belt installed to determine the phase angle. A Hall effect speed sensor 500 is positioned to monitor the un-occupied sprocket 201. Each time the tooth passes the speed sensor a TTL (transistor to transistor logic) signal is generated, see curve “A” in Figure 13. A counter is used to count the time between adjacent rising edges of TTL signal. Although the pitch “p” of the sprocket is constant, the time elapsed between two teeth may not be the same due to shaft torsional vibration, as illustrated in curve “B” in Figure 13. Microphone 805 is placed on top of the belt 300 and beside the speed sensor 500. The sound level pressure measurement is sectioned by the time marker of the speed sensor 500 and the sound distribution within each pitch can be quantified. Next, the phase “s” between the maximum dBA peak value and the minimum dBA valley value can be determined within each pitch. By adding a second sound wave from a second belt with a shifted angle “s” the second wave sound peak will be aligned with the first wave sound valley hence the noise cancellation effect can be achieved, see curve “C” in Figure 13. The second wave peak sound input is generated by a second belt in the system, namely belt 400, which is not shown in the test configuration in Figure 12. Belt 400 would be adjacent to belt 300 as shown in Figure 1, for example.

[0056] While the invention has been particularly shown and described with reference to a number of embodiments, it would be understood by those skilled in the art that changes in the form and details may be made to the various embodiments disclosed herein without departing from the spirit and scope of the invention and that the various embodiments disclosed herein are not intended to act as limitations on the scope of the claims. All references cited herein are incorporated in their entirety by reference.

CLAIMS

What is claimed is:

1. A sprocket system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth;

a tooth of said first teeth aligned with a radius (A) of said first sprocket;

a tooth of said second teeth offset a distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200); and

a toothed belt (300) entrained between the first sprocket and the second sprocket.

2. The sprocket system as in claim 1, wherein (P1) and (P2) are equal.

3. The sprocket system as in claim 2, wherein distance (x) is equal to (P1)/2.

4. The sprocket system as in claim 1 further comprising a second belt entrained between the first sprocket and the second sprocket.

5. The sprocket system as in claim 1, wherein the first teeth have a diameter (D) that is not equal to a diameter of the second teeth.

6. The sprocket system as in claim 1, wherein the second sprocket comprises:

a plurality of transverse first teeth (201) extending parallel to an axis of rotation (A-A) and having a pitch;

the second sprocket further comprising a plurality of transverse second teeth (202) having a pitch and disposed immediately adjacent the first teeth (201), the second teeth parallel to the first teeth;

a tooth of said first teeth (201) aligned with a radius (A) of said second sprocket; and a tooth of said second teeth (202) disposed a distance (x) from said radius (A), wherein (x) is greater than zero.

7. A drive system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth;

a tooth of said first teeth aligned with a radius (R) of said first sprocket;

a tooth of said second teeth disposed a distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200); and

a first toothed belt (300) and a second toothed belt (400), each belt entrained between the first sprocket and the second sprocket.

8. The drive system as in claim 7, wherein (P1) and (P2) are equal.

9. The drive system as in claim 8, wherein distance (x) is equal to (P1)/2.

10. A drive system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth;

a tooth of said first teeth aligned with a radius (A) of said first sprocket;

a tooth of said second teeth disposed a distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200) comprising a plurality of transverse first teeth (201) extending parallel to an axis of rotation (A-A) and having a pitch;

the second sprocket further comprising a plurality of transverse second teeth (202) having a pitch and disposed immediately adjacent the first teeth (201), the second teeth parallel to the first teeth;

a tooth of said first teeth (201) aligned with a radius (A) of said second sprocket, a tooth of said second teeth (202) disposed a distance (x) from said radius (A), wherein (x) is greater than zero; and

a first toothed belt (300) and a second toothed belt (400) entrained between the first sprocket and the second sprocket.

11. The drive system as in claim 10, wherein (P1) and (P2) are equal.

12. The drive system as in claim 11, wherein distance (x) is equal to (P1)/2.

13. A drive system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth, a radially extending flange (107) disposed between the transverse first teeth and the transverse second teeth;

a tooth of said first teeth aligned with a radius (A) of said first sprocket;

a tooth of said second teeth disposed a circumferential distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200); and

a first toothed belt (300) and a second toothed belt (400), each belt entrained between the first sprocket and the second sprocket.

14. The sprocket system as in claim 13, wherein (P1) and (P2) are equal.

15. The sprocket system as in claim 14, wherein circumferential distance (x) is equal to (P1)/2.

AMENDED CLAIMS
received by the International Bureau on 18 February 2014 (18.02.2014)

1. A sprocket system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth;

a tooth of said first teeth aligned with a radius (A) of said first sprocket;

a tooth of said second teeth offset a distance (x) from said radius (A), wherein (x) is greater than zero, a radially extending flange (107) disposed between the transverse first teeth and the transverse second teeth;

a second sprocket (200); and

a toothed belt (300) entrained between the first sprocket and the second sprocket, a second belt (400) entrained between the first sprocket and the second sprocket, the radially extending flange preventing contact between toothed belt (300) and toothed belt (400).

2. The sprocket system as in claim 1, wherein (P1) and (P2) are equal.

3. The sprocket system as in claim 2, wherein distance (x) is equal to (P1)/2.

4. (Cancelled).

5. The sprocket system as in claim 1, wherein the first teeth have a diameter (D) that is not equal to a diameter of the second teeth.

