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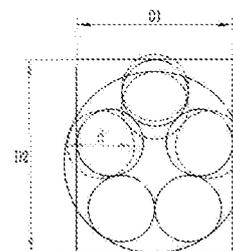
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STEEL CORD AND PRODUCTION METHOD THEREFOR, AND TIRE.

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The invention discloses a steel cord, a production method thereof, and a tire. The steel cord is formed by twisting multiple steel wires, wherein at least one of the steel wires is deformable to allow the cord to have an irregular surface morphology, and the irregular surface morphology is located at one or two symmetrical identical positions in an axial direction of the cord, such that a cross-section of the cord has a long axis and a short axis unequal to the long axis. The irregular surface morphology of the cord designed in the application is located at identical positions in the axial direction of the cord and destroys the uniform support state of steel wires in the circumferential direction of the cord, and it is difficult for the cord to maintain its original circular cross-section form in the subsequent stress relieving process, such that a flat cord can be produced; in the application, the flat cord is produced by means of the irregular surface morphology, so the production process is controllable, and the flat cord can be produced easily; and the rubber penetration rate of the cord can be increased by allowing the irregular surface morphology to be located on one or two sides of the cord.



STEEL CORD, PRODUCTION METHOD THEREOF, AND TIRE

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BACKGROUND OF THE INVENTION

[0001] 1. Technical Field

5 [0002] The invention relates to the technical field of steel cords, in particular to a steel cord, a production method thereof, and a tire.

[0003] 2. Description of Related Art

10 [0004] Automobiles have high requirements for the properties of tires during the driving process, especially for the orientation of the cords of tire belts. Generally, in the radial direction of tires, steel cords are desired to have a smaller rigidity, a higher flexibility and better softness to provide good comfort when automobiles drive on uneven roads; and in the axial direction of the tires, the cords of the tire belts are designed to have a larger rigidity to reduce hysteresis when the tires make turns, so as to improve the steering performance and maneuverability of automobiles.

15 [0005] Conventional steel cords generally have the same properties in the circumferential direction and thus cannot satisfy the requirements for different properties of the tire belts. Cords with different properties in different directions have to be processed by specific methods. US Patent No.US5223060A provides a flat steel cord with a 05 structure, which is manufactured by: producing a loose cord or a cord formed by steel wires having
20 large gaps therebetween; and after rubber is adhered to the cord, performing rubber extrusion and filling to change the cross-section of the cord in the rubber until the cord is flat in the rubber. Such a cord is difficult to control, and the rubber extrusion and filling process is uncontrollable.

25 [0006] How to provide a cord which has a high rubber penetration rate and is easy to produce is an issue under study.

BRIEF SUMMARY OF THE INVENTION

30 [0007] The objective of the invention is to provide a steel cord, a production method thereof, and a tire to solve the problems of a low rubber penetration rate and an uncontrollable production process of flat cords in the prior art.

[0008] To fulfill the above objective, the invention adopts the following technical solution:

[0009] In a first aspect, the invention discloses a steel cord, which is formed by twisting multiple steel wires, wherein at least one of the steel wires is deformable to allow the

cord to have an irregular surface morphology, and the irregular surface morphology is located at one or two symmetrical identical positions in an axial direction of the cord, such that a cross-section of the cord has a long axis and a short axis unequal to the long axis. LU506939

5 [0010] Further, the cord is a cord with a $1 \times n$ structure, a cord with a $1+n$ structure or a cord with a layered structure, and the number of steel wires in an outermost layer of the cord with the layered structure is n ; wherein, $n \geq 5$.

[0011] Further, at least one of untwisted steel wires of the cord has a periodic complex waveform, and the complex waveform comprises a first waveform and a second waveform overlaid on the first waveform.

10 [0012] Further, in a projection of each of the untwisted steel wires within unit cord length on the cross-section, unsmooth curves produced by the second waveform are in a same direction.

[0013] Further, within unit twist pitch, the second waveforms of all the untwisted steel wires are sequentially arranged in the axial direction of the cord.

15 [0014] Further, all the untwisted steel wires of the cord have the periodic complex waveform.

[0015] Further, an angle of a projection of the irregular surface morphology on the cross-section of the cord ranges from 0° to 180° .

20 [0016] Further, the angle of the projection of the irregular surface morphology on the cross-section of the cord ranges from 0° to 120° .

[0017] Further, a ratio of the long axis to the short axis ranges from 1 to 1.546.

[0018] Further, the ratio of the long axis to the short axis ranges from 1 to 1.394.

[0019] In a second aspect, the invention discloses a production method of the steel cord in the first aspect, comprising:

25 [0020] periodically deforming steel wires to allow the steel wires to have periodic complex waveforms after being twisted by a stranding machine; and

[0021] twisting at least one of the deformed steel wires and other steel wires to form the cord, wherein during the twisting process, the periodic waveforms of the steel wires are arranged at one or two symmetrical identical positions in an axial direction of the cord allow the cord to have an irregular surface morphology at the identical positions in the axial direction.

30 [0022] In a third aspect, the invention discloses a tire, comprising the steel cord in the first aspect.

