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(54) ROLL CRUSHER OF COOLER DEVICE

WALZENBRECHER FÜR EINE KÜHLERVORRICHTUNG

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EP 3 345 680 B2

Description

Technical Field

[0001] The present invention relates to a roll crusher of a cooler apparatus for cooling down a high-temperature granular conveyed material, such as granular cement clinker, while conveying the granular conveyed material.

Background Art

[0002] A cement plant is equipped with a cooler apparatus that conveys high-temperature cement clinker produced through preheating, calcination, and firing in a conveying direction while cooling down the cement clinker. One example of such a cooler apparatus is a cooler disclosed by Patent Literature 1. In the cooler of Patent Literature 1, clinker is conveyed through a cooling unit while being cooled down therein, and the clinker is discharged from the cooling unit at its discharge end. The cooler includes four rolls that are positioned near the discharge end and that extend orthogonally to the conveying direction. Among the four rolls, three rolls positioned at the discharge end side make normal rotation (i.e., forward rotation in the conveying direction). The fourth roll is a reversely rotating roll that makes reverse rotation. Massive clinker is sandwiched between the reversely rotating roll and its adjacent roll, and thereby compression-crushed. CN 104525310 A discloses a roll crusher according to the preamble of claim 1.

Citation List

Patent Literature

[0003] PTL 1: Japanese Laid-Open Patent Application Publication No. S61-295264

Summary of Invention

Technical Problem

[0004] In relation to the four rolls disclosed in Patent Literature 1, it is conceivable to form a plurality of teeth on the outer peripheral surfaces of the four rolls in order to crush the clinker more efficiently. By rotating such rolls, the clinker discharged from the discharge end is crushed with the teeth. In such a configuration, when the clinker is crushed with the teeth, loads are exerted on the rolls. When the clinker is crushed with the teeth at multiple positions on the rolls at the same time, the loads on the rolls increase extremely only in a particular period. For this reason, a rotating machine capable of rotating the rolls even when great loads are exerted on the rolls, i.e., a rotating unit such as an electric motor capable of generating great driving force, is required. The external dimensions and power consumption of such a rotating unit capable of generating great driving force are great. Therefore, in order to reduce the size and power consumption of the rotating unit, it is desired to suppress the roll load from increasing extremely only in a particular period.

[0005] In view of the above, an object of the present invention is to provide a roll crusher of a cooler apparatus, the roll crusher being capable of leveling out temporal changes in the roll load.

Solution to Problem

[0006] According to the present invention, the above object is achieved by a roll crusher of a cooler apparatus as laid down in claim 1.

[0007] According to the present invention, the plurality of crushing teeth of the at least one crushing ring are arranged such that they are shifted in the circumferential direction. Therefore, when the roll is rotated, the timing at which a crushing load exerted on the crushing ring whose crushing teeth are shifted in the circumferential direction becomes great, and the timing at which a crushing load exerted on the other crushing ring(s) becomes great, can be shifted relative to each other. This makes it possible to level out temporal changes in the load exerted on the load-reducing roll, and as a result, temporal changes in the load on the rotating unit can be leveled out.

[0008] In the above invention, the plurality of crushing teeth may be arranged on the outer peripheral surface of each crushing ring at a predetermined pitch, such that the plurality of crushing teeth of each crushing ring are shifted by 1/n (where n is an integer of not less than 2) of the pitch in the circumferential direction toward one side relative to the plurality of crushing teeth of the crushing ring that is adjacent to the each crushing ring in an axial direction in which the axes extend.

[0009] According to the above configuration, the crushing teeth are arranged in the axial direction to form teeth lines, and each teeth line is formed in a manner to twist in the circumferential direction toward the one side. Accordingly, by rotating the load-reducing roll, the granular conveyed material in a massive form that has not been crushed and that remains on the roll can be passed in the axial direction toward one side. By passing the massive granular conveyed material in this manner, the remaining massive granular conveyed material can be brought into collision with another massive granular conveyed material, and thereby the massive granular conveyed materials can be crushed. Also, by thus passing the granular conveyed material, the granular conveyed material remaining on the roll can be guided to a gap in which the granular conveyed material can be caught successfully. Thus, even the granular conveyed material with a large grain diameter can be caught in the gap successfully.

[0010] In the above invention, the load-reducing roll may include a shaft that extends in the axial direction and that is rotated about the axis of the load-reducing roll by the corresponding rotating unit. The shaft may include, on an outer peripheral surface thereof, one of an engaging piece and an engaged groove that extend in the axial direction and that are engageable with each other, Each of the plurality of crushing rings may include, on an inner peripheral surface thereof, the other of the engaging piece and the engaged groove, and when the engaging piece and the engaged groove engage with each other, the plurality of crushing rings may be externally attached to the shaft such that the plurality of crushing rings are non-displaceable relative to the shaft in the circumferential direction. The plurality of crushing rings may include a first crushing ring and a second crushing ring. The first crushing ring may include a first reference tooth that is one of the plurality of crushing teeth. The second crushing ring may include a second reference tooth that is one of the plurality of crushing teeth. The first reference tooth may be positioned on a line that connects between a center of the first crushing ring and a center of the other of the engaging piece and the engaged groove. The second reference tooth may be disposed such that the second reference tooth is shifted relative to the first reference tooth in the circumferential direction by $360 / (n \times N)$ degrees (where N is the number of teeth of the second crushing ring).

[0011] According to above configuration, by reversing the second crushing ring, the reversed second crushing ring can be used as a crushing ring whose crushing teeth are arranged such that they are shifted relative to the crushing teeth of the first crushing ring by $360 \times (n - 1) / (n \times N)$ degrees (i.e., as a crushing ring whose crushing teeth are shifted relative to the crushing teeth of the first crushing ring in the circumferential direction toward the one side by (n-1) / n of the pitch). Therefore, the number of types of molds for manufacturing the crushing rings can be made less than the number of types of crushing rings to be used, and thereby the manufacturing cost can be reduced.

[0012] In the above invention, the plurality of crushing teeth may include a high tooth and a low tooth, the high tooth being the crushing tooth with a first height, the low tooth being the crushing tooth with a second height lower than the first height.

[0013] According to the above configuration, since the low tooth is formed, the granular conveyed material in a large massive form that cannot be caught with the high tooth can be caught and crushed with the low tooth. This makes it possible to lower the possibility that the granular conveyed material in a large massive form does not get caught between the rolls and remains on the rolls.

[0014] In the above invention, high teeth forming portions, in each of which a plurality of the high teeth are arranged in the circumferential direction, and low teeth forming portions, in each of which a plurality of the low teeth are arranged in the circumferential direction, may be present on an outer peripheral surface of the load-reducing roll, and the high teeth forming portions and the low teeth forming portions may be arranged in a staggered manner.

[0015] According to the above configuration, at the time of crushing, since the low teeth and the high teeth are arranged alternately in the axial direction between the rolls, temporal changes in the load exerted on the load-reducing roll can be leveled out, and as a result, temporal changes in the load on the rotating unit can be leveled out.

[0016] In the above invention, the load-reducing roll may include a shaft that extends in an axial direction in which the axis of the load-reducing roll extends, the shaft being rotated about the axis by the corresponding rotating unit. The plurality of crushing teeth may be arranged on the outer peripheral surface of each crushing ring at the regular intervals at a predetermined pitch, such that the plurality of crushing teeth of each crushing ring are shifted by 1/2 of the pitch in the circumferential direction toward one side relative to the plurality of crushing teeth of the crushing ring that is adjacent to the each crushing ring in the axial direction. The shaft may include, on an outer peripheral surface thereof, one of an engaging piece and an engaged groove that extend in the axial direction and that are engageable with each other. Each of the plurality of crushing rings may include, on an inner peripheral surface thereof, the other of the engaging piece and the engaged groove, and when the engaging piece and the engaged groove engage with each other, the plurality of crushing rings may be externally attached to the shaft such that the plurality of crushing rings are non-displaceable relative to the shaft in the circumferential direction. The high teeth forming portions, in each of which at least two of the high teeth are arranged, and the low teeth forming portions, in each of which at least two of the low teeth are arranged, may be present on the outer peripheral surface of each crushing ring. The plurality of crushing rings may include a first crushing ring and a second crushing ring. The first crushing ring may include a first reference tooth that is one of the plurality of crushing teeth and that is positioned on a line that connects between a center of the first crushing ring and a center of the other of the engaging piece and the engaged groove, and on the outer peripheral surface of the first crushing ring, the high teeth forming portions and the low teeth forming portions may be arranged alternately in the circumferential direction with reference to the first reference tooth. The second crushing ring may include a second reference tooth that is one of the plurality of crushing teeth and that is disposed such that the second reference tooth is shifted relative to the first reference tooth in the circumferential direction toward the one side by 1/2 of the pitch, and on the outer peripheral surface of the second crushing ring, the high teeth forming portions and the low teeth forming portions may be arranged alternately in the circumferential direction with reference to the second reference tooth. The first crushing ring and the second crushing ring may be formed such that each of the first crushing ring and the second crushing ring is rotationally symmetrical with respect to the axis.

[0017] According to the above configuration, the first crushing ring and the second crushing ring in a normal orientation are externally attached to the shaft, and adjacently thereto, the first crushing ring and the second crushing ring in a reverse orientation are externally attached to the shaft; and this externally attaching process is repeated. In this manner, the load-reducing roll can be manufactured, in which the crushing teeth are shifted by 1/2 of the pitch between every adjacent crushing rings, and the high teeth regions and the low teeth regions are arranged in a staggered manner. Even though four types of crushing rings are used in the manufacturing of the load-reducing roll, these crushing rings can be manufactured by using only two types of molds, and thereby the manufacturing cost can be reduced.