6. The sprocket system as in claim 1, wherein the second sprocket comprises:

a plurality of transverse first teeth (201) extending parallel to an axis of rotation (A-A) and having a pitch;

the second sprocket further comprising a plurality of transverse second teeth (202) having a pitch and disposed immediately adjacent the first teeth (201), the second teeth parallel to the first teeth;

a tooth of said first teeth (201) aligned with a radius (A) of said second sprocket; and a tooth of said second teeth (202) disposed a distance (x) from said radius (A), wherein (x) is greater than zero.

7. A drive system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth, the first teeth have a diameter (D) that is not equal to a diameter of the second teeth;

a tooth of said first teeth aligned with a radius (R) of said first sprocket;

a tooth of said second teeth disposed a distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200); and

a first toothed belt (300) and a second toothed belt (400), each belt entrained between the first sprocket and the second sprocket.

8. The drive system as in claim 7, wherein (P1) and (P2) are equal.

9. The drive system as in claim 8, wherein distance (x) is equal to (P1)/2.

10. A drive system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth;

a tooth of said first teeth aligned with a radius (A) of said first sprocket;

a tooth of said second teeth disposed a distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200) comprising a plurality of transverse first teeth (201) extending parallel to an axis of rotation (A-A) and having a pitch;

the second sprocket further comprising a plurality of transverse second teeth (202) having a pitch and disposed immediately adjacent the first teeth (201), the second teeth parallel to the first teeth;

the first teeth have a diameter (D) that is not equal to a diameter of the second teeth;

a tooth of said first teeth (201) aligned with a radius (A) of said second sprocket, a tooth of said second teeth (202) disposed a distance (x) from said radius (A), wherein (x) is greater than zero; and

a first toothed belt (300) and a second toothed belt (400) entrained between the first sprocket and the second sprocket.

11. The drive system as in claim 10, wherein (P1) and (P2) are equal.

12. The drive system as in claim 11, wherein distance (x) is equal to (P1)/2.

13. A drive system comprising:

a first sprocket (100) comprising a plurality of transverse first teeth (101) extending parallel to an axis of rotation (A-A) and having a first pitch (P1);

the first sprocket further comprising a plurality of transverse second teeth (102) having a second pitch (P2) and disposed immediately adjacent the first teeth, the second teeth parallel to the first teeth, a radially extending flange (107) disposed between the transverse first teeth and the transverse second teeth;

a tooth of said first teeth aligned with a radius (A) of said first sprocket;

a tooth of said second teeth disposed a circumferential distance (x) from said radius (A), wherein (x) is greater than zero;

a second sprocket (200); and

a first toothed belt (300) and a second toothed belt (400), each belt entrained between the first sprocket and the second sprocket, the radially extending flange preventing contact between toothed belt (300) and toothed belt (400).

14. The sprocket system as in claim 13, wherein (P1) and (P2) are equal.

15. The sprocket system as in claim 14, wherein circumferential distance (x) is equal to (P1)/2.

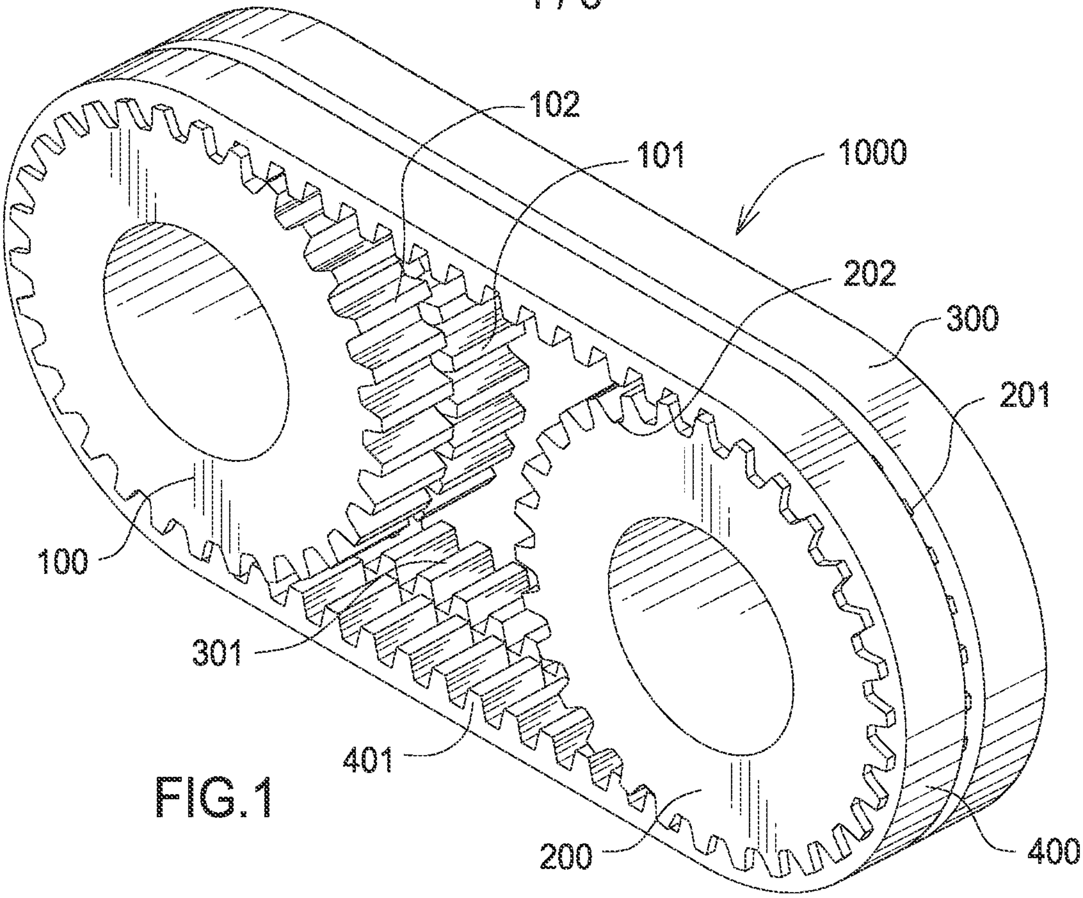
102
101
1000
202
300
201
100
301
401
200
400