[0023] Beneficial effects: the irregular surface morphology of the cord designed in the application is located at identical positions in the axial direction of the cord and destroys the uniform support state of steel wires in the circumferential direction of the cord, and it is difficult for the cord to maintain its original circular cross-section form in the subsequent stress relieving process, such that a flat cord, the cross-section of which has a long axis and a short axis unequal to the long axis, can be produced; in the application, the flat cord is produced by means of the irregular surface morphology, so the production process is controllable, and the flat cord can be produced easily; and the rubber penetration rate of the cord can be increased by allowing the irregular surface morphology to be located on one or two sides of the cord.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0024] FIG. 1 is a morphometric diagram of one cross-section of a cord with a 1×5 structure according to the invention;

[0025] FIG. 2 is a morphometric diagram of another cross-section of the cord with a 1×5 structure according to the invention;

[0026] FIG. 3 is a side view of the cord with a 1×5 structure according to the invention;

[0027] FIG. 4 is a schematic diagram of the morphology of untwisted steel wires within the last twist pitch of a conventional cord;

[0028] FIG. 5 is a schematic diagram of the morphology of untwisted steel wires within the last twist pitch of a cord according to the invention;

[0029] FIG. 6(a) and FIG. 6(b) are respectively a top view of an irregular surface morphology of the cord with a 1×5 structure and a morphometric diagram of the cross-section of the cord with a 1×5 structure according to the invention;

[0030] FIG. 7(a) and FIG. 7(b) are respectively a top view of an irregular surface morphology of a cord with a 1×6 structure and a morphometric diagram of the cross-section of the cord with a 1×6 structure according to the invention;

[0031] FIG. 8(a) and FIG. 8(b) are respectively a schematic diagram of the morphology of one untwisted steel wire of the conventional cord and a schematic diagram of the projection of the steel wire on the cross-section of the conventional cord;

[0032] FIG. 9(a) and FIG. 9(b) are respectively a schematic diagram of the morphology of one untwisted steel wire of the cord and a schematic diagram of the projection

of the steel wire on the cross-section of the cord according to the invention;

[0033] FIG. 10 is a schematic diagram of the projection of each untwisted steel wire on the cross-section of the cord with a 1×5 structure according to the invention;

5 [0034] FIG. 11 is a schematic diagram of a production device used for producing the cord according to the invention;

[0035] FIG. 12 is a schematic structural diagram of a pair of deformation gears of the deformation device in FIG. 11;

[0036] FIG. 13(a) and FIG. 13(b) are respectively a schematic diagram of a deformation device and an enlarged view of processed steel wires according to the invention;

10 [0037] FIG. 14(a) and FIG. 14(b) are respectively a schematic diagram of untwisted steel wires of the cord and a calculation diagram of the length of the untwisted steel wires.

DETAILED DESCRIPTION OF THE INVENTION

15 [0038] To gain a good understanding of the technical means, creative features, objectives and effects of the invention, the invention is further expounded below in conjunction with specific embodiments.

[0039] Embodiment 1

20 [0040] As shown in FIG. 1 to FIG. 10, a steel cord is formed by twisting multiple steel wires, wherein at least one of the steel wires is deformable to allow the cord to have an irregular surface morphology, and the irregular surface morphology is located at one or two symmetrical identical positions in an axial direction of the cord, such that a cross-section of the cord has a long axis and a short axis unequal to the long axis.

25 [0041] The irregular surface morphology of the cord designed in the application is located at identical positions in the axial direction of the cord and destroys the uniform support state of steel wires in the circumferential direction of the cord, and it is difficult for the cord to maintain its original circular cross-section form in the subsequent stress relieving process, such that a flat cord, the cross-section of which has a long axis and a short axis unequal to the long axis, can be produced; in the application, the flat cord is produced by means of the irregular surface morphology, so the production process is controllable, and the
30 flat cord can be produced easily; and the rubber penetration rate of the cord can be increased by allowing the irregular surface morphology to be located on one or two sides of the cord.

[0042] In some further embodiments, at least one of entwisted steel wires of the cord has a periodic second waveform, which is overlaid on a periodic first waveform, and as

shown in FIG. 4, within one twist pitch, the second waveform and the first waveform may be referred to as a complex waveform. In a further embodiment, all the untwisted steel wires of the cord have the periodic second waveform. Untwisted steel wires of a conventional cord have only one waveform, and the distance between adjacent wave peaks or wave troughs is the twist pitch T of the cord.

[0043] The irregular surface morphology of the cord and the projection of the irregular surface morphology on the cross-section of the cord are determined by the morphology of the second waveform of the steel wires of the cord. As shown in FIG. 8(a) and FIG. 8(b), the projection of untwisted steel wires in the conventional cord on the cross-section of the cord is a circle. The projection of untwisted steel wires in the cord on the cross-section of the cord in the invention is a circle with an unsmooth curve, as shown in FIG. 9(a) and FIG. 9(b).