[0018] The plurality of rolls include at least two load-reducing rolls that are adjacent to each other. Each of the adjacent load-reducing rolls includes the crushing rings such that the shift amount by which the plurality of crushing teeth are shifted in the circumferential direction differs between the adjacent load-reducing rolls.

[0019] The configuration according to the invention makes it possible to further level out temporal changes in the loads exerted on the load-reducing rolls, and as a result, temporal changes in the loads on the rotating units can be further leveled out.

Advantageous Effects of Invention

[0020] The present invention makes it possible to level out temporal changes in the roll load.

Brief Description of Drawings

[0021]

Fig. 1 is a schematic diagram showing the configuration of a cement plant equipped with a cooler apparatus according to the present invention.

Fig. 2 is a perspective view schematically showing the configuration of the cooler apparatus of Fig. 1.

Fig. 3 is a perspective view showing a roll crusher of the cooler apparatus of Fig. 2.

Fig. 4 is a front view showing a first crushing ring of a first roll of Fig. 3.

Fig. 5 is a front view showing part of the first crushing ring of the first roll of Fig. 3.

Fig. 6 is a front view showing a second crushing ring of the first roll of Fig. 3.

Fig. 7 is a front view showing part of the second crushing ring of the first roll of Fig. 4.

Fig. 8 is an enlarged perspective view showing part of the first roll of Fig. 3 in an enlarged manner.

Fig. 9 is a front view showing a first crushing ring of a second roll of Fig. 3.

Fig. 10 is a front view showing a second crushing ring of the second roll of Fig. 3.

Fig. 11 is a front view showing part of the second crushing ring of the second roll of Fig. 3.

Fig. 12 is an enlarged perspective view showing part of the second roll of Fig. 3 in an enlarged manner.

Description of Embodiments

[0022] Hereinafter, a cooler apparatus 1 according to one embodiment of the present invention is described with reference to the drawings. Directions mentioned in the description below are used for the sake of convenience of the description, but do not suggest that the orientation and the like of the components of the present invention are limited to such directions. The cooler apparatus 1 described below is merely one embodiment of the present invention. Therefore, the present invention is not limited to the embodiment below, and additions, deletions, and modifications can be made to the embodiment without departing from the present invention as defined by the claims.

[Embodiment 1]

<Cement Plant>

[0023] Cement is produced through the following steps: a raw meal grinding step of grinding cement raw meal containing limestone, clay, silica stone, iron, and so forth; a pyroprocessing step of firing the ground cement raw meal; and a finishing step that is the final step. These three steps are performed in a cement plant. In the pyroprocessing step, which is one of these three steps, the ground cement raw meal is fired and cooled down, and thereby granular cement clinker is produced. Fig. 1 shows a pyroprocessing facility 3 of the cement plant, and shows a part where the pyroprocessing step in cement manufacturing is performed. The pyroprocessing facility 3 performs preheating, calcination, and firing of the cement raw meal that has been ground in the raw meal grinding step, and cools down the granular cement clinker that is in a high-temperature state due to the firing.

[0024] The part where the pyroprocessing step is performed is hereinafter described in further detail. The pyroprocessing facility 3 includes a preheater 4, and the preheater 4 includes a plurality of cyclones 5. The cyclones 5 are arranged vertically in a staged manner. Each cyclone 5 causes exhaust gas therein to flow upward to the cyclone 5 of the upper stage (see dashed arrows in Fig. 1), separates cement raw meal fed therein by a swirl flow, and feeds the separated cement raw meal into the cyclone 5 of the lower stage (see solid arrows in Fig. 1). The cyclone 5 positioned immediately above the cyclone 5 of the lowermost stage feeds the cement raw meal into a precalciner 6. The precalciner 6 includes a burner. By heat from the burner and heat from exhaust gas described below, the precalciner 6 causes a reaction by which carbon dioxide is separated from the fed cement raw meal (i.e., calcination reaction). The cement raw meal subjected to the calcination reaction in the precalciner 6 is led to the cyclone 5 of the lowermost stage as described below, and the cement raw meal in the lowermost cyclone 5 is supplied to a rotary kiln 7.

[0025] The rotary kiln 7 is formed in a horizontally long cylindrical shape, and is several tens of meters long or longer. The rotary kiln 7 is disposed such that it is slightly inclined downward from an inlet positioned at the cyclone 5 side toward an outlet positioned at the forward end side. Therefore, by rotating the rotary kiln 7 about its axis, the cement raw meal present at the inlet side is conveyed toward the outlet side. A combustor 8 is provided at the outlet of the rotary kiln 7. The combustor 8 generates a high-temperature flame, and fires the cement raw meal.

[0026] Also, the combustor 8 injects high-temperature combustion gas toward the inlet side, and the combustion gas injected by the combustor 8 flows in the rotary kiln 7 toward the inlet while firing the cement raw meal. The combustion gas that flows as high-temperature exhaust gas forms a jet flow. The jet flow flows upward in the precalciner 6 from the lower end of the precalciner 6 (see dashed arrows in Fig. 1), and causes the cement raw meal fed in the precalciner 6 to flow upward. The cement raw meal is heated to about 900°C by the exhaust gas and the burner, that is, the cement raw meal is calcined. The cement raw meal flowing upward flows together with the exhaust gas into the cyclone 5 of the lowermost stage, in which the exhaust gas and the cement raw meal that have flowed therein are separated from each other. The separated cement raw meal is supplied to the rotary kiln 7, and the separated exhaust gas is caused to flow upward to the cyclone 5 positioned immediately above the cyclone 5 of the lowermost stage. The exhaust gas flowing upward exchanges heat, in each cyclone 5, with the cement raw meal fed therein to heat the cement raw meal. Then, the exhaust gas is separated from the cement raw meal again. The separated exhaust gas flows further upward to the cyclone 5 positioned above to repeat the heat exchange. Then, the exhaust gas is discharged to the atmosphere from the cyclone 5 of the uppermost stage.

[0027] In the pyroprocessing facility 3 configured as above, the cement raw meal is fed therein at a position near the cyclone 5 of the uppermost stage; the fed cement raw meal is sufficiently preheated while exchanging heat with the exhaust gas, and moves downward to the cyclone 5 positioned immediately above the cyclone 5 of the lowermost stage; and then the cement raw meal is fed into the precalciner 6. In the precalciner 6, the cement raw meal is calcined by the burner and the high-temperature gas. Thereafter, the cement raw meal is led to the cyclone 5 of the lowermost stage, in which the cement raw meal is separated from the exhaust gas and supplied to the rotary kiln 7. The supplied cement raw meal is conveyed toward the outlet side while being subjected to the firing in the rotary kiln 7. As a result of performing the preheating, calcination, and firing in this manner, the cement clinker is formed. The cooler apparatus 1 is provided at the outlet of the rotary kiln 7, and the formed cement clinker is discharged from the outlet of the rotary kiln 7 to the cooler apparatus 1.

<Cooler Apparatus>

[0028] The cooler apparatus 1 is configured to cool down the cement clinker (high-temperature granular conveyed material) discharged from the rotary kiln 7 while conveying the cement clinker in a predetermined conveying direction. A fixed inclined grate 11 is disposed immediately under the outlet of the rotary kiln 7. The fixed inclined grate 11 is inclined downward in the conveying direction from the outlet side of the rotary kiln 7. The granular cement clinker discharged from the outlet of the rotary kiln 7 falls in the conveying direction in a manner to roll down on the fixed inclined grate 11. At the forward end of the fixed inclined grate 11 in the conveying direction, a plurality of cooling grate lines 13 are provided. The cement clinker is deposited on the plurality of cooling grate lines 13 and forms a clinker bed 14. The cooling grate lines 13 are structures each extending in the conveying direction, and are arranged side by side adjacently to each other in a lateral direction orthogonal to the conveying direction (hereinafter, the lateral direction is also referred to as "the orthogonal direction"). The clinker bed 14 lies on the plurality of cooling grate lines 13, such that the clinker bed 14 entirely covers the plurality of cooling grate lines 13 (see two-dot chain lines in Fig. 2).

[0029] The cooling grate lines 13 configured as above include a truck that is not shown, and are movable toward one side and the other side in the conveying direction. The cooling grate lines 13 are moved and stopped repeatedly, and thereby the granular cement clinker is conveyed. Specific examples of the conveyance method include: a method in which all the cooling grate lines 13 arranged in the orthogonal direction are moved forward, and then non-adjacent cooling grate lines 13 are moved backward a plurality of times separately; and a method in which a cross bar extending in the orthogonal direction is provided above the cooling grate lines 13, and the cross bar is moved in the conveying direction to feed the clinker bed 14 in the conveying direction. It should be noted that the configuration for and the method of feeding the clinker bed 14 in the conveying direction are not limited to the above-described examples, but may be any configuration and method, so long as the clinker bed 14 can be fed in the conveying direction. The cement clinker conveyed in this manner falls downward from the forward end of the cooling grate lines 13. A roll crusher 15 is disposed immediately under the forward end of the cooling grate lines 13.