FIG.1

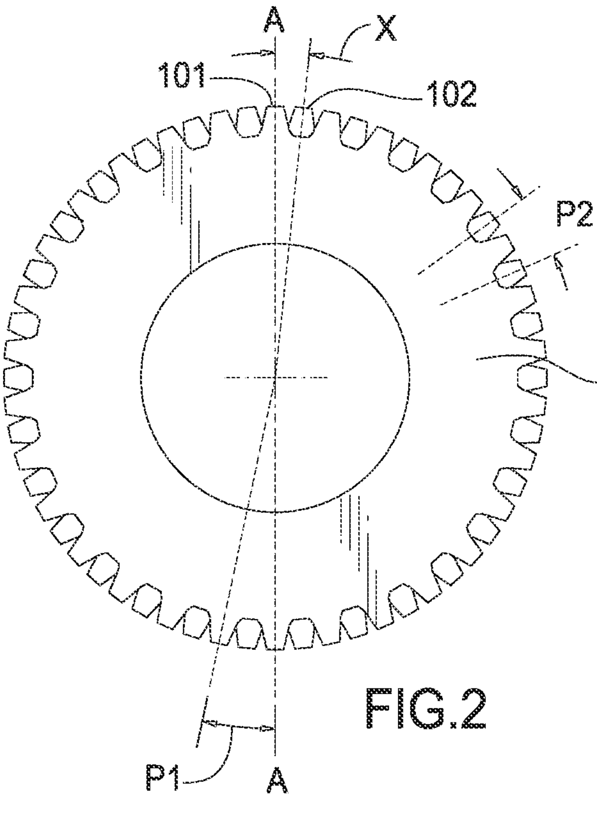
A
X
101
102
P2
100
P1
A

FIG.2

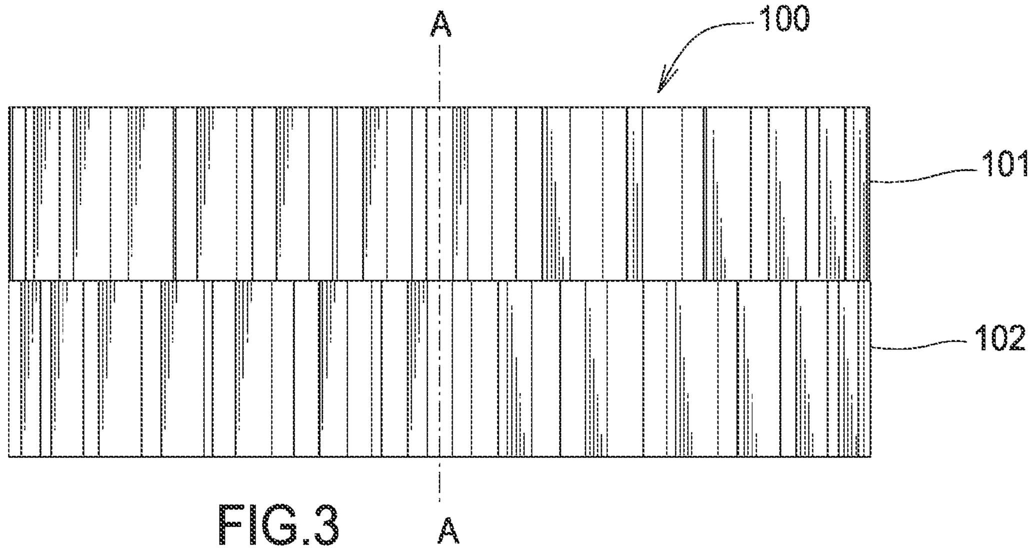

FIG.3

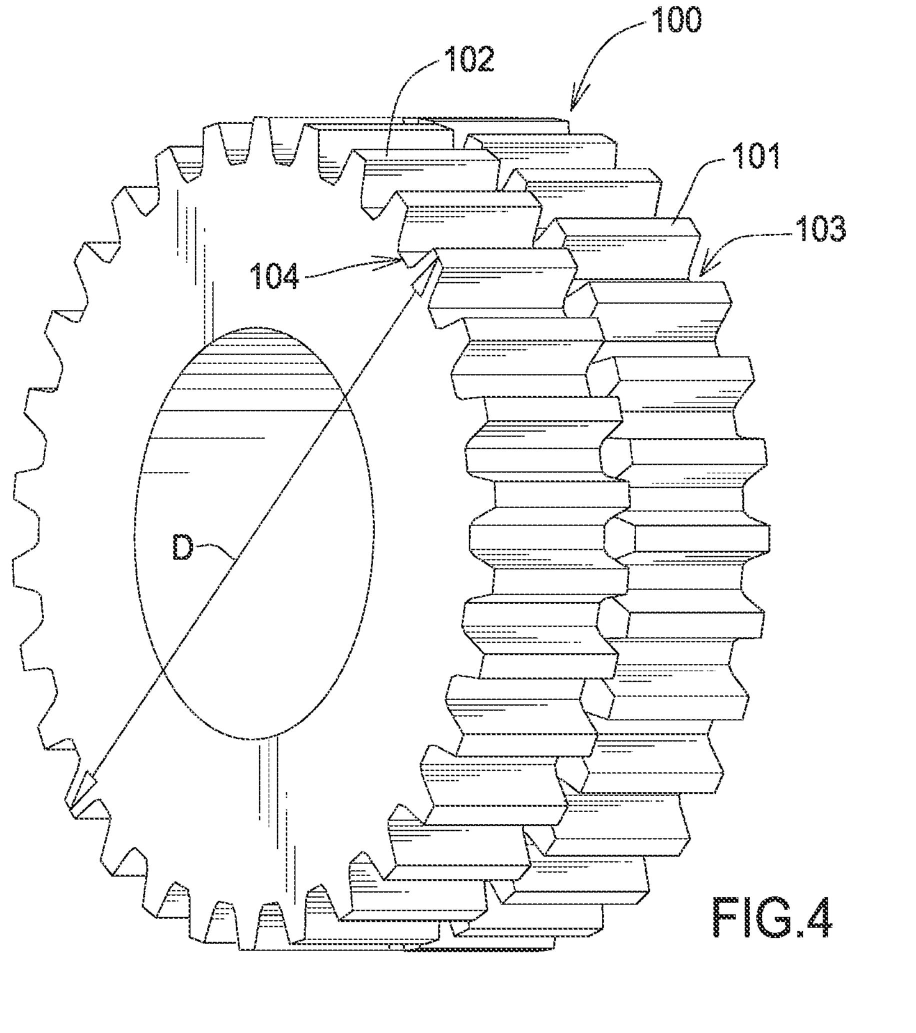

FIG.4

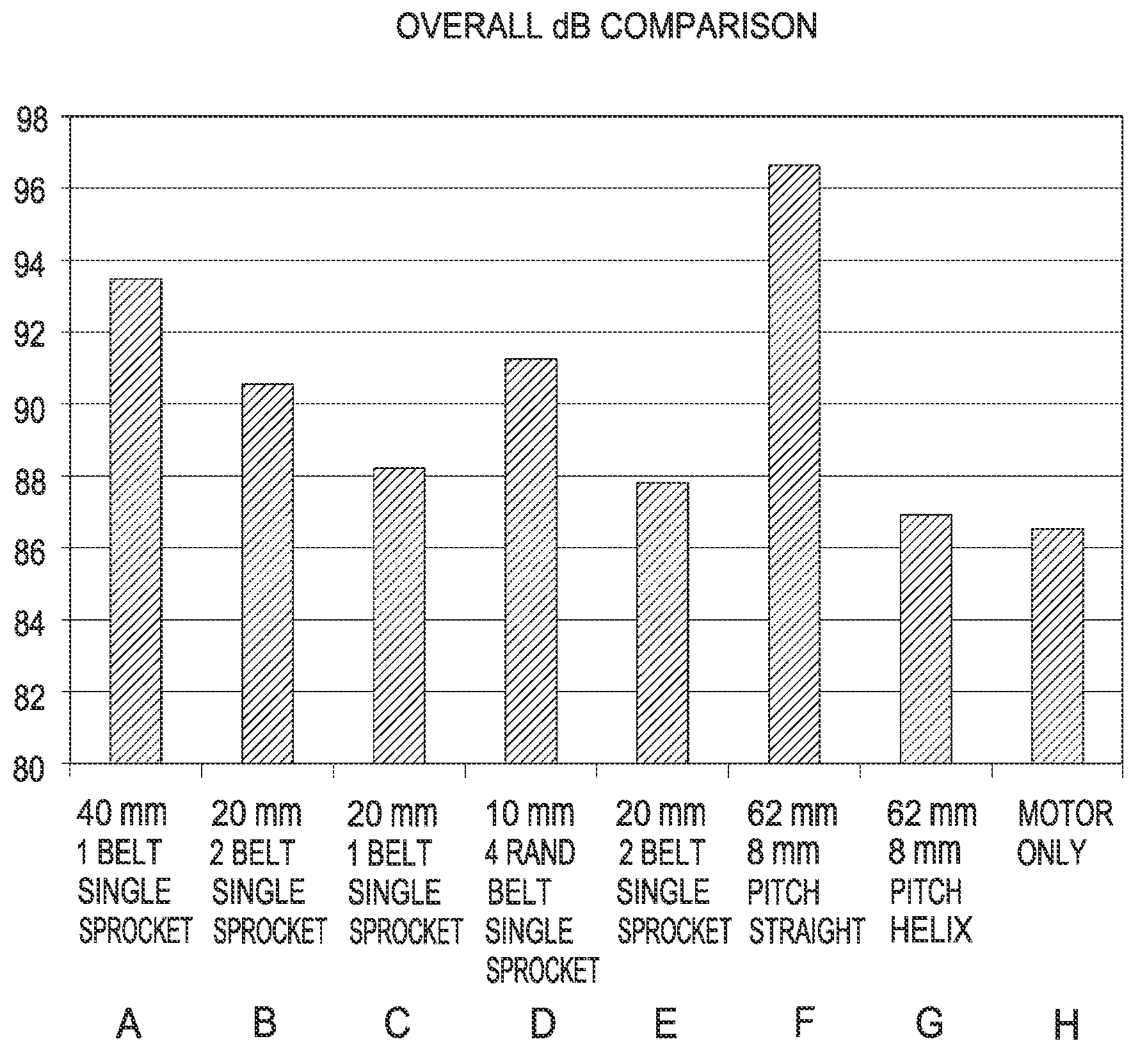
OVERALL dB COMPARISON
98
96
94
92
90
88
86
84
82
80
40 mm 1 BELT SINGLE SPROCKET
20 mm 2 BELT SINGLE SPROCKET
20 mm 1 BELT SINGLE SPROCKET
10 mm 4 RAND BELT SINGLE SPROCKET
20 mm 2 BELT SINGLE SPROCKET
62 mm 8 mm PITCH STRAIGHT
62 mm 8 mm PITCH HELIX
MOTOR ONLY
A
B
C
D
E
F
G
H