[0044] According to the cord in the invention, within the unit cord length, the unsmooth curves of the projections of the untwisted steel wires on the cross-section are in the same direction. For example, for a cord with a 1×5 structure, the morphology of each untwisted steel wire within unit cord length is shown in FIG. 3, the morphology of the five untwisted steel wires is manifested as an irregular surface morphology on the surface of the cord, and the projection of each untwisted steel wire on the cross-section is shown in FIG. 10.

[0045] According to the cord in the invention, for the cord with a 1×5 structure, the second waveforms of all the untwisted steel wires within unit twist pitch are sequentially arranged in the axial direction of the cord, as shown in FIG. 5.

[0046] The cord in the invention may be a cord with a $1 \times n$ structure, a cord with a $1+n$ structure or a cord with a layered structure, and the number of steel wires in an outermost layer of the cord with the layered structure is n ; wherein, $n \geq 5$. As shown in FIG. 7(a) and FIG. 7(b), the invention further provides a side view of a cord with a 1×6 structure and a morphometric diagram of the cross-section of the cord with a 1×6 structure.

[0047] Further, the angle of a projection of the irregular surface morphology on the cross-section of the cord ranges from 0° to 180° . Further, the angle of the projection of the irregular surface morphology on the cross-section of the cord ranges from 0° to 120° . In some embodiments where the cord has a 1×5 or $1+5$ structure, the ratio of the long axis to the short axis of the cross-section of the cord ranges from 1 to 1.394. In some embodiments where the cord has a 1×6 or $1+6$ structure, the ratio of the long axis to the short axis of the cross-section of the cord ranges from 1 to 1.46.

Long axis/short axis	1.05	1.18	1.19	1.05	1.19	1.23
Twist pitch mm	12.5	12.5	12.5	16	16	16
Pre-deformation period L	/	12.6	12.6	/	16.1	16.1
α°	/	80	121.5	/	86	142
Comparison of breaking loads	100%	90%	98%	100%	96%	100%
Ratio of bending rigidity in the long-axis direction to the bending rigidity in the short-axis direction after rubber adhesion	1.0	1.35	1.30	1.0	1.29	1.33
Rubber penetration rate % measured by the pressure drop method	0	100%	100%	0	100%	100%
Comparison of breaking elongation	100%	87%	86%	100%	85%	87%

[0055] With a 1×6×0.30 flat cord as an example, steel wires with different periodic deformations before twisting can be obtained using different deformation gears, and the performance indicators of cords obtained after twisting are shown in Table 2.

[0056] Table 2

	Comparative example 1	Embodiment 1	Embodiment 2
Specification	6×0.30	6×0.30	6×0.30
Long axis/short axis	1.05	1.35	1.40
Twist pitch mm	16	16	16
Pre-deformation period L	/	8.05	8.05
α°	/	78.5	118

Comparison of breaking loads	100%	95%	100%
Ratio of bending rigidity in the long-axis direction to the bending rigidity in the short-axis direction after rubber adhesion	1.0	1.54	1.61
Rubber penetration rate % measured by the pressure drop method	0	100%	100%
Comparison of breaking elongation	100%	86%	87%

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[0057] It can be clearly seen, from Table 1 and Table 2, that compared with cords in the prior art, the cord in the invention shows good rubber penetration performance and discrepancy in bending rigidity in different directions of the cord. Although, there is a risk of reducing the strength of the cord, this risk can be avoided by corresponding approaches, for example, by adjusting the tooth form of deformation gears, increasing the wave height and length of deformed steel wires, reducing the bending radius of steel wires during periodic pre-deformation, so as to reduce a strength loss of pre-deformed steel wires after twisting. The increase of the pre-deformation wave length will increase the length AB of the irregular surface morphology of the cord after twisting (the section AB in FIG. 6), thus increasing the angle α . The breaking elongation of the cord provided by the application is reduced.

[0058] Still with the 1×5×0.30 flat cord as an example, the performance indicators of cords obtained by the production method in the inventio are shown in Table 3.

[0059] Table 3

	Comparative example	Embodiment
Specification	5×0.30	5×0.30
Long axis/short axis	1.17	1.19
Twist pitch mm	18.2	18.3
Pre-deformation period L	/	18.2
α°	/	135
Comparison of breaking loads	100%	98%
Ratio of bending rigidity in the long-axis direction to the bending rigidity in the short-axis direction after rubber adhesion	1.29	1.30
Rubber penetration rate % measured by the	100%	100%

pressure drop method		
Comparison of breaking elongation	100%	95%
Comparison of adhesive and peeling force	100%	110%

[0060] Data in Table 3 indicate that compared with flat cords in the prior art, the cord in the invention has a high adhesive and peeling force under the mechanical meshing effect of the irregular surface state of the cord.

[0061] Embodiment 2

5 [0062] The invention further discloses a production method of a steel cord. The production method comprises the following steps: periodically deforming steel wires to allow the steel wires to have periodic complex waveforms after being twisted by a stranding machine; and twisting at least one of the deformed steel wires and other steel wires to form the cord, wherein during the twisting process, the periodic waveforms of the steel wires are
10 arranged at one or two symmetrical identical positions in an axial direction of the cord allow the cord to have an irregular surface morphology at the identical positions in the axial direction. The method can be used for producing the cord disclosed in Embodiment 1.

