Sept. 20, 1971 YOSHIAKI SUGIMOTO 3,605,513

MULTIPLE CONTACT SPROCKETS

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FIG.1

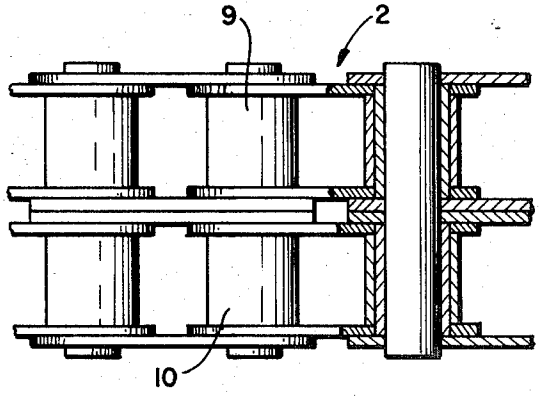

FIG.2

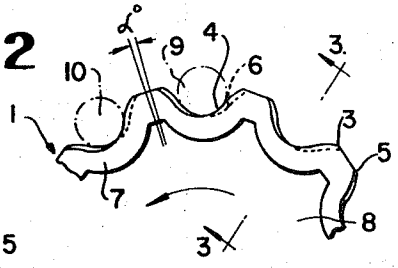

FIG.3

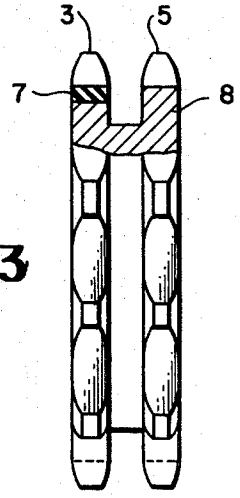

FIG.4

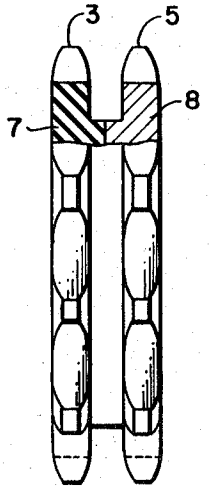

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FIG.5

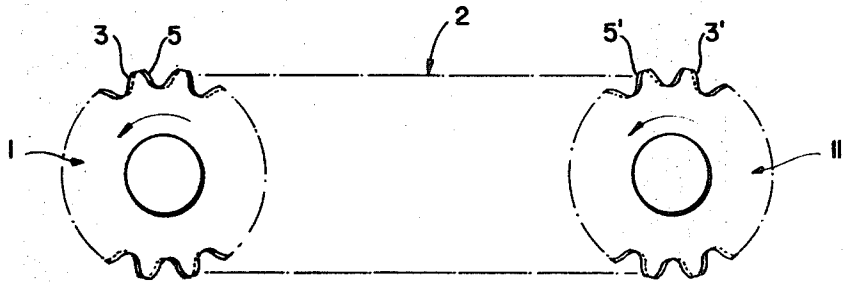
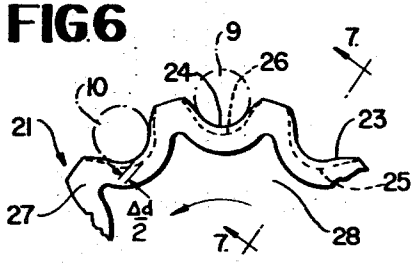