[0030] As shown in Fig. 3, the roll crusher 15 is intended for crushing the cement clinker falling from the forward end of the cooling grate lines 13 into finer pieces. The roll crusher 15 includes four load-reducing rolls (hereinafter, simply referred to as "rolls") 15a to 15d. The four rolls 15a to 15d are columnar rod-shaped components each extending in the orthogonal direction, and are rotatably supported by a bearing mechanism that is not shown, such that the four rolls 15a to 15d are rotatable about their respective central axes, which are rotational axes L1 to L4. The four rolls 15a to 15d are arranged side by side in the conveying direction, such that their respective rotational axes L1 to L4 are parallel to each other and are spaced apart from each other at predetermined intervals. Each of the four rolls 15a to 15d is provided with a different rotating unit 17. The rotating units 17 are electric motors, and in accordance with commands inputted thereto, cause the corresponding rolls 15a to 15d to make normal rotation or reverse rotation. A controller 18 is connected to the rotating units 17. The controller 18 controls the motion of the rotating units 17, thereby rotating the four rolls 15a to 15d to crush massive cement clinker. Hereinafter, the four rolls 15a to 15d are described in detail.

[0031] The four rolls 15a to 15d are made up of two types of rolls. Specifically, the first and the third rolls from the downstream side in the conveying direction are first-type rolls, and the second and the fourth rolls from the downstream side in the conveying direction are second-type rolls. Hereinafter, the configuration of a first roll 15a, which is the first roll serving as a first-type roll, is described with reference to Fig. 4 to Fig. 8, and then the configuration of a second roll 15b, which is the second roll, is described with reference to Fig. 9 to Fig. 12. The configuration of a third roll 15c, which is the third roll, and the configuration of a fourth roll 15d, which is the fourth roll, are the same as the configuration of the first roll 15a and the configuration of the second roll 15b, respectively. Therefore, the components of the third and the fourth rolls 15c and 15d are denoted by the same reference signs as those used for the components of the first and the second rolls 15a and 15b, and the description of the third and the fourth rolls 15c and 15d is omitted.

[0032] The first roll 15a includes a first shaft 21 and a plurality of crushing rings 22 and 23. The first shaft 21 is a roughly columnar member extending in the orthogonal direction, and the vicinities of both end portions of the first shaft 21 are rotatably supported by the bearing mechanism that is not shown, such that the first shaft 21 is rotatable about the rotational axis L1. One end portion of the first shaft 21 is coupled to the rotating unit 17, and is driven by the rotating unit 17 to rotate about the rotational axis L1. Two keys 21a are formed on the outer peripheral surface of the first shaft 21. Each of the two keys 21a, which are engaging pieces, protrudes radially outward and extends from one end to the other end of the first shaft 21. The two keys 21a are arranged such that they are separated by 180 degrees in the circumferential direction. On the outer peripheral surface of the first shaft 21 having such a shape, two types of crushing rings that are crushing rings 22 and crushing rings 23 are externally attached alternately. Hereinafter, the configurations of the two types of crushing rings 22 and 23, i.e., a first crushing ring 22 and a second crushing ring 23, are described.

[0033] The first crushing ring 22 shown in Fig. 4 is a roughly cylindrical member extending in the orthogonal direction. The first crushing ring 22 includes two key grooves 22a formed in its inner peripheral surface. The key grooves 22a, which are engaged grooves, have the same shape as that of the keys 21a of the first shaft 21, and extend from one end to the other end of the first crushing ring 22. The key grooves 22a are arranged such that they are separated by 180 degrees in the circumferential direction. When the first crushing ring 22 is externally attached to the first shaft 21, the keys 21a fit in the key grooves 22a. The first crushing ring 22 is externally attached to the first shaft 21 in this manner so that the first crushing ring 22 will not rotate relative to the first shaft 21. A plurality of crushing teeth 24 are formed on the outer peripheral surface of the first crushing ring 22. In the present embodiment, eighteen crushing teeth 24 are formed on the outer peripheral surface of the first crushing ring 22, and the eighteen crushing teeth 24 are arranged at a regular pitch p1. Each of the crushing teeth 24 protrudes radially outward, and extends from one end to the other end of the first crushing ring 22 in the orthogonal direction. The plurality of crushing teeth 24 include crushing teeth 24 with different tooth depths. In the present embodiment, the plurality of crushing teeth 24 include three types of teeth with different tooth depths, i.e., six high teeth 24a, four medium-height teeth 24b, and eight low teeth 24c.

[0034] Among the three types of teeth, the high teeth 24a have the greatest tooth depth. Among the six high teeth 24a, one high tooth 24a is positioned on an imaginary center plane PL11, which includes the central axis of the first crushing ring 22 (i.e., the rotational axis L1) and the center of one key groove 22a. The one high tooth 24a serves as a first reference tooth. On the outer peripheral surface of the first crushing ring 22, on one side with reference to the first reference tooth 24d of Fig. 4 in the circumferential direction, two high teeth 24a are arranged, and a medium-height tooth 24b is disposed next thereto. The medium-height teeth 24b are lower than the high teeth 24a, but higher than the low teeth 24c. That is, the tooth depth of the medium-height teeth 24b is less than the tooth depth of the high teeth 24a, but greater than the tooth depth of the low teeth 24c, In addition, adjacently on the one side of the medium-height tooth 24b in the circumferential direction, four low teeth 24c are arranged side by side at the regular pitch p1. Among the three types of teeth, the low teeth 24c have the smallest tooth depth. Adjacently on the one side of the four low teeth 24c in the circumferential direction, a medium-height tooth 24b is disposed again, and a high tooth 24a is disposed next thereto. The high tooth 24a is positioned on the imaginary center plane PL11. Subsequently, on the one side of the high tooth 24a in the circumferential direction, two high teeth 24a are arranged side by side at the regular pitch p1. Further subsequently, a medium-height tooth 24b, four low teeth 24c, and a medium-height tooth 24b are arranged in this order at the regular pitch p1.

[0035] In the first crushing ring 22 configured as above, two sets of three side-by-side high teeth 24a are arranged on the outer peripheral surface, and the three high teeth 24a in the side-by-side arrangement of each set form a first high teeth forming portion 25 (e.g., a shaded portion of the first roll 15a in Fig. 8, which will be described below). Between the two first high teeth forming portions 25, on each of the one side and the other side in the circumferential direction, four low teeth 24c are arranged side by side, and the four low teeth 24c in the side-by-side arrangement on each side form a first low teeth forming portion 26. Accordingly, on the outer peripheral surface of the first crushing ring 22, the first high teeth forming portions 25 and the first low teeth forming portions 26 are arranged alternately in this order toward the one side in the circumferential direction. The first crushing ring 22 having such a shape can be externally attached to the first shaft 21 when the first crushing ring 22 is in a normal orientation, in which the high teeth 24a adjacent to the first reference tooth 24d are positioned on the one side of the first reference tooth 24d in the circumferential direction.

[0036] The first crushing ring 22 is rotationally symmetrical with respect to its central axis, and the key grooves 22a are arranged at respective positions that are separated by 180 degrees. Therefore, even when the first crushing ring 22 is in a reverse orientation, in which one side and the other side of the first crushing ring 22 are reversed with respect to the imaginary center plane PL11, the first crushing ring 22 can still be externally attached to the first shaft 21. In the reverse orientation, as shown in Fig. 5, the position of the first reference tooth 24d in the circumferential direction does not change, but two high teeth 24a are arranged side by side on the other side of the first reference tooth 24d in the circumferential direction. Thus, by reversing the right side and the left side of the first crushing ring 22 with respect to the imaginary center plane PL11, the first high teeth forming portions 25 and the first low teeth forming portions 26 can be arranged alternately in this order toward the other side in the circumferential direction on the outer peripheral surface of the first crushing ring 22 with reference to the first reference tooth 24d.

[0037] The second crushing ring 23 shown in Fig. 6 is a roughly cylindrical member extending in the orthogonal direction, and has substantially the same configuration as that of the first crushing ring 22. That is, the second crushing ring 23 includes: two key grooves 23a, which are engaged grooves formed in the inner peripheral surface of the second crushing ring 23; and a plurality of crushing teeth 27 formed on the outer peripheral surface of the second crushing ring 23. Similar to the plurality of crushing teeth 24 of the first crushing ring 22, the plurality of crushing teeth 27 include crushing teeth 27 with different tooth depths. In the present embodiment, the plurality of crushing teeth 27 include three types of teeth with different tooth depths, i.e., six high teeth 27a, four medium-height teeth 27b, and eight low teeth 27c. The arrangement of the plurality of crushing teeth 27 is the same as the arrangement of the plurality of crushing teeth 24 of the first crushing ring 22. A second reference tooth 27e corresponds to the first reference tooth 24d. On the one side of the second reference tooth 27e in the circumferential direction, two high teeth 27a, a medium-height tooth 27b, four low teeth 27c, a medium-height tooth 27b, three high teeth 27a, a medium-height tooth 27b, four low teeth 27c, and a medium-height tooth 27b are arranged in this order on the outer peripheral surface of the second crushing ring 23. The second crushing ring 23 is different from the first crushing ring 22 in the following points. In the second crushing ring 23, a tooth bottom 27d formed between the second reference tooth 27e and the medium-height tooth 27b is positioned on an imaginary center plane PL12, which includes the central axis of the second crushing ring 23 and the center of one key groove 23a, and the second reference tooth 27e is disposed such that it is shifted relative to the imaginary center plane by 1/2 of the pitch p1. That is, the entire plurality of crushing teeth 27 are arranged such that they are shifted relative to the plurality of crushing teeth 24 of the first crushing ring 22 about the rotational axis L1 by 1/2 of the pitch p1.

[0038] In the second crushing ring 23 formed as above, similar to the first crushing ring 22, the three high teeth 27a in the side-by-side arrangement form a second high teeth forming portion 28, and the four low teeth 27c in the side-by-side arrangement form a second low teeth forming portion 29. That is, also on the outer peripheral surface of the second crushing ring 23, such second high teeth forming portions 28 and second low teeth forming portions 29 are arranged alternately toward the one side in the circumferential direction with reference to the second reference tooth 27e. The second crushing ring 23 having such a shape can be externally attached to the first shaft 21 when the second crushing ring 23 is in a normal orientation, in which the high teeth 27a adjacent to the second reference tooth 27e are positioned on the one side of the second reference tooth 27e in the circumferential direction.