[0063] In the application, in the step of twisting at least one of the deformed steel wires and other steel wires to form the cord, the other steel wires may be steels which are
15 periodically deformed in the application or steel wires not periodically deformed.

[0064] Further, periodically deforming steel wires refers to periodically deforming the steel wires in a length direction, and the periodic length is $0.5L$ or L . Wherein, L is the length of untwisted steel wires of the cord.

[0065] In the invention, the steel wires are periodically deformed by means of a
20 deformation device 1, part of tooth structures of which are arranged periodically, as shown in FIG. 11 and FIG. 13.

[0066] The range of the irregular morphology on the surface of the cord is controlled by the tooth form of the deformation device 1. When the tooth form is large, the length of the second waveform is large, and the angle of the projection of the deformed region on the
25 cross-section of the cord is large. Similarly, when the tooth form is large, the curvature radius of the bending deformation of the steel wires is relatively large, so after the steel wires are twisted, the loss of the breaking force of the steel wires during the twisting process will not be increased, and the breaking force of the cord is basically the same as that of conventional cords.

30 [0067] As shown in FIG. 14(a) and FIG. 14(b), the length L of the untwisted steel

wires of the cord is calculated by:

$$L = \sqrt{T^2 + [\pi(D - d)]^2}$$

[0068]

[0069] Where, T is the twist pitch, D is the diameter of the cord, and the diameter D of an irregular cord is a mean value of the maximum diameter and the minimum diameter of the irregular cord, and d is the diameter of the steel wires.

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[0070] Similarly, a cord with a 1×n structure, a cord with a 1+n structure or a cord with a layered structure can also be produced by the above method, wherein the number of steel wires in an outermost layer of the cord with the layered structure is n, and $n \geq 5$.

[0071] As shown in FIG. 11 which is a schematic diagram of the production method of the flat cord of the invention, steel wires from paying-off units are periodically pre-deformed by the pre-deformation device 1 and then twisted together at a twisting point. FIG. 12 is a schematic structural diagram of one pair of deformation gears (an upper deformation gear 11 and a lower deformation gear) of the deformation device 1, and the actual number of pairs of deformation gears can be set according to the number of steel wires to be deformed. Because the positions of the second waveforms of the steel wires of the cord are periodically controlled, the second waveforms on the steel wires are regularly arranged on one side of the cord to form an irregular surface morphology of the cord when the steel wires are twisted to form the cord, and a flat structure is formed on this side when a straightener is used for relieving the stress of the cord later.

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[0072] Embodiment 3

[0073] Based on the steel cord provided in Embodiment 1, the application further provides a tire comprising the steel cord in Embodiment 1.

[0074] It can be known, based on technical knowledge, that the invention can also be implemented by other embodiments without departing from the essential spirit or necessary features of the invention. Therefore, in all aspects, the above embodiments are merely illustrative ones rather than unique ones. All variations made within the scope of the invention or its equivalents should be included in the invention.

25

CLAIMS

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1. A steel cord, being formed by twisting multiple steel wires, wherein at least one of the steel wires is deformable to allow the cord to have an irregular surface morphology, and the irregular surface morphology is located at one or two symmetrical identical positions in an axial direction of the cord, such that a cross-section of the cord has a long axis and a short axis unequal to the long axis.
2. The steel cord according to Claim 1, wherein the cord is a cord with a $1 \times n$ structure, a cord with a $1+n$ structure or a cord with a layered structure, and the number of steel wires in an outermost layer of the cord with the layered structure is n ; wherein, $n \geq 5$.
3. The steel cord according to Claim 1 or 2, wherein at least one of untwisted steel wires of the cord has a periodic complex waveform, and the complex waveform comprises a first waveform and a second waveform overlaid on the first waveform.
4. The steel cord according to Claim 3, wherein in a projection of each of the untwisted steel wires within unit cord length on the cross-section, unsmooth curves produced by the second waveform are in a same direction.
5. The steel cord according to Claim 3, wherein within unit twist pitch, the second waveforms of all the untwisted steel wires are sequentially arranged in the axial direction of the cord.
6. The steel cord according to Claim 3, wherein all the untwisted steel wires of the cord have the periodic complex waveform.
7. The steel cord according to Claim 1, wherein an angle of a projection of the irregular surface morphology on the cross-section of the cord ranges from 0° to 180° .
8. The steel cord according to Claim 7, wherein the angle of the projection of the irregular surface morphology on the cross-section of the cord ranges from 0° to 120° .

9. The steel cord according to Claim 1, wherein a ratio of the long axis to the short axis ranges from 1 to 1.546. LU506939

10. The steel cord according to Claim 9, wherein the ratio of the long axis to the short axis ranges from 1 to 1.394.

11. A production method of the steel cord according to any one of Claims 1-10, comprising:
periodically deforming steel wires to allow the steel wires to have periodic complex waveforms after being twisted by a stranding machine; and
twisting at least one of the deformed steel wires and other steel wires to form the cord, wherein during the twisting process, the periodic waveforms of the steel wires are arranged at one or two symmetrical identical positions in an axial direction of the cord allow the cord to have an irregular surface morphology at the identical positions in the axial direction.