FIG.6



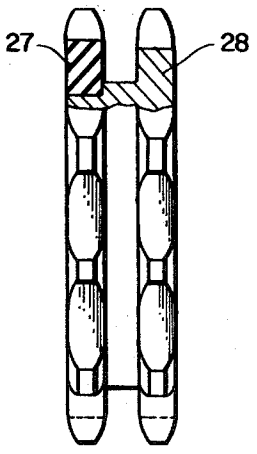


FIG.7

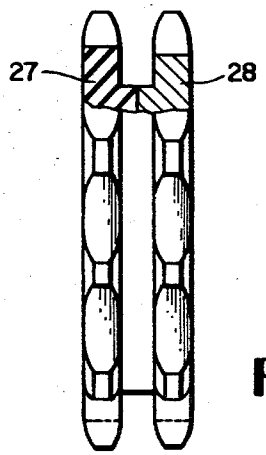


FIG.8

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MULTIPLE CONTACT SPROCKETS

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FIG.9

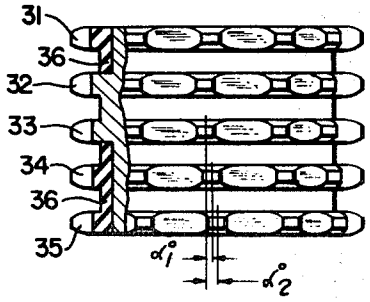


FIG.10

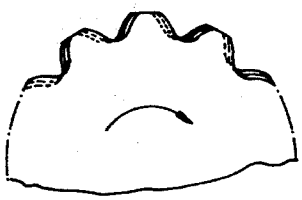


FIG.11

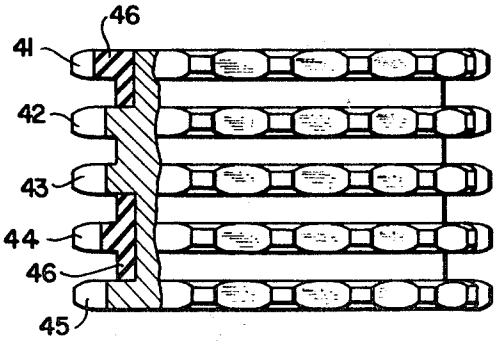


FIG.12

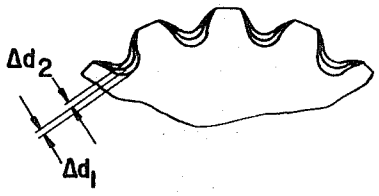
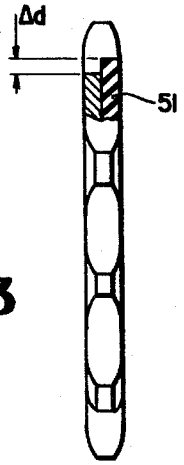


FIG.13



BY Wenderoth, Lind & Ponack
ATTORNEYS

United States Patent Office 3,605,513 Patented Sept. 20, 1971

3,605,513

MULTIPLE CONTACT SPROCKETS

Yoshiaki Sugimoto, Tokorozawa, Saitama Prefecture, Japan, assignor to The Tsubakimoto Chain Mfg. Co., Ltd., Osaka, Japan

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Int. Cl. F16h 55/14, 55/18, 55/30
U.S. Cl. 74—243PC 10 Claims

ABSTRACT OF THE DISCLOSURE

A sprocket wheel having two surfaces of contact for contacting the same roller of sprocket chain. One of the contact surfaces consists of an elastic material and contacts the roller before the other contact surfaces. This is because the one contact surface either is out of phase with the other contact surface or has a larger bottom diameter than the other contact surface. A chain drive system uses a driving wheel having one row of sprockets forwardly out of phase of another row and a driven wheel having one row of sprockets rearwardly out of phase with another row.

BACKGROUND OF THE INVENTION

This invention relates to sprocket wheels, and in particular to sprocket wheels used in high speed chain drives.

A well-known method of mechanical power transmission involves the use of a chain drive wherein power is transmitted from a driving shaft to a first sprocket wheel mounted thereon and through a chain to a second sprocket wheel mounted on a driven shaft. In such chain drive systems, collisions occur between the chain rollers and the tension surfaces of the sprockets of the driving sprocket wheel. These collisions create noise and vibration which in the past have been considered unavoidable. Furthermore these collisions expend energy causing wear and fatigue of the sprockets and of the chain rollers and roller bushings. Such wear and fatigue results in undesirable break downs and in high maintenance costs. These collisions are aggravated by a slack drive chain.

With these disadvantages in mind, it is an object of this invention to provide an improved sprocket wheel which cushions these collisions and thereby eliminates noise and vibration and prevents the undesirable expenditure of energy.

It is a further object of this invention to provide a multi-row sprocket wheel which performs these functions.

It is a still further object of this invention to provide an improved chain drive system employing both driving and driven sprocket wheels which cushion the sprockets and the chain due to the slack of the chain.