[0039] The second crushing ring 23 is rotationally symmetrical with respect to its central axis, and similar to the first crushing ring 22, the key grooves 23a are arranged at respective positions that are separated by 180 degrees. Therefore, even when the second crushing ring 23 is in a reverse orientation, in which one side and the other side of the second crushing ring 23 are reversed with respect to the imaginary center plane PL12, the second crushing ring 23 can still be externally attached to the first shaft 21. In the reverse orientation, as shown in Fig. 7, the position of the second reference tooth 27e is reversed with respect to the imaginary center plane PL12, and two high teeth 27a are arranged side by side on the other side of the second reference tooth 27e in the circumferential direction. Thus, by reversing the second crushing ring 23 with respect to the imaginary center plane PL12, the second high teeth forming portions 28 and the second low teeth forming portions 29 can be arranged alternately in this order toward the other side in the circumferential direction on the outer peripheral surface of the second crushing ring 23 with reference to the second reference tooth 27e.

[0040] These two types of crushing rings 22 and 23 configured as above are alternately and externally attached to the first shaft 21 in such a manner that the orientations of the respective crushing rings are varied between the normal orientation and the reverse orientation. Specifically, the plurality of crushing rings 22 and 23 are externally attached to the first shaft 21 as shown in Fig. 8. A first crushing ring 22 in the normal orientation is externally attached to the first shaft 21 at the other farthest end thereof, and a second crushing ring 23 in the normal orientation is externally attached to the first shaft 21 adjacently to the first crushing ring 22. As a result, the second crushing ring 23T in the normal orientation is disposed such that the second reference tooth 27e is shifted relative to the first reference tooth 24d of the first crushing ring 22T in the normal orientation by 1/2 of the pitch p1. That is, the second crushing ring 23T is externally attached to the first shaft 21 such that the entire plurality of crushing teeth 27 are shifted relative to the entire plurality of crushing teeth 24 of the first crushing ring 22 by 1/2 of the pitch p1. When the two crushing rings 22T and 23T are externally attached to the first shaft 21 in this manner, the first high teeth forming portions 25 and the second high teeth forming portions 28 are basically arranged on the one side of the imaginary center plane PL11 and the one side of the imaginary center plane PL12, respectively, in the circumferential direction,

[0041] Further, adjacently to the two crushing rings 22T and 23T, a first crushing ring 22 in the reverse orientation is externally attached to the first shaft 21, and a second crushing ring 23 in the reverse orientation is externally attached to the first shaft 21 adjacently to the first crushing ring 22. When these two crushing rings 22R and 23R in the reverse orientation are externally attached to the first shaft 21 in this manner, the first high teeth forming portions 25 and the second high teeth forming portions 28 are basically arranged on the other side of the imaginary center plane PL11 and the other side of the imaginary center plane PL12, respectively, in the circumferential direction. That is, the first high teeth forming portions 25 and the second high teeth forming portions 28 of the two crushing rings 22R and 23R in the reverse orientation, and the first high teeth forming portions 25 and the second high teeth forming portions 28 of the crushing rings 22T and 23T in the normal orientation, are positioned at the opposite side to each other with respect to the imaginary center planes PL11 and PL12.

[0042] Further, adjacently to the two crushing rings 22R and 23R in the reverse orientation, two crushing rings 22T and 23T in the normal orientation are externally attached to the first shaft 21 in this order. In addition, adjacently to the two crushing rings 22T and 23T in the normal orientation, two crushing rings 22R and 23R in the reverse orientation are externally attached to the first shaft 21 in this order. Thus, the first roll 15a is formed by externally attaching the plurality of crushing rings 22T, 22R, 23T, and 23R to the first shaft 21 in this manner.

[0043] On the outer peripheral surface of the first roll 15a configured in this manner, the first high teeth forming portion 25 and the second high teeth forming portion 28 that are adjacent to each other form a high teeth forming portion 30H, and the first low teeth forming portion 26 and the second low teeth forming portion 29 that are adjacent to each other form a low teeth forming portion 30L. When seen in the orthogonal direction, such high teeth forming portions 30H are arranged on the one side and the other side of the imaginary center planes PL11 and PL 12 alternately, and also, such low teeth forming portions 30L are arranged on the one side and the other side of the imaginary center planes PL11 and PL12 alternately. In this manner, the high teeth forming portions 30H and the low teeth forming portions 30L are arranged on the outer peripheral surface of the first roll 15a in a staggered manner. The second roll 15b is disposed adjacently to the first roll 15a in the conveying direction with a predetermined interval formed therebetween.

[0044] The second roll 15b includes a second shaft 31 and a plurality of crushing rings 32 and 33. The second shaft 31 has the same shape as that of the first shaft 21. That is, the second shaft 31 is a columnar member extending in the orthogonal direction, and the vicinities of both end portions of the second shaft 31 are rotatably supported by the bearing mechanism that is not shown, such that the second shaft 31 is rotatable about the rotational axis L2. One end portion of the second shaft 31 is coupled to the rotating unit 17, and is driven by the rotating unit 17 to rotate about the rotational axis L2. Two keys 31a (engaging pieces) are formed on the outer peripheral surface of the second shaft 31, and are arranged such that they are separated by 180 degrees in the circumferential direction. On the outer peripheral surface of the second shaft 31 having such a shape, two types of crushing rings that are crushing rings 32 and crushing rings 33 are externally attached.

[0045] A first crushing ring 32 shown in Fig. 9 is a roughly cylindrical member extending in the orthogonal direction. The first crushing ring 32 includes two key grooves 32a formed in its inner peripheral surface. The key grooves 32a, which are engaged grooves, have the same shape as that of the keys 3 1a of the second shaft 31, and extend from one end to the other end of the first crushing ring 32. The key grooves 32a are arranged such that they are separated by 180 degrees in the circumferential direction. When the first crushing ring 32 is externally attached to the second shaft 31, the keys 31a fit in the key grooves 32a. The first crushing ring 32 is externally attached to the second shaft 31 in this manner so that the first crushing ring 32 will not rotate relative to the second shaft 31. A plurality of crushing teeth 34 are formed on the outer peripheral surface of the first crushing ring 32. In the present embodiment, eighteen crushing teeth 34 are formed on the outer peripheral surface of the first crushing ring 32, and the eighteen crushing teeth 34 are arranged at a regular pitch p2. Each of the crushing teeth 34 protrudes radially outward, and extends from one end to the other end of the first crushing ring 32. The crushing teeth 34 are formed on the outer peripheral surface of the first crushing ring 32 in such a manner that all the crushing teeth 34 have the same tooth depth.

[0046] To be more specific, a first reference tooth 34a, which is one of the plurality of crushing teeth 34, is positioned on an imaginary center plane PL21, which includes the central axis of the first crushing ring 32 (i.e., the rotational axis L2) and the center of one key groove 32a. With reference to the first reference tooth 34a, the other crushing teeth 34 are arranged side by side on the outer peripheral surface of the first crushing ring 32 at the regular pitch p2. The first crushing ring 32 thus configured is rotationally symmetrical with respect to its central axis. The first crushing ring 32 is externally attached to the second shaft 31, such that the first reference tooth 34a is positioned radially outward of one key 31a of the second shaft 31.

[0047] A second crushing ring 33 shown in Fig. 10 is a roughly cylindrical member extending in the orthogonal direction, and has substantially the same configuration as that of the first crushing ring 32. That is, the second crushing ring 33 includes: two key grooves 33a (engaged grooves) formed in the inner peripheral surface of the second crushing ring 33; and a plurality of crushing teeth 35 formed on the outer peripheral surface of the second crushing ring 33. Similar to the first crushing ring 32, the plurality of crushing teeth 35 are formed on the outer peripheral surface of the second crushing ring 33 in such a manner that all the crushing teeth 35 have the same tooth depth. In the present embodiment, eighteen crushing teeth 35 are formed on the outer peripheral surface of the second crushing ring 33, and the eighteen crushing teeth 35 are arranged at the regular pitch p2. The second crushing ring 33 includes a second reference tooth 35a, which is one of the plurality of crushing teeth 35 and which corresponds to the first reference tooth 34a. The second reference tooth 35a is disposed such that it is shifted relative to an imaginary center plane PL22, which includes the central axis of the second crushing ring 33 (i.e., the rotational axis L2) and the center of one key groove 33a, by 1/3 of the pitch p2. That is, the entire plurality of teeth of the second crushing ring 33 are arranged such that they are shifted relative to the plurality of crushing teeth 34 of the first crushing ring 32 about the rotational axis L2 by 1/3 of the pitch p2. The second crushing ring 33 having such a shape can be externally attached to the second shaft 31 when the second crushing ring 33 is in a normal orientation, in which the second reference tooth 35a is positioned on the one side of the imaginary center plane PL22 in the circumferential direction.