12. A tire, comprising the steel cord according to any one of Claims 1-10.

ANSPRÜCHE

1. Stahlseil, das durch Verdrillen mehrerer Stahldrähte gebildet wird, wobei mindestens einer der Stahldrähte verformbar ist, um zu ermöglichen, dass das Seil eine unregelmäßige Oberflächenmorphologie aufweist, und die unregelmäßige Oberflächenmorphologie an einer oder zwei symmetrischen identischen Positionen in einer axialen Richtung des Seils angeordnet ist, so dass ein Querschnitt des Seils eine lange Achse und eine kurze Achse ungleich der langen Achse aufweist.
2. Stahlkord nach Anspruch 1, wobei der Kord ein Kord mit einer $1 \times n$ -Struktur, ein Kord mit einer $1+n$ -Struktur oder ein Kord mit einer geschichteten Struktur ist und die Anzahl der Stahldrähte in einer äußersten Schicht des Kords mit der geschichteten Struktur n ist; wobei $n \geq 5$.
3. Stahlseil nach Anspruch 1 oder 2, wobei mindestens einer der unverdrillten Stahldrähte des Seils eine periodische komplexe Wellenform aufweist und die komplexe Wellenform eine erste Wellenform und eine zweite Wellenform umfasst, die der ersten Wellenform überlagert ist.
4. Stahlkord nach Anspruch 3, wobei in einer Projektion jedes der unverdrillten Stahldrähte innerhalb einer Einheitscordlänge auf den Querschnitt die durch die zweite Wellenform erzeugten ungleichmäßigen Kurven in derselben Richtung verlaufen.
5. Stahlkord nach Anspruch 3, wobei die zweiten Wellenformen aller unverdrillten Stahldrähte innerhalb der Einheits-Drallsteigung in axialer Richtung des Cords nacheinander angeordnet sind.
6. Stahlseil nach Anspruch 3, wobei alle unverdrillten Stahldrähte des Seils die periodische komplexe Wellenform aufweisen.
7. Stahlseil nach Anspruch 1, wobei ein Winkel einer Projektion der unregelmäßigen Oberflächenmorphologie auf den Querschnitt des Seils im Bereich von 0° bis 180° liegt.

8. Stahlseil nach Anspruch 7, wobei der Winkel der Projektion der unregelmäßigen Oberflächenmorphologie auf den Querschnitt des Seils im Bereich von 0° bis 120° liegt.

9. Stahlseil nach Anspruch 1, wobei das Verhältnis der langen Achse zur kurzen Achse im Bereich von 1 bis 1,546 liegt.

10. Stahlseil nach Anspruch 9, wobei das Verhältnis der langen Achse zur kurzen Achse im Bereich von 1 bis 1,394 liegt.

11. Verfahren zur Herstellung eines Stahlcords nach einem der Ansprüche 1 bis 10, umfassend: periodisches Verformen von Stahldrähten, um zu ermöglichen, dass die Stahldrähte periodische komplexe Wellenformen aufweisen, nachdem sie durch eine Verseilmaschine verdrillt wurden; und

Verdrillen mindestens eines der verformten Stahldrähte und anderer Stahldrähte, um das Seil zu bilden, wobei während des Verdrillens die periodischen Wellenformen der Stahldrähte an einer oder zwei symmetrischen identischen Positionen in einer axialen Richtung des Seils angeordnet sind, so dass das Seil eine unregelmäßige Oberflächenmorphologie an den identischen Positionen in der axialen Richtung aufweist.