FIG.5

		14 [mm]	8 [mm] STRAIGHT	14 [mm] HELIX
BELT LENGTH	[TEETH]	125	140	138
BELT WIDTH	[mm]	40/20/10	62	62
DRIVER SPEED	[rpm]	1750	1750	1750
POWER	[KW]	50	41	41
DRIVEN TORQUE	[N-m]	273	224	224
EFFECTIVE TENSION	[N]	4082	4393	3514
T1	[N]	4665	5020	4016
T2	[N]	583	628	502
TENSION RATIO	[T1/T2]	8	8	8
HUB LOAD	[N]	5248	5648	4518
DRIVER SPROCKET	[TEETH]	30	40	50
DRIVEN SPROCKET	[TEETH]	30	40	50
TOOTH MESHING FREQUENCY	[Hz]	875	1167	1458
LINEAR SPEED	[m/sec]	12.25	9.33	11.67

FIG.6

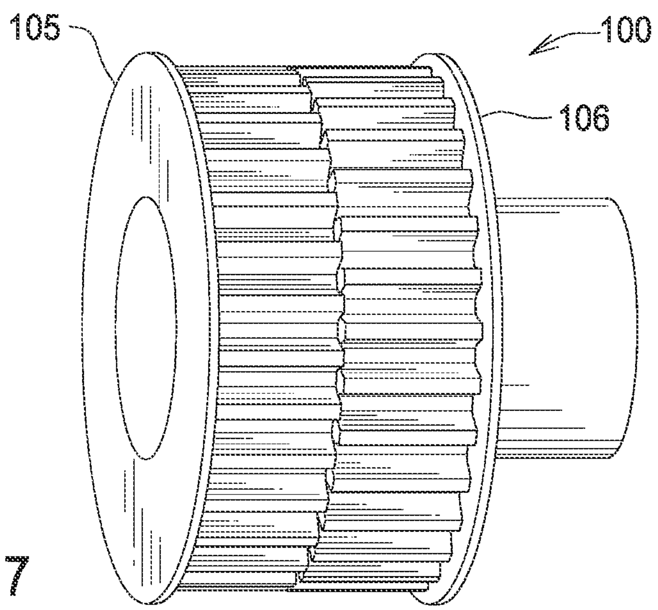

FIG.7

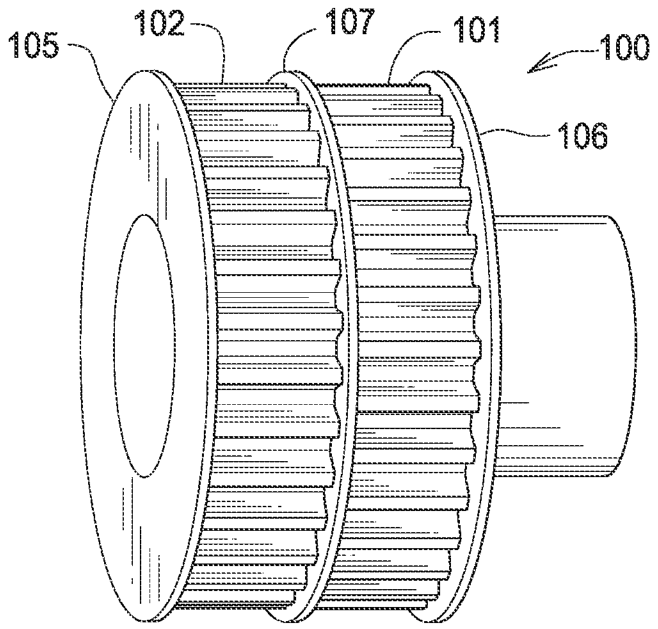
105
102
107
101
100
106

FIG.8

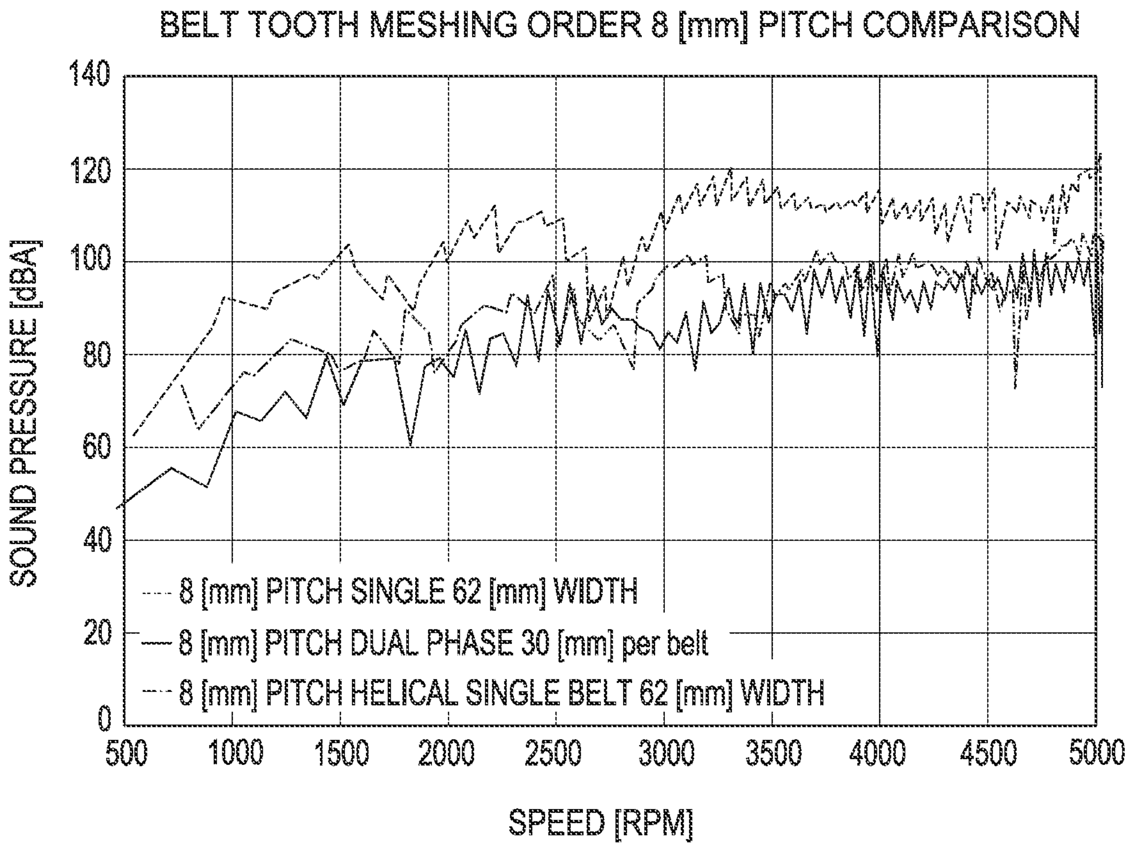
BELT TOOTH MESHING ORDER 8 [mm] PITCH COMPARISON
SOUND PRESSURE [dBA]
140
120
100
80
60
40
20
0
8 [mm] PITCH SINGLE 62 [mm] WIDTH
8 [mm] PITCH DUAL PHASE 30 [mm] per belt
8 [mm] PITCH HELICAL SINGLE BELT 62 [mm] WIDTH
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
SPEED [RPM]