[0048] The second crushing ring 33 is rotationally symmetrical with respect to its central axis, and the key grooves 33a are arranged at respective positions that are separated by 180 degrees. Therefore, even when the second crushing ring 33 is in a reverse orientation, in which one side and the other side of the second crushing ring 33 are reversed with respect to the imaginary center plane PL22, the second crushing ring 33 can still be externally attached to the second shaft 31. By bringing the second crushing ring 33 into the reverse orientation, as shown in Fig. 11, the position of the second reference tooth 35a is reversed with respect to the imaginary center plane PL22, and the second reference tooth 35a is disposed such that it is shifted relative to the imaginary center plane PL22 in the circumferential direction toward the other side by 1/3 of the pitch p2. That is, the entire plurality of crushing teeth 35 of the second crushing ring 33 are arranged such that they are shifted relative to the plurality of crushing teeth 34 of the first crushing ring 32 about the rotational axis L2 by 2/3 of the pitch p2. Thus, by reversing the second crushing ring 33 with respect to the imaginary center plane PL22, the second crushing ring 33 can be brought into a state where the entire plurality of crushing teeth 35 are shifted relative to the plurality of crushing teeth 34 of the first crushing ring 32 about the rotational axis L2 by 2/3 of the pitch p2.

[0049] These two types of crushing rings 32 and 33 configured as above are externally attached to the second shaft 31 in such a manner that the crushing teeth 34 and 35 formed on the crushing rings 32 and 33 are arranged such that they are shifted relative to each other by 1/3 of the pitch p2. Specifically, the plurality of crushing rings 32 and 33 are externally attached to the second shaft 31 as shown in Fig. 12. A first crushing ring 32 is externally attached to the second shaft 31 at the other farthest end thereof, and the first reference tooth 34a is positioned radially outward of the key 31 a of the second shaft 31.

[0050] Adjacently to the first crushing ring 32, a second crushing ring 33 in the normal orientation is externally attached to the second shaft 31. The second crushing ring 33T in the normal orientation is disposed such that the second reference tooth 35a is shifted relative to the first reference tooth 34a of the first crushing ring 32 in the circumferential direction toward the one side by 1/3 of the pitch p2. That is, the second crushing ring 33T is externally attached to the second shaft 31 such that the entire plurality of crushing teeth 35 are shifted relative to the entire crushing teeth 34 of the first crushing ring 32 by 1/3 of the pitch p2. Further, adjacently to the second crushing ring 33T in the normal orientation, a second crushing ring 33 in the reverse orientation is externally attached to the second shaft 31. The second crushing ring 33R in the reverse orientation is disposed such that the second reference tooth 35a is shifted relative to the first reference tooth 34a of the first crushing ring 32 in the circumferential direction toward the other side by 1/3 of the pitch p2. That is, the second crushing ring 33R is externally attached to the second shaft 31 such that the entire plurality of crushing teeth 35 are shifted relative to the entire crushing teeth 34 of the first crushing ring 32 by 2/3 of the pitch p2. Still further, adjacently to the second crushing ring 33R in the reverse orientation, a first crushing ring 32, a second crushing ring 33T in the normal orientation, and a second crushing ring 33R in the reverse orientation are externally attached to the second shaft 31 in this order repeatedly. Thus, the second roll 15b is formed by externally attaching the plurality of crushing rings 32, 33T, and 33R to the second shaft 31 in this manner.

[0051] On the outer peripheral surface of the second roll 15b configured in this manner, teeth lines 36 are formed, each of which is formed by crushing teeth 34 and 35 that are adjacent to each other in the axial direction, i.e., the orthogonal direction. It should be noted that since the crushing teeth 34 adjacent to each other are arranged such that they are shifted relative to each other by 1/3 of the pitch p2, each teeth line 36 extends in the orthogonal direction in a manner to twist in the circumferential direction toward the one side on the outer peripheral surface of the second roll 15b (see, for example, a shaded portion of the second roll 15b in Fig. 3 and Fig. 12 as one of the teeth lines 36). It should be noted that, also on the first roll 15a disposed adjacently to the second roll 15b, teeth lines are formed, each of which is formed by crushing teeth 24 and 27 that are adjacent to each other in the axial direction, i.e., the orthogonal direction, and that are arranged such that the crushing teeth 27 are shifted relative to the crushing teeth 24 in the circumferential direction toward the other side by 1/2 of the pitch p1. Each teeth line extends in the orthogonal direction in a manner to twist in the circumferential direction toward the other side on the outer peripheral surface of the first roll 15a.

[0052] It should be noted that, as previously mentioned, the third roll 15c is configured in the same manner as the first roll 15a, and the fourth roll 15d is configured in the same manner as the second roll 15b.

[0053] As previously mentioned, the four rolls 15a to 15d configured as above are arranged in the conveying direction at predetermined intervals. Gaps S1 to S3 are formed between the adjacent rolls 15a to 15d. Since the rolls 15a to 15d rotate and the crushing teeth 24, 27, 34, and 35 are formed on the outer peripheral surfaces of the rolls 15a to 15d, the widths of the respective gaps S1 to S3 (i.e., the lengths of the respective gaps S1 to S3 in the conveying direction) change in accordance with the positions of the crushing teeth 24, 27, 34, and 35 relative to each other. Specifically, when the high teeth 24a and 27a are butted with the crushing teeth 34 and 35, the widths of the respective gaps S1 to S3 are minimized (minimum widths), and when the tooth bottoms face each other, the widths of the respective gaps S1 to S3 are maximized (maximum widths). By reducing the widths of the respective gaps S1 to S3, the grain diameter of the cement clinker after being crushed can be reduced, but the loads exerted on the rolls 15a to 15d at the time of crushing will increase. On the other hand, by increasing the widths of the respective gaps S1 to S3, the loads exerted on the rolls 15a to 15d at the time of crushing can be reduced, but the cement clinker discharged downward will have a large grain diameter. In consideration of these, the minimum widths of the respective gaps S1 to S3 are set in accordance with a tolerable load amount exerted on each of the rolls 15a to 15d at the time of crushing, and the maximum widths of the respective gaps S1 to S3 are set in accordance with a tolerable grain diameter of the cement clinker. In addition, the intervals between the adjacent rolls 15a to 15d and the tooth depths of the crushing teeth 24, 27, 34, and 35 are set in accordance with these minimum widths and maximum widths.

[0054] Each of the four rolls 15a to 15d thus configured is driven by the corresponding rotating unit 17 to rotate. For example, the controller 18 is capable of selecting the crushing mode between a normal mode and a high crushing ratio mode. In the normal mode, the first roll 15a rotates in the circumferential direction toward the other side, and the second to the fourth rolls 15b to 15d rotate in the circumferential direction toward the one side. In the high crushing ratio mode, the first and the third rolls 15a and 15c rotate in the circumferential direction toward the other side, and the second and the fourth rolls 15b and 15d rotate in the circumferential direction toward the one side. The four rolls 15a to 15d rotating in this manner receive the cement clinker falling from the forward end of the cooler apparatus 1, and crush the received cement clinker so that the cement clinker after being crushed will have a grain diameter that is less than or equal to the tolerable grain diameter.

[0055] To be more specific, in the normal mode, the second to the fourth rolls 15b to 15d feed the cement clinker falling thereon toward the first roll 15a. At the time, cement clinker having a grain diameter of less than or equal to the tolerable grain diameter falls through the gaps S2 and S3 of the second to the fourth rolls 15b to 15d, and large massive cement clinker having a large grain diameter is fed toward the first roll 15a. The first roll 15a rotates together with the second roll 15b such that the cement clinker on the first and the second rolls 15a and 15b gets caught between them (i.e., caught in the gap S1). The cement clinker is crushed as a result of getting caught between the first and the second rolls 15a and 15b. As a result of being crushed, the large massive cement clinker turns into cement clinker having a grain diameter of less than or equal to the tolerable grain diameter, and the resulting cement clinker falls downward through the gap S1.

[0056] On the other hand, in the high crushing ratio mode, the third roll 15c also rotates together with the fourth roll 15d such that the cement clinker on the third and the fourth rolls 15c and 15d gets caught between them (i.e., caught in the gap S3). The cement clinker is crushed as a result of getting caught between the third and the fourth rolls 15c and 15d. In this manner, the roll crusher 15 performs the crushing at two positions, and thereby more cement clinker can be crushed and caused to fall downward.

[0057] In the first roll 15a and the third roll 15c of the roll crusher 15 configured as above, the loads exerted on the crushing rings 22T, 22R, 23T, and 23R during the rotation of the first roll 15a and the third roll 15c are great at a time when the cement clinker is crushed by the crushing teeth 24 and 27, but the exerted loads are small at other times. In the first roll 15a and the third roll 15c, since the adjacent crushing teeth 24 and 27 are arranged such that they are shifted relative to each other in the circumferential direction by 1/2 of the pitch p1, during the rotation of the first roll 15a and the third roll 15c, the timings at which the loads exerted on the crushing rings become great can be varied among the crushing rings 22T, 22R, 23T, and 23 R. That is, during the rotation, among the crushing rings 22T, 22R, 23T, and 23R, the timings at which the loads are exerted thereon can be shifted relative to each other. This makes it possible to level out temporal changes in the loads exerted on the first roll 15a and the third roll 15c, and as a result, temporal changes in the loads on the rotating units 17 can be leveled out.

[0058] In the first roll 15a and the third roll 13c, each crushing ring 22 includes the crushing teeth 24a to 24c having different tooth depths from each other, and each crushing ring 23 includes the crushing teeth 27a to 27c having different tooth depths from each other. That is, not only the high teeth 24a but also the low teeth 24c are formed on each crushing ring 22, and not only the high teeth 27a but also the low teeth 27c are formed on each crushing ring 23. Accordingly, large massive cement clinker that cannot be caught and crushed with the high teeth 24a and 27a can be caught and crushed with the low teeth 24c and 27c. This makes it possible to lower the possibility that large massive cement clinker does not get caught between rolls and remains on the first roll 15a and the third roll 15c.