In accordance with the present invention these objects are accomplished by the provision of a sprocket having two surfaces of contact with each chain roller. One of said surfaces is adapted to contact the roller prior to the other of said surfaces and is formed of an elastic material. In one embodiment of the invention, the sprocket wheel has two rows of sprockets, one of said rows being forwardly out of phase with the other of said rows, thereby providing the two surfaces of contact. In a second embodiment of the present invention, the sprocket wheel has two rows of sprockets, one of said rows having a different bottom diameter than the other of said rows to form the two surfaces of contact. Either of the said embodiments may comprise a sprocket wheel having a single row of sprockets, the sprockets being divided in the direction of their widths to form the two surfaces of contact. Furthermore, in either of said embodiments more than two rows of sprockets may be provided. Each row may be

adapted to successively contact the chain roller, the number of contact actions being equal to the number of rows. However, this becomes impractical with a large number of rows. Each alternate row may have the same contact surface, there then being two contact actions. Or any desired contact sequence may be employed.

Other objects will become apparent from the following detailed description, taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a sprocket chain used in conjunction with the present invention;

FIG. 2 is a partial side view of a sprocket wheel of a first embodiment of the present invention;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is similar to FIG. 3 but of a slightly modified sprocket wheel;

FIG. 5 is a schematic view of the sprocket wheel of FIG. 2 used in a power drive system;

FIG. 6 is a partial side view of a sprocket wheel of a second embodiment of the present invention;

FIG. 7 is a sectional view taken along line 7—7 of FIG. 6;

FIG. 8 is similiar to FIG. 7 but of a slightly modified sprocket wheel;

FIGS. 9 and 10 are top and side views, respectively, of a multi-row sprocket wheel according to the first embodiment of the present invention;

FIGS. 11 and 12 are top and side views, respectively, of a multi-row sprocket wheel according to the second embodiment of the present invention; and

FIG. 13 is a partial section view of a single row sprocket wheel of the second embodiment of the present invention.

Referring to FIGS. 1 and 2, a novel sprocket wheel embodying the present invention is designated generally by **1** and a mating drive chain by **2**. Drive chain **2** has a number of rollers, each having portions **9** and **10**. A first row of sprockets **3** having contact surfaces **4** are forwardly out of phase by angle α, i.e. forwardly in the direction of rotation of the sprocket wheel **1** as shown by the arrow, with a second row of sprockets **5** having contact surfaces **6**. The contact surfaces **4** of sprockets **3** comprise an elastic material **7** to be hereinafter described in detail.

The angle α is the relative phase difference between the two rows of sprockets, and its value is dependent upon the mechanical properties and the shape of both the elastic surface and the metallic body of the sprocket.

The α in radian may be calculated by the formula below:

$$\frac{\alpha R}{P}=\frac{\alpha R}{R\sin\frac{180^\circ}{N}}=\frac{\alpha}{R\sin\frac{180^\circ}{N}}=0-0.3$$

$$\alpha=(0-0.3)\sin\frac{180^\circ}{N}$$

wherein:

P=Pitch of chain
R=Radius of the pitch circle
N=Number of teeth

The surface **4** may be provided with elastic material in any convenient manner. FIG. 3 shows sprocket wheel **1** partially in cross-section wherein elastic material **7** comprises a coating and the remainder of the sprocket wheel is a metal base **8**. When this arrangement is used, the coating must at least be as thick as the difference in phase between the rows of sprockets.

FIG. 4 shows an arrangement similar to that of FIG. 3, but wherein the entire row of forwardly phased sprockets **3** consists of elastic material **7**, and the other row of sprockets **5** consists of metal base **8**.

Referring again to FIG. 2, the operation of this embodiment of the invention will be explained. As sprocket wheel **1** drives chain **2**, portion **10** of a chain roller contacts with surface **4** of one of the forwardly phased sprockets **3**. The elastic material **7** is deformed until portion **9** (dashed lines) contacts surface **6** of the lagging sprocket **5**.

This operation allows the force of collision between sprocket wheel **1** and chain **2** to be absorbed by elastic material **7**. The reaction force received by the sprockets from chain **2** is first applied to sprocket **3**. Then, when elastic material **7** is deformed until phase angle α becomes zero, to sprocket **5** and metal base **8**. Since elastic material **7** absorbs the initial force of collision, the reaction force between chain **2** and sprocket wheel **1** is essentially all transmitted to metal base **8**. This arrangement both reduces noise and vibration and increases chain and sprocket life by eliminating metal to metal collisions and by providing the absorbing action of the elastic material.