FIG.9

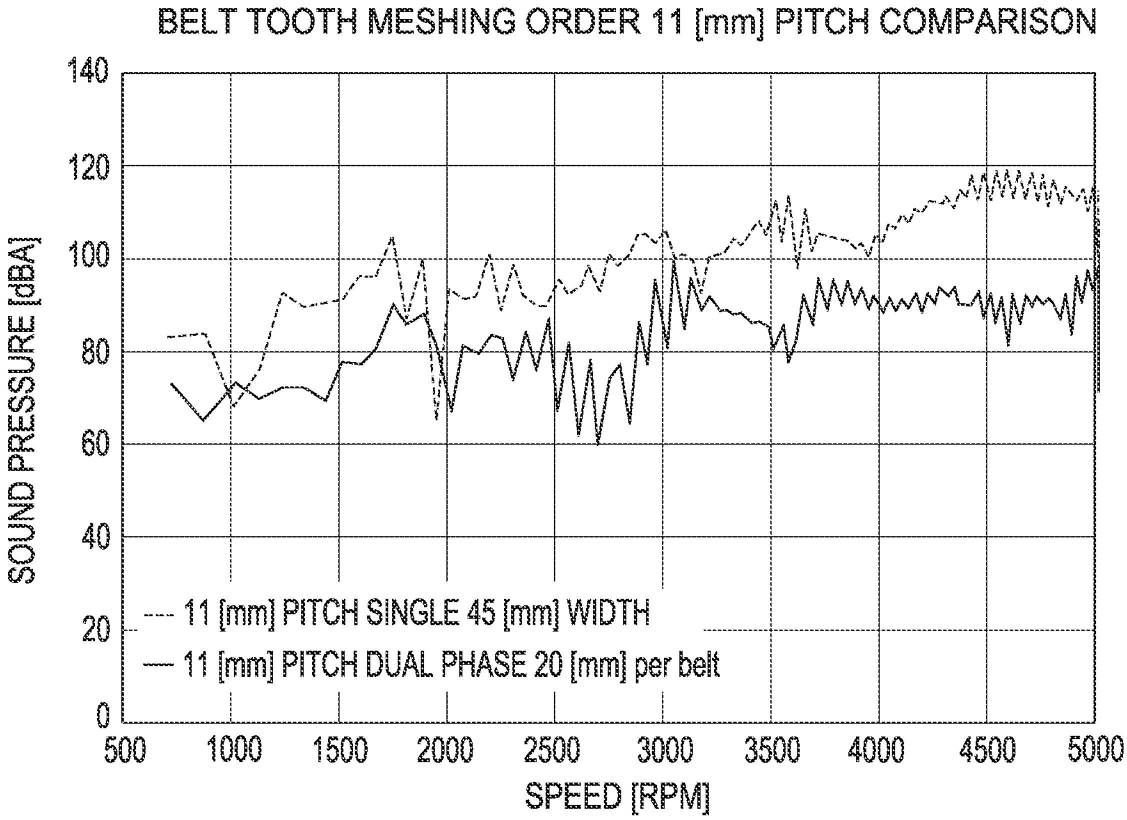
BELT TOOTH MESHING ORDER 11 [mm] PITCH COMPARISON
SOUND PRESSURE [dBA]
140
120
100
80
60
40
20
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
SPEED [RPM]
11 [mm] PITCH SINGLE 45 [mm] WIDTH
11 [mm] PITCH DUAL PHASE 20 [mm] per belt