[0059] Moreover, in the first roll 15a and the third roll 15c, the loads exerted on the crushing rings 22 and 23 reach their peaks when the high teeth 24a and 27a of the high teeth forming portion 30H crush the cement clinker. On the outer peripheral surface of each of the first roll 15a and the third roll 15c, the high teeth forming portions 30H and the low teeth forming portions 30L are arranged in a staggered manner, and thereby the high teeth 24a and 27a of each of the first roll 15a and the third roll 15c are prevented from being adjacent to each other in the orthogonal direction. This makes it possible to level out temporal changes in the loads exerted on the first roll 15a and the third roll 15c, and as a result, temporal changes in the loads on the rotating units 17 can be leveled out.

[0060] Each of the first roll 15a and the third roll 15c is manufactured in the following manner: externally attaching the first crushing ring 22 and the second crushing ring 23 in the normal orientation to the first shaft 21, and externally attaching the first crushing ring 22 and the second crushing ring 23 in the reverse orientation to the first shaft 21 adjacently to the first crushing ring 22 and the second crushing ring 23 in the normal orientation; and repeating this externally attaching process. Thus, each of the first roll 15a and the third roll 15c can be manufactured by using the two types of crushing rings, i.e., the crushing rings 22 and the crushing rings 23. Therefore, even though four types of crushing rings 22T, 22R, 23T, and 23R are used, these crushing rings can be manufactured by using only two types of molds, and thereby the manufacturing cost can be reduced.

[0061] Also in each of the second roll 15b and the fourth roll 15d, the crushing teeth 34 and 35 adjacent to each other are arranged such that they are shifted relative to each other in the circumferential direction by 1/3 of the pitch p2, and thereby the timings at which the loads exerted on the crushing rings become great can be varied among the crushing rings 32, 33T, and 33R during the rotation of the second roll 15b and the fourth roll 15d. That is, during the rotation, among the crushing rings 32, 33T, and 33R, the timings at which the loads are exerted thereon can be shifted relative to each other. This makes it possible to level out temporal changes in the loads exerted on the second roll 15b and the fourth roll 15d, and as a result, temporal changes in the loads on the rotating units 17 can be leveled out.

[0062] On the outer peripheral surface of each of the second roll 15b and the fourth roll 15d, the teeth lines 36 extend in the orthogonal direction in a manner to twist in the circumferential direction toward the one side (see the shaded portion of the second roll 15b in Fig. 3 and Fig. 12). Therefore, by rotating the second roll 15b and the fourth roll 15d, large massive cement clinker that has not fallen through the gaps S1 to S3 and that remains on the rolls 15b and 15d can be passed in the orthogonal direction toward one side (e.g., toward the other end portion of the second shaft 31). By passing the cement clinker in this manner, the cement clinker can be brought into collision with other massive cement clinker, and thereby the massive cement clinker can be crushed. Also, by thus passing the cement clinker, the massive cement clinker remaining on the rolls 15b and 15d can be guided to any of the gaps S1 to S3, in which the massive cement clinker can be caught successfully. Thus, even the large massive cement clinker can be caught in a gap between the rolls successfully.

[0063] It should be noted that, also in the first roll 15a, the crushing teeth 24 and 27 that are adjacent to each other in the orthogonal direction are arranged such that the crushing teeth 27 are shifted relative to the crushing teeth 24 in the circumferential direction toward the other side by 1/2 of the pitch p1, and the crushing teeth 24 and 27 that are shifted relative to each other in this manner form teeth lines. On the outer peripheral surface of the first roll 15a, these teeth lines extend in the orthogonal direction in a manner to twist in the circumferential direction toward the other side. Therefore, by rotating the first roll 15a in the circumferential direction toward the other side, large massive cement clinker that remains on the roll 15a can be passed in the orthogonal direction toward the one side by the teeth lines, and thus the teeth lines of the first roll 15a exert the same advantageous effects as those exerted by the teeth lines 36 of the second and the fourth rolls 15b and 15d.

[0064] Each of the second and the fourth rolls 15b and 15d is manufactured in the following manner: externally attaching the first crushing ring 32 to the second shaft 31, and externally attaching the second crushing ring 33T in the normal orientation and the second crushing ring 33R in the reverse orientation to the second shaft 31 in this order adjacently to the first crushing ring 32; and repeating this externally attaching process. Thus, each of the second roll 15b and the fourth roll 15d can be manufactured by using the two types of crushing rings, i.e., the crushing rings 32 and the crushing rings 33. Therefore, even though three types of crushing rings 32, 33T, and 33R are used, these crushing rings can be manufactured by using only two types of molds, and thereby the manufacturing cost can be reduced.

[0065] In the roll crusher 15 of the cooler apparatus 1, the first to the fourth rolls 15a to 15d are arranged in this order side by side such that, among the rolls 15a to 15d, the rolls adjacent to each other are different types of rolls. With such arrangement, various portions can be butted with each other at the gaps S1 to S3 during the rotation of the first to the fourth rolls 15a to 15d. For example, high teeth 24a and tooth bottoms can be butted with each other; low teeth 24c and crushing teeth 34 can be butted with each other; and low teeth 24c and tooth bottoms can be butted with each other. This makes it possible to further level out temporal changes in the magnitudes of the loads exerted on the crushing rings 22, 23, 32, and 33, and as a result, temporal changes in the loads on the rotating units 17 can be leveled out.

<Other Embodiments>

[0066] In the cooler apparatus 1 of the present embodiment, the four rolls 15a to 15d are arranged such that, among the rolls 15a to 15d, the rolls adjacent to each other are different types of rolls. However, as an alternative, all the four rolls 15a to 15d may be the same type of rolls. For example, four rolls each having the same structure as the first roll 15a, or four rolls each having the same structure as the second roll 15b, may be adopted as the four rolls 15a to 15d. The rotation control mode of the four rolls 15a to 15d at the time of performing crushing is not limited to either the normal mode or the high crushing ratio mode mentioned above. The four rolls 15a to 15d may be rotated in a different rotation control mode.

[0067] The adjacent crushing teeth 24 and 27 are shifted relative to each other, and the adjacent crushing teeth 34 and 35 are shifted relative to each other, by 1/2 or 1/3 of the pitch. Alternatively, the shift amount may be 1/4 of the pitch. That is, it will suffice if the adjacent crushing teeth 24 and 27 are shifted relative to each other, and the adjacent crushing teeth 34 and 35 are shifted relative to each other, by a shift amount of 1/n (n is an integer) of the pitch. By shifting the adjacent crushing teeth relative to each other by 1/n of the pitch in this manner, the second reference tooth is disposed such that it is shifted relative to the first reference tooth in the circumferential direction by 360 / (n × N) degrees (where N is the number of teeth of the second crushing ring). Accordingly, by reversing the second crushing ring, the reversed second crushing ring can be used as a crushing ring whose crushing teeth are arranged such that they are shifted relative to the crushing teeth of the first crushing ring by 360 × (n - 1) / (n × N) degrees (i.e., as a crushing ring whose crushing teeth are shifted relative to the crushing teeth of the first crushing ring in the circumferential direction toward the one side by (n-1) / n of the pitch). Therefore, the number of types of molds for manufacturing the crushing rings can be made less than the number of types of crushing rings to be used, and thereby the manufacturing cost can be reduced.

[0068] Further, in the present embodiment, in each of the first roll 15a and the third roll 15c, the positions of the tooth top surfaces of the crushing teeth 24 are varied, and also, the positions of the tooth top surfaces of the crushing teeth 27 are varied, thereby varying the widths of the gaps S1 to S3. However, as an alternative, the widths of the gaps S1 to S3 may be varied by varying the positions of the tooth bottoms. In the rolls 15a to 15d, the keys 21a and 31a are formed on the shafts 21 and 31, and the key grooves 22a, 23a, 32a, and 33a are formed in the crushing rings 22, 23, 32, and 33. However, as an alternative, the key grooves may be formed in the shafts, and the keys may be formed on the crushing rings.

[0069] Although the plurality of crushing rings 22 and 23 are sequentially arranged, as an alternative, the plurality of crushing rings may include at least one crushing ring having crushing teeth that are arranged differently from the arrangement of the crushing teeth of the other crushing rings. Also in this case, the timing at which the load exerted on the at least one crushing ring becomes great can be shifted relative to the timings at which the loads exerted on the other crushing rings become great. Therefore, this alternative arrangement of the crushing rings is also useful for leveling out temporal load changes.

[0070] The high teeth forming portions 30H and the low teeth forming portions 30L of each of the first roll 15a and the third roll 15c need not be arranged in a staggered manner, but may be arranged in a banded manner. Alternatively, the high teeth forming portions 30H and the low teeth forming portions 30L may be arranged at random.