FIG. 5 discloses an arrangement of this embodiment of the invention wherein the consequences of a slack chain are overcome. In practice, the actual length of the chain is made longer than theoretically necessary to facilitate the mounting of the chain over the sprockets. But, the resultant slack chain accentuates the problems of noise, vibration and collision.

In FIG. 5 the sprocket wheel **1** of FIG. 2 is the driving wheel, and a sprocket wheel **11** is the driven wheel. Chain **2** is made longer than necessary as explained above. Wheel **1** has one row of sprockets **3** forwardly phased from a second row of sockets **5**, thereby absorbing collisions between driving wheel **1** and chain **2**. However, driven wheel **11** has a first row of sprockets **3'**, aligned with sprockets **3**, which are rearwardly out of phase from a second row of sprockets **5'**, aligned with sprockets **5**.

Therefore, collisions between chain **2** and driven wheel **11** are absorbed in a like manner to the collisions between driving wheel **1** and chain **2**.

FIG. 6 shows a second embodiment of applicant's invention. Sprocket wheel **21** comprises a first row of sprockets **23** having contact surfaces **24**, and a second row of sprockets **25** having contact surfaces **26**. The bottom diameter of sprockets **23** is greater than the bottom diameter of sprockets **25**. The contact surfaces **24** of sprockets **23** comprise an elastic material **27** to be hereinafter described in detail.

The difference (Δd) of the bottom diameters is usually denoted relative to the radius of the standard tooth root R, and to be in the range as

$$\Delta d/2R = 0 - 0.3$$
$$d + \Delta d = d + (0 - 0.3)R$$

d=bottom diameter of the standard tooth. This value depends on the mechanical property of elastic material, and the shape of both the elastic surface and the metallic body of the sprocket.

As is the case with the first embodiment of the invention, the surface **24** may be provided with elastic material **27** in any convenient manner. FIG. 7 shows sprocket wheel **21** partially in cross-section wherein elastic material **27** comprises a coating and the remainder of the sprocket wheel is metal base **28**. When this arrangement is used, the coating must be at least as thick as the difference in bottom diameters between the rows of sprockets.

FIG. 8 shows an arrangement similar to that of FIG. 7, but wherein the entire row of sprockets **23** consists of elastic material **27**, and the other row of sprockets **25** consists of metal base **28**.

Referring again to FIG. 6, the operation of this embodiment of the invention will be explained as sprocket wheel **21** drives the chain, portion **10** of a chain roller contacts surface **24** of one of the sprockets **23**. The elastic material **27** is deformed until portion **9'** (dashed lines) contacts surface **26** of the sprocket **25**.

The force of collision between sprocket wheel and the chain is thereby absorbed by the elastic material **27**, and the reaction force is received by the metal base **28** in a manner similar to that described with regard to the first embodiment, thereby reducing noise and vibration and increasing chain and sprocket life.

FIGS. 9 and 10 show a multi-row sprocket wheel of the first embodiment of the invention. The sprocket wheel has five rows of sprockets **31**, **32**, **33**, **34** and **35**. Rows **31** and **34** having a coating of elastic material **36** are phased forwardly of rows **32** and **33** by α_1 and row **35**, also having a coating of elastic material **36**, is forwardly phased from rows **32** and **33** by α_2, α_2 being approximately twice α_1. The sprocket wheel of FIGS. 9 and 10 will thusly have three contact actions with a chain roller, first by sprockets **35**, then by sprockets **31** and **34** ,and last by sprockets **32** and **33**.

FIGS. 11 and 12 show a multi-row sprocket wheel of the second embodiment of the invention. This sprocket wheel also has five rows of sprockets **41**, **42**, **43**, **44** and **45**. Row **44** has a coating of elastic material **46** and has a bottom diameter greater than that of rows **42**, **43** and **45** by an amount Δd_1. Row **41** also has a coating of elastic material **46** and has a bottom diameter greater than that of row **44** by an amount Δd_2, Δd_1 being approximately equal to Δd_2. The sprocket wheel of FIGS. 11 and 12 will thus have three contact actions with a chain roller, first by sprocket **41**, then by sprocket **44**, and last by sprockets **42**, **43** and **45**.