FIG.10

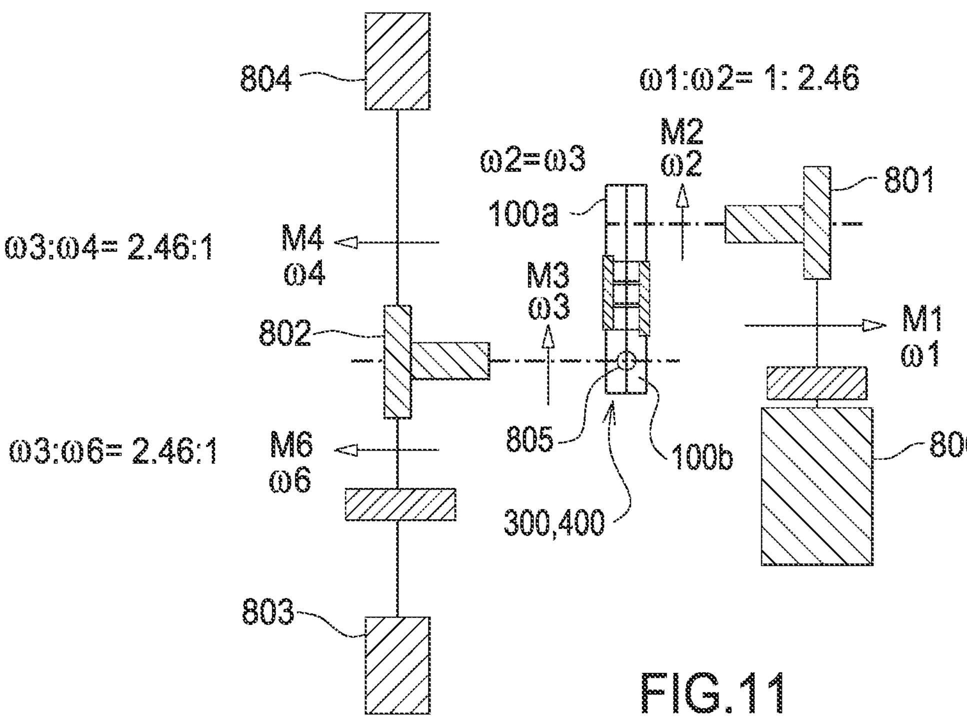
804
ω1:ω2= 1: 2.46
ω2=ω3
M2
ω2
801
100a
ω3:ω4= 2.46:1
M4
ω4
M3
ω3
M1
ω1
802
805
100b
800
ω3:ω6= 2.46:1
M6
ω6
300,400
803