Reference Signs List

[0071]

1 cooler apparatus
15 roll crusher
15a first roll
15b second roll

15c	third roll
15d	fourth roll
17	rotating unit
21	first shaft
21a	key
22	first crushing ring
22a	key groove
23	second crushing ring
23a	key groove
24	crushing teeth
24a	high teeth
24c	low teeth
24d	first reference tooth
25	first high teeth forming portion
26	first low teeth forming portion
27	crushing teeth
27a	high teeth
27c	low teeth
27e	second reference tooth
28	second high teeth forming portion
29	second low teeth forming portion
30H	high teeth forming portion
30L	low teeth forming portion
31	second shaft
31a	key
32	first crushing ring
32a	key groove
33	second crushing ring
33a	key groove
34	crushing teeth
34a	first reference tooth
35	crushing teeth
35a	second reference tooth
36	teeth line

Claims

1. A roll crusher of a cooler apparatus (1) for cooling down a granular conveyed material while conveying the granular conveyed material, the roll crusher being configured to crush the granular conveyed material, the roll crusher comprising:

a plurality of rolls (15) arranged side by side in a conveying direction such that a gap is formed between the rolls, the plurality of rolls being rotated about respective axes thereof by corresponding rotating units (17) to crush the granular conveyed material, the axes being parallel to each other and orthogonal to the conveying direction, wherein at least one of the plurality of rolls is a load-reducing roll, the load-reducing roll includes a plurality of crushing rings (22, 23), each of the plurality of crushing rings includes a plurality of crushing teeth (24, 27) arranged on an outer peripheral surface thereof, the plurality of crushing teeth being arranged at regular intervals in a circumferential direction, and
the plurality of crushing teeth of each of the plurality of crushing rings on the load-reducing roll are arranged such that the plurality of crushing teeth are shifted by a same shift amount in the circumferential direction relative to the plurality of crushing teeth of the crushing ring that is adjacent to the each crushing ring,
wherein the plurality of rolls (15) include at least two of the load-reducing rolls that are adjacent to each other, **characterised in that**
each of the adjacent load-reducing rolls includes the crushing rings (22) such that a the shift amount by which the plurality of crushing teeth (24) are shifted in the circumferential direction differs between the adjacent load-reducing rolls.

2. The roll crusher of the cooler apparatus according to claim 1, wherein
the plurality of crushing teeth (24, 27) are arranged on the outer peripheral surface of each crushing ring (22, 23) at a predetermined pitch, such that the plurality of crushing teeth of each crushing ring are shifted by 1/n (where n is an integer of not less than 2) of the pitch in the circumferential direction toward one side relative to the plurality of crushing teeth of the crushing ring that is adjacent to the each crushing ring in an axial direction in which the axes extend.

3. The roll crusher of the cooler apparatus according to claim 2, wherein

the load-reducing roll (15) includes a shaft (21) that extends in the axial direction and that is rotated about the axis of the load-reducing roll by the corresponding rotating unit (17),
the shaft includes, on an outer peripheral surface thereof, one of an engaging piece (21a) and an engaged groove that extend in the axial direction and that are engageable with each other,
each of the plurality of crushing rings (22, 23) includes, on an inner peripheral surface thereof, the other of the engaging piece and the engaged groove (22a, 23a), and when the engaging piece and the engaged groove engage with each other, the plurality of crushing rings are externally attached to the shaft such that the plurality of crushing rings are non-displaceable relative to the shaft in the circumferential direction,
the plurality of crushing rings include a first crushing ring (22) and a second crushing ring (23),
the first crushing ring includes a first reference tooth (24d) that is one of the plurality of crushing teeth,
the second crushing ring includes a second reference tooth (27e) that is one of the plurality of crushing teeth,

the first reference tooth is positioned on a line that connects between a center of the first crushing ring and a center of the other of the engaging piece and the engaged groove, and

the second reference tooth is disposed such that the second reference tooth is shifted relative to the first reference tooth in the circumferential direction by 360 / (n * N) degrees (where N is the number of teeth of the second crushing ring).

4. The roll crusher of the cooler apparatus according to claim 1, wherein
the plurality of crushing teeth (24, 27) include a high tooth (24a, 27a) and a low tooth (24c, 27c), the high tooth being the crushing tooth with a first height, the low tooth being the crushing tooth with a second height lower than the first height.

5. The roll crusher of the cooler apparatus according to claim 4, wherein
high teeth forming portions (25, 28), in each of which a plurality of the high teeth (24a, 27a) are arranged in the circumferential direction, and low teeth forming portions (26, 29), in each of which a plurality of the low teeth (24c, 27c) are arranged in the circumferential direction, are present on an outer peripheral surface of the load-reducing roil (15), and the high teeth forming portions and the low teeth forming portions are arranged in a staggered manner.

6. The roll crusher of the cooler apparatus according to claim 5, wherein

the load-reducing roll (15) includes a shaft (21) that extends in an axial direction in which the axis of the load-reducing roll extends, the shaft being rotated about the axis by the corresponding rotating unit (17),

the plurality of crushing teeth (24, 27) are arranged on the outer peripheral surface of each crushing ring (22, 23) at the regular intervals at a predetermined pitch, such that the plurality of crushing teeth of each crushing ring are shifted by 1/2 of the pitch in the circumferential direction toward one side relative to the plurality of crushing teeth of the crushing ring that is adjacent to the each crushing ring in the axial direction, the shaft includes, on an outer peripheral surface thereof, one of an engaging piece (21a) and an engaged groove that extend in the axial direction and that are engageable with each other,

each of the plurality of crushing rings (22, 23) includes, on an inner peripheral surface thereof, the other of the engaging piece and the engaged groove (22a, 23a), and when the engaging piece and the engaged groove engage with each other, the plurality of crushing rings are externally attached to the shaft such that the plurality of crushing rings are non-displaceable relative to the shaft in the circumferential direction,

the high teeth forming portions (25, 28), in each of which at least two of the high teeth (24a, 27a) are arranged, and the low teeth forming portions (26, 29), in each of which at least two of the low teeth (24c, 27c) are arranged, are present on the outer peripheral surface of each crushing ring,

the plurality of crushing rings include a first crushing ring (22) and a second crushing ring (23),

the first crushing ring includes a first reference tooth (24d) that is one of the plurality of crushing teeth and that is positioned on a line that connects between a center of the first crushing ring and a center of the other of the engaging piece and the engaged groove, and on the outer peripheral surface of the first crushing ring, the high teeth forming portions and the low teeth forming portions are arranged alternately in the circumferential direction with reference to the first reference tooth,

the second crushing ring includes a second reference tooth (27e) that is one of the plurality of crushing teeth and that is disposed such that the second reference tooth is shifted relative to the first reference tooth in the circumferential direction toward the one side by 1/2 of the pitch, and on the outer peripheral surface of the second crushing ring, the high teeth forming portions and the low teeth forming portions are arranged alternately in the circumferential direction with reference to the second reference tooth, and

the first crushing ring and the second crushing ring are formed such that each of the first crushing ring and the second crushing ring is rotationally symmetrical with respect to the axis.

Patentansprüche

1. Ein Walzenbrecher für eine Kühlervorrichtung (1) zum Abkühlen eines körnigen Fördermaterials, während das körnige Fördermaterial gefördert wird, wobei der Walzenbrecher dazu konfiguriert ist, das körnige Fördermaterial zu zerkleinern, wobei der Walzenbrecher Folgendes umfasst:

eine Vielzahl von Walzen (15), die derart nebeneinander in einer Beförderungsrichtung ausgerichtet sind, dass zwischen den Walzen eine Lücke ausgebildet ist, wobei die Vielzahl von Walzen durch entsprechende Dreheinheiten (17) um ihre jeweilige

Achse gedreht wird, um das körnige Fördermaterial

zu zerkleinern, wobei die Achsen parallel zueinander und rechtwinklig zu der Beförderungsrichtung sind, wobei: wenigstens eine aus der Vielzahl von Walzen eine lastreduzierende Walze ist, die lastreduzierende Walze eine Vielzahl von Brechringen (22, 23) umfasst, jeder aus der Vielzahl von Brechringen eine Vielzahl von Brechzähnen (24, 27) umfasst, die an einer äußeren Umfangsfläche derselben ausgerichtet sind, wobei die Vielzahl von Brechzähnen in regelmäßigen Abständen in einer Umfangsrichtung ausgerichtet ist, und

die Vielzahl von Brechzähnen jedes aus der Vielzahl von Brechringen auf der lastreduzierenden Walze derart ausgerichtet ist, dass die Vielzahl von Brechzähnen um den gleichen Versatzbetrag in der Umfangsrichtung im Verhältnis zu der Vielzahl von Brechzähnen des Brechrings, der benachbart zu dem jeweiligen Brechring ist, versetzt ist,

wobei die Vielzahl von Walzen (15) wenigstens zwei benachbarte lastreduzierenden Walzen umfasst, **dadurch gekennzeichnet, dass**

jede der benachbarten lastreduzierenden Walzen die Brechringe (22) derart umfasst, dass der Versatzbetrag, um den die Vielzahl von Brechzähnen (24) in der Umfangsrichtung versetzt ist, sich zwischen den benachbarten lastreduzierenden Walzen unterscheidet.

2. Der Walzenbrecher für eine Kühlervorrichtung nach Anspruch 1, wobei die Vielzahl von Brechzähnen (24, 27) in einem vorbestimmten Abstand auf der äußeren Umfangsfläche jedes Brechrings (22, 23) ausgerichtet ist, so dass die Vielzahl von Brechzähnen jedes Brechrings um 1/n (wobei es sich bei n um eine ganze Zahl handelt, die nicht kleiner als 2 ist) des Abstands in der Umfangsrichtung in Richtung einer Seite im Verhältnis zu der Vielzahl von Brechzähnen des Brechrings, der zu dem genannten Brechring in einer axialen Richtung, in der die Achsen sich erstrecken, benachbart ist, versetzt ist.