12. Reifen, umfassend den Stahlkord nach einem der Ansprüche 1-10.

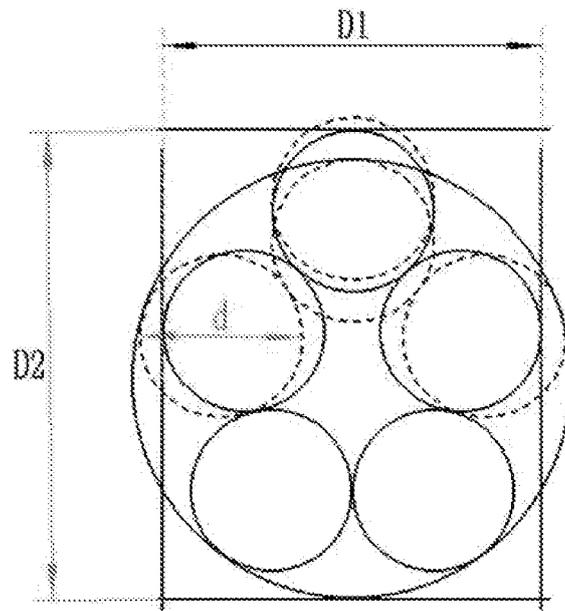


FIG. 1

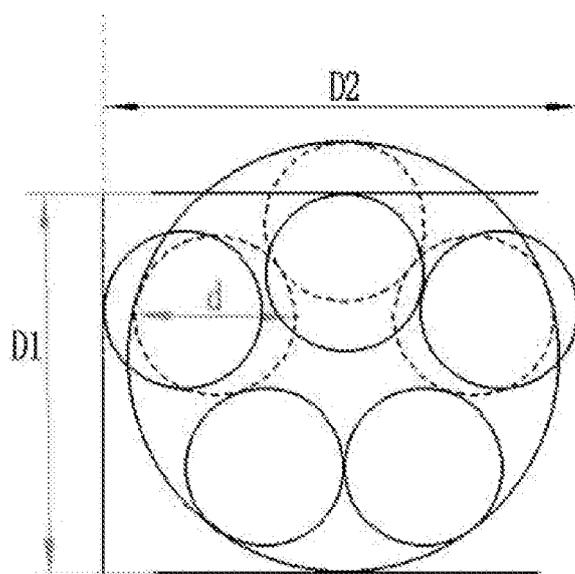


FIG. 2

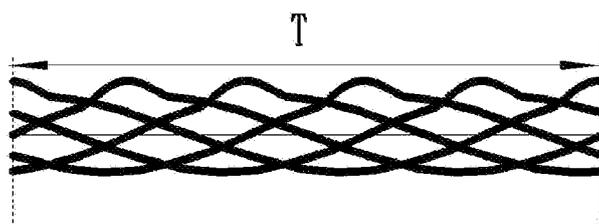


FIG. 3

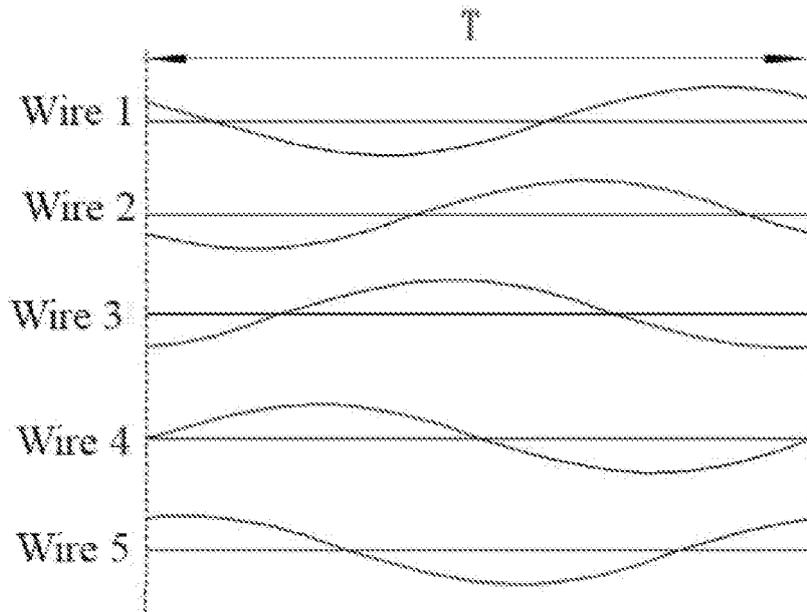