FIG.11

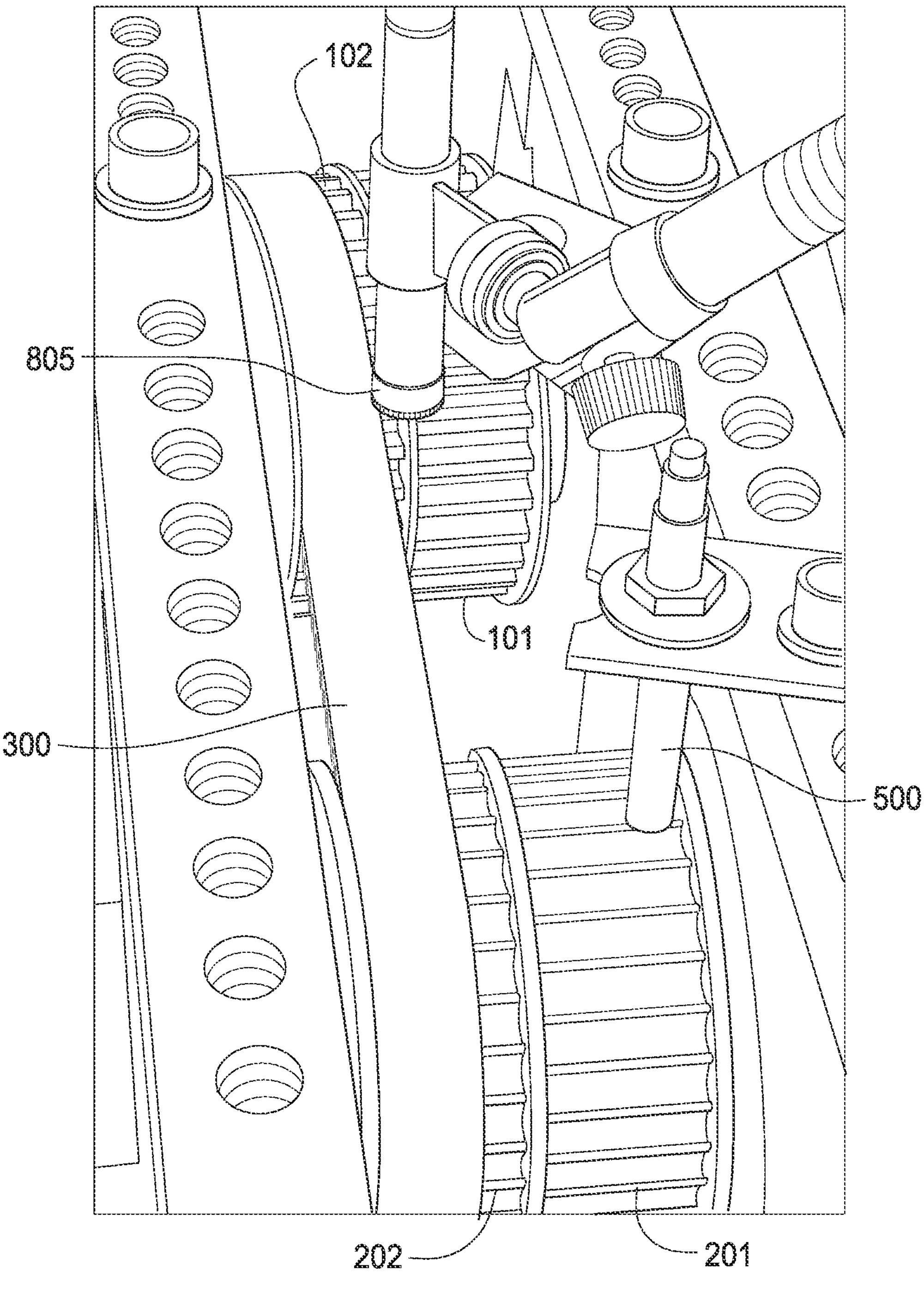

FIG.12

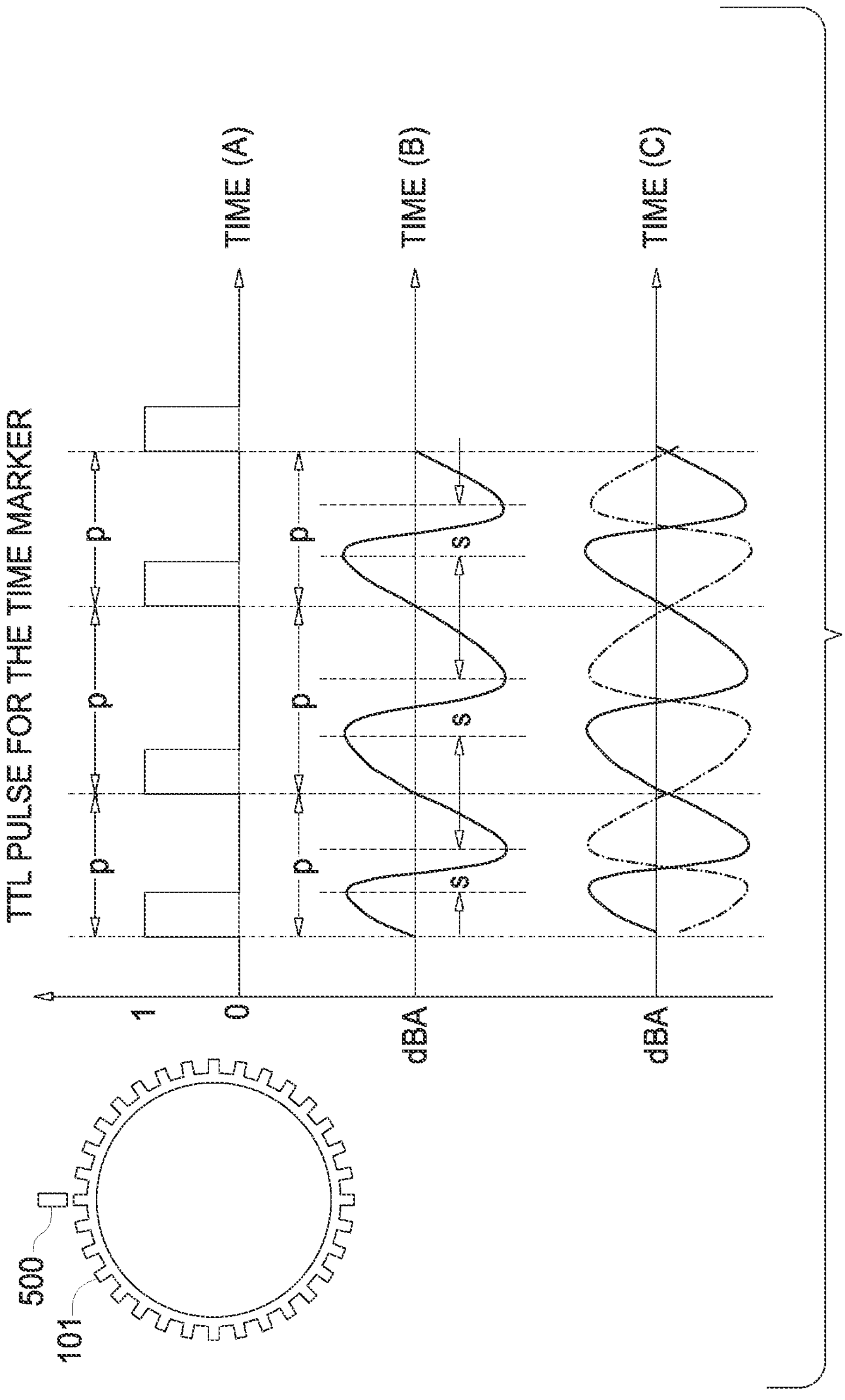
TTL PULSE FOR THE TIME MARKER
TIME (A)
TIME (B)
TIME (C)
p
s
1
0
dBA
dBA
500
101

FIG.13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/065272

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H55/30 F16H55/36 F16H55/40
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	WO 2008/115501 A1 (VEYANCE TECHNOLOGIES INC [US]; ACKERMAN MARK [US]) 25 September 2008 (2008-09-25)	1-3,6
Y	figure 4	4,7-15
X	EP 1 277 987 A2 (BORGWARNER INC [US]) 22 January 2003 (2003-01-22) figures 1,3	1-3,6
X	US 2011/094856 A1 (GULDENFELS DIETER [CH] ET AL) 28 April 2011 (2011-04-28) figures 1,2	1,2,6
Y	WO 02/08639 A1 (GATES CORP [US]) 31 January 2002 (2002-01-31) figure 1,	4,7-15
	-/--	

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

[X] 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

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

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2014	21/01/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hassiotis, Vasilis

1

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 1 217 256 A1 (GOODYEAR TIRE & RUBBER [US]) 26 June 2002 (2002-06-26) the whole document -----	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/065272

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			KR	20030046390	A	12-06-2003
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			DE	60105954	T2	13-10-2005
			EP	1217256	A1	26-06-2002
			JP	3777119	B2	24-05-2006
			JP	2002243002	A	28-08-2002
			US	2002119854	A1	29-08-2002