3. Der Walzenbrecher für eine Kühlervorrichtung nach Anspruch 2, wobei:
die lastreduzierende Walze (15) eine Welle (21) umfasst, die sich in der axialen Richtung erstreckt und die durch die entsprechende Dreheinheit (17) um die Achse der lastreduzierenden Welle gedreht wird,

die Welle auf ihrer äußeren Umfangsfläche eines aus einem Eingriffsteil (21a) und einer Eingriffsnut umfasst, die sich in der axialen Richtung erstrecken und die miteinander in Eingriff gebracht werden können,

jeder aus der Vielzahl von Brechringen (22, 23) auf seiner inneren Umfangsfläche das andere aus dem Eingriffsteil und der Eingriffsnut (22a, 23a) umfasst, und wenn das Eingriffsteil und die Eingriffsnut miteinander in Eingriff sind, die Vielzahl von Brechringen derart extern an der Welle arretiert sind, dass die Vielzahl von Brechringen im Verhältnis zu der Welle in Umfangsrichtung nicht verschiebbar ist,

die Vielzahl von Brechringen einen ersten Brechring (22) und einen zweiten Brechring (23) umfasst,

der erste Brechring einen ersten Referenzzahn (24d) umfasst, bei dem es sich um einen aus der Vielzahl von Brechzähnen handelt,

der zweite Brechring einen zweiten Referenzzahn (27e) umfasst, bei dem es sich um einen aus der Vielzahl von Brechzähnen handelt,

der erste Referenzzahn auf einer Linie angeordnet ist, die den Mittelpunkt des ersten Brechrings mit dem Mittelpunkt des anderen aus dem Eingriffsteil und der Eingriffsnut verbindet, und

der zweite Referenzzahn derart angeordnet ist, dass der zweite Referenzzahn im Verhältnis zu dem ersten Referenzzahn in der Umfangsrichtung um 360/(n * N) Grad versetzt ist (wobei es sich bei N um die Anzahl von Zähnen des zweiten Brechrings handelt).

4. Der Walzenbrecher für die Kühlervorrichtung nach Anspruch 1, wobei die Vielzahl von Brechzähnen (24, 27) einen hohen Zahn (24a, 27a) und einen niedrigen Zahn (24c, 27c) umfasst, wobei es sich bei dem hohen Zahn um einen Brechzahn mit einer ersten Höhe handelt und bei dem niedrigen Zahn um einen Brechzahn mit einer zweiten Höhe handelt, wobei die zweite Höhe niedriger als die erste Höhe ist.

5. Der Walzenbrecher für die Kühlervorrichtung nach Anspruch 4, wobei auf der äußeren Umfangsrichtung der lastreduzierenden Walze (15) Abschnitte (25, 28) zur Bildung von hohen Zähnen in Umfangsrichtung vorhanden sind, in denen jeweils eine Vielzahl der hohen Zähne (24a, 27a) in Umfangsrichtung ausgerichtet ist, und Abschnitte (26, 29) zur Bildung von niedrigen Zähnen in Umfangsrichtung vorhanden sind, in denen jeweils eine Vielzahl der niedrigen Zähne (24c, 27c) in Umfangsrichtung ausgerichtet ist, wobei die Abschnitte zur Bildung von hohen Zähnen und die Abschnitte zur Bildung von niedrigen Zähnen versetzt ausgerichtet sind.

6. Der Walzenbrecher für die Kühlervorrichtung nach Anspruch 5, wobei:

die lastreduzierende Walze (15) eine Welle (21) umfasst, die sich in einer axialen Richtung erstreckt, in der sich die Achse der lastreduzierenden Welle erstreckt, wobei die Welle durch die entsprechende Dreheinheit (17) um die Achse gedreht wird, die Vielzahl von Brechzähnen (24, 27) in einem vorbestimmten Abstand in regelmäßigen Intervallen auf der äußeren Umfangsfläche jedes Brechrings (22, 23) ausgerichtet ist, so dass die Vielzahl von Brechzähnen jedes Brechrings um 1/2 des Abstands in der Umfangsrichtung in Richtung einer Seite im Verhältnis zu der Vielzahl von Brechzähnen des Brechrings, der zu dem genannten Brechring in einer axialen Richtung, in der die Achsen sich erstrecken, benachbart ist, die Welle auf ihrer äußeren Umfangsfläche eines aus einem Eingriffsteil (21a) und einer Eingriffsnut umfasst, die sich in der axialen Richtung erstrecken und die miteinander in Eingriff gebracht werden können,

jeder aus der Vielzahl von Brechringen (22, 23) auf seiner inneren Umfangsfläche das andere aus dem Eingriffsteil und der Eingriffsnut (22a, 23a) umfasst, und wenn das Eingriffsteil und die Eingriffsnut miteinander in Eingriff sind, die Vielzahl von Brechringen derart extern an der Welle arretiert sind, dass die Vielzahl von Brechringen im Verhältnis zu der Welle in Umfangsrichtung nicht verschiebbar ist,

auf der äußeren Umfangsrichtung jedes Brechrings die Abschnitte (25, 28) zur Bildung von hohen Zähnen vorhanden sind, in denen jeweils wenigstens zwei der hohen Zähne (24a, 27a) ausgerichtet sind, und die Abschnitte (26, 29) zur Bildung von niedrigen Zähnen vorhanden sind, in denen jeweils wenigstens zwei der niedrigen Zähne (24c, 27c) ausgerichtet sind,

die Vielzahl von Brechringen einen ersten Brechring (22) und einen zweiten Brechring (23) umfasst,

der erste Brechring einen ersten Referenzzahn (24d) umfasst, bei dem es sich um einen aus der Vielzahl von Brechzähnen handelt und der auf einer Linie angeordnet ist, die den Mittelpunkt des ersten Brechrings mit dem Mittelpunkt des anderen aus dem Eingriffsteil und der Eingriffsnut verbindet, und wobei die Abschnitte zur Bildung von hohen Zähnen und die Abschnitte zur Bildung von niedrigen Zähnen in Bezug auf den ersten Referenzzahn abwechselnd in Umfangsrichtung auf der äußeren Umfangsfläche des ersten Brechrings ausgerichtet sind,

der zweite Brechring einen zweiten Referenzzahn (27e) umfasst, bei dem es sich um einen aus der Vielzahl von Brechzähnen handelt und der derart angeordnet ist, dass der zweite Referenzzahn im Verhältnis zu dem ersten Referenzzahn in Umfangsrichtung um 1/2 des Abstands in Richtung einer Seite in Umfangsrichtung versetzt ist, und die Abschnitte zur Bildung von hohen Zähnen und die Abschnitte zur Bildung von niedrigen Zähnen in Bezug auf den zweiten Referenzzahn abwechselnd in Umfangsrichtung auf der äußeren Umfangsfläche des zweiten Brechrings ausgerichtet sind, und der erste Brechring und der zweite Brechring derart ausgebildet sind, dass jeder aus dem ersten Brechring und dem zweiten Brechring in Bezug auf die Achse drehsymmetrisch ist.

Revendications

1. Concasseur à cylindres d'un dispositif de refroidissement (1) destiné à refroidir un matériau granulaire transporté pendant le transport du matériau granulaire transporté, le concasseur à cylindres étant configuré de manière à concasser le matériau granulaire transporté, le concasseur à cylindres comprenant :

une pluralité de cylindres (15) agencés côte à côte dans une direction de transport de telle sorte qu'un espace est formé entre les cylindres, les cylindres de la pluralité de cylindres étant entraînés en rotation autour de leurs axes respectifs par des unités d'entraînement en rotation (17) correspondantes afin de concasser le matériau granulaire transporté, les axes étant parallèles les uns aux autres et orthogonaux par rapport à la direction de transport, dans lequel au moins un de la pluralité de cylindres est un cylindre de réduction de charge, le cylindre de réduction de charge comporte une pluralité de bagues de concassage (22, 23), chacune de la pluralité de bagues de concassage comporte une pluralité de dents de concassage (24, 27) agencées sur sa surface périphérique externe, les dents de la pluralité de dents de concassage étant agencées à intervalles réguliers dans une direction circonférentielle, et

les dents de la pluralité de dents de concassage de chacune de la pluralité de bagues de concassage sur le cylindre de réduction de charge sont agencées de telle sorte que les dents de la pluralité de dents de concassage sont décalées d'une même valeur de décalage dans la direction circonférentielle par rapport à la pluralité de dents de concassage de la bague de concassage qui est adjacente à chaque bague de concassage,

dans lequel la pluralité de cylindres (15) comporte au moins deux des cylindres de réduction de charge qui sont adjacents l'un par rapport à l'autre, **caractérisé en ce que**

chacun des cylindres de réduction de charge adjacents comporte des bagues de concassage (22) telles que la valeur de décalage de laquelle les dents de la pluralité de dents de concassage (24) sont décalées dans la direction circonférentielle diffère entre les cylindres de réduction de charge adjacents.

2. Concasseur à cylindres de dispositif de refroidissement selon la revendication 1, dans lequel la pluralité de dents de concassage (24, 27) est agencée sur la surface périphérique externe de chaque bague de concassage (22, 23) suivant un pas prédéterminé, de telle sorte que les dents de la pluralité de dents de concassage de chaque bague de concassage sont décalées de 1/n du pas (où n est un entier non inférieur à 2) dans la direction circonférentielle vers un côté par rapport à la pluralité de dents de concassage de la bague de concassage qui est adjacent à chaque bague de concassage dans une direction axiale dans laquelle s'étendent les axes.

3. Concasseur à cylindres de dispositif de refroidissement selon la revendication 2, dans lequel

le cylindre de réduction de charge (15) comporte un arbre (21) qui s'étend dans la direction axiale et qui est entraîné en rotation autour de l'axe du cylindre de réduction de charge par l'unité d'entraînement en rotation (17) correspondante,
l'arbre comporte, sur sa surface périphérique externe, l'une d'un pièce de couplage (21a) et d'une rainure couplée qui s'étendent dans la direction axiale et qui peuvent être couplées l'une à l'autre,
chacune de la pluralité de bagues de concassage (22, 23) comporte, sur sa surface périphérique interne, l'autre de la