FIG. 4

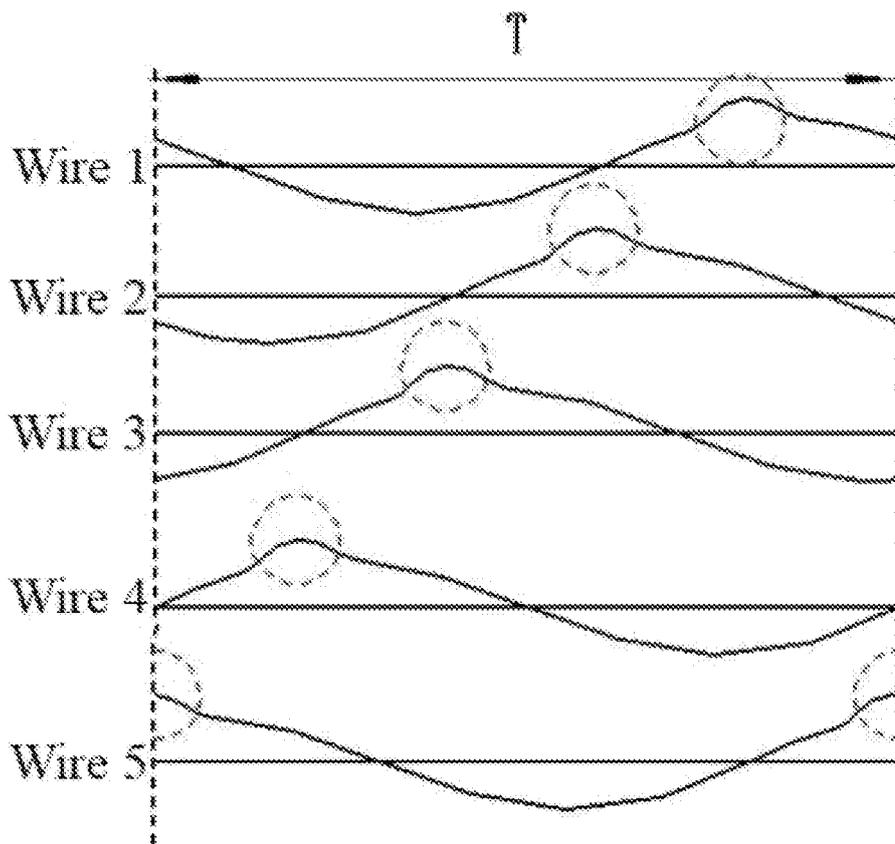


FIG. 5



FIG. 6

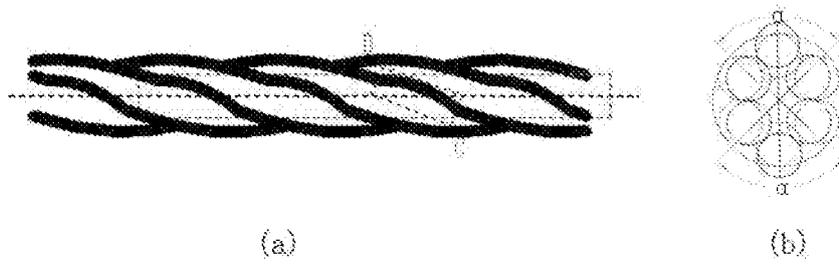


FIG. 7

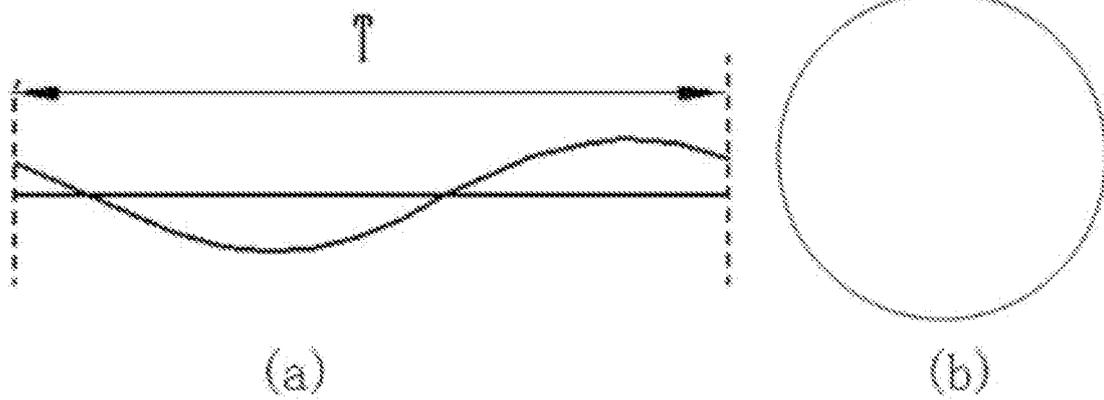


FIG. 8

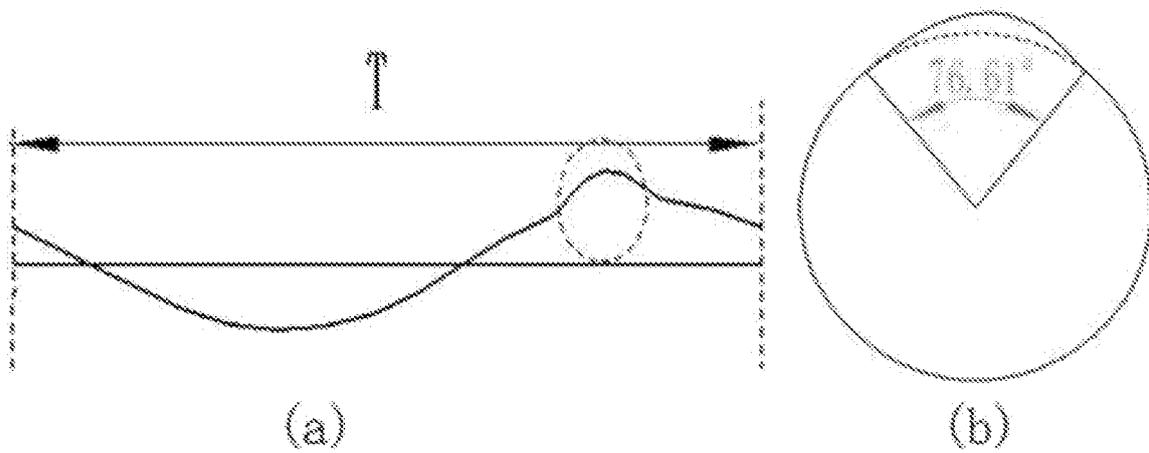


FIG. 9