Similar multi-row sprocket wheels may be provided having a number of rows different than five. Furthermore, the number of contact actions may be other than three. For instance, each row may be spaced, either by phase or by bottom diameter, from every other row. The number of contact actions would then equal the number of rows. Or, alternate rows of sprockets may be equally spaced, either by phase or by bottom diameter, thereby creating two contact actions. It will be apparent that many such arrangements may be provided.

FIG. 13 shows a single row sprocket wheel of the second embodiment of the present invention. The single row of sprockets is divided in the direction of sprocket width to form two contact surfaces. Contact surface **51** comprises an elastic material and has a bottom diameter greater than the bottom diameter of contact surface **52** by an amount Δd. A single row sprocket wheel divided in the direction of sprocket width may also be constructed according to the first embodiment of the invention. In such a sprocket wheel, the contact surface comprising the elastic material is phased forwardly of the other contact surface.

What is claimed is:

1. A sprocket wheel adapted to mesh with a sprocket chain in a chain drive system, said sprocket wheel comprising a metal base having a plurality of sprockets spaced around the periphery thereof, said sprockets each having at least two surfaces adapted to be contacted by a roller of said sprocket chain, a first of said contact surfaces comprising a surface means of elastic material for causing a first contact action with said roller and a second of said contact surfaces being integral with said metal base for causing a second contact action with said roller, whereby the collision between said sprocket and said roller is cushioned, and the noise and vibration in said chain drive system is reduced.

2. A sprocket wheel as claimed in claim **1** wherein said wheel comprises a multi-row sprocket wheel, said surface means of elastic material consists of the sprocket surfaces of a portion of the rows of said wheel, and said contact

surface integral with said metal base consists of the sprocket surfaces of the remaining rows of said wheel.

3. A sprocket wheel as claimed in claim 2 wherein said portion of the rows of said wheel are out of phase in the direction of rotation of said wheel with said remaining rows of said wheel.

4. A sprocket wheel as claimed in claim 2 wherein said portion of the rows of said wheel have a greater bottom diameter than said remaining rows of said wheel.

5. A sprocket wheel as claimed in claim 1 wherein said wheel comprises a single row sprocket wheel, said wheel is divided into halves in the direction of sprocket width, said surface of elastic material consists of the sprocket surfaces of one of said halves of said divided wheel, and said contact surface means integral with said metal base consists of the sprocket surfaces of the other of said halves of said divided wheel.

6. A sprocket wheel as claimed in claim 5, wherein said one of said halves of said divided wheel is out of phase in the direction of rotation of said wheel with said other of said halves of said divided wheel.

7. A sprocket wheel as claimed in claim 5 wherein said one of said halves of said divided wheel has a greater bottom diameter than said other of said halves of said divided wheel.

8. A sprocket wheel as claimed in claim 1 wherein said surface means of elastic material is out of phase in the direction of rotation of said wheel with said contact surface integral with said metal base.

9. A sprocket wheel as claimed in claim 1 wherein said surface means of elastic material has a greater bottom diameter than said contact surface integral with said metal base.

10. A chain drive system having a driving sprocket, a driven sprocket and a drive chain mounted around said sprockets, said chain having slack therein; said driving sprocket having a first base wheel, a first surface formed of an elastic material and adapted to contact a first roller of said drive chain in a first contact action, and a second surface integral with said first base wheel and adapted to contact said first roller in a second contact action, said first surface being out of phase in the direction of rotation of said sprocket with said second surface; and said driven sprocket having a second base wheel, a third surface formed of an elastic material and adapted to contact a second roller of said drive chain in a third contact action, and a fourth surface integral with said second base wheel and adapted to contact said second roller in a fourth contact action, said fourth surface being out of phase in the direction of rotation of said sprocket with said third surface; whereby collision between the sprockets and chain is cushioned and the noise and vibration in said chain drive system is reduced.

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LEONARD H. GERIN, Primary Examiner

U.S. Cl. X.R.

74—409, 411, 440, 443