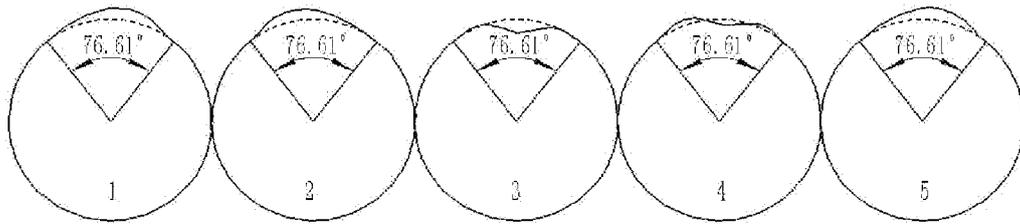


FIG. 10

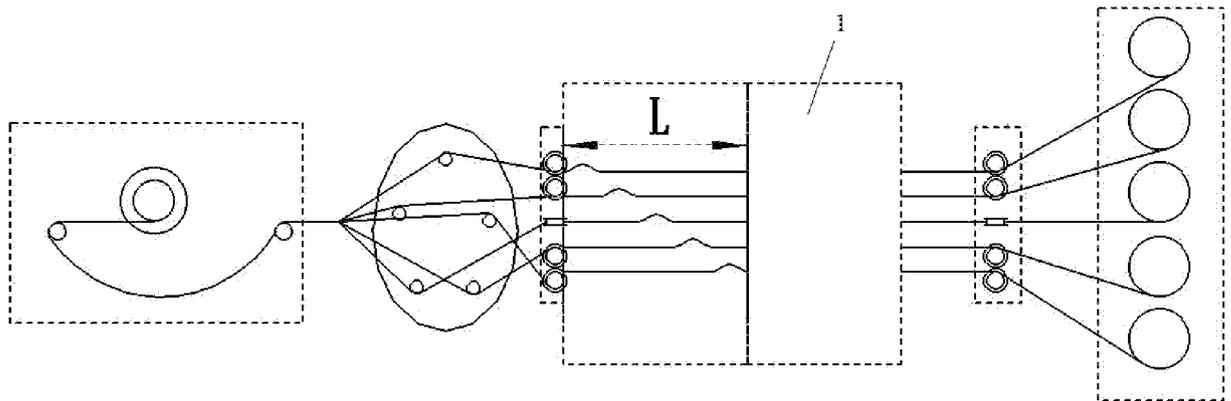


FIG. 11

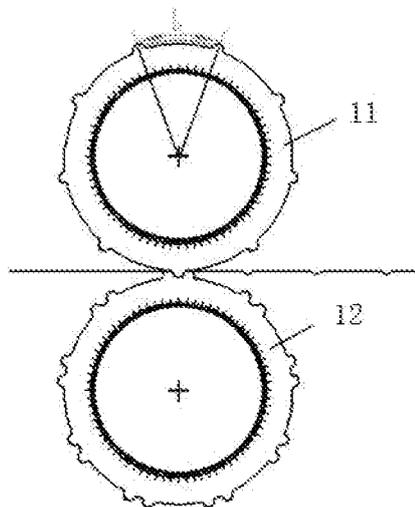


FIG. 12

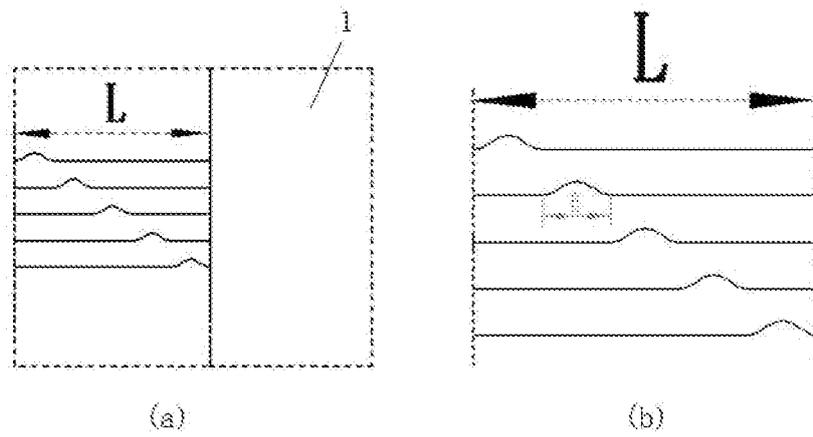


FIG. 13

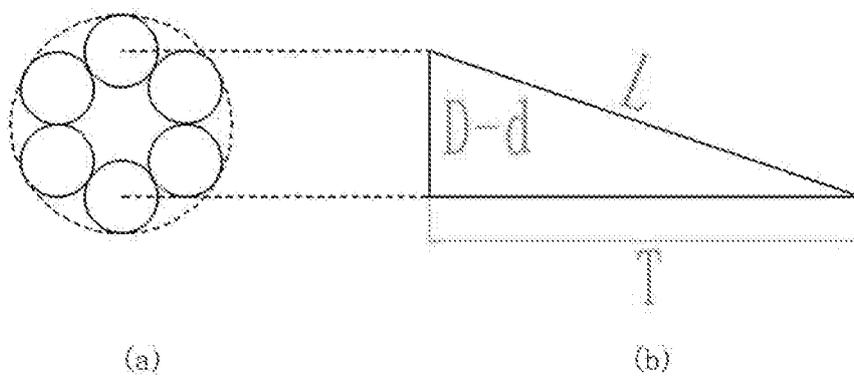


FIG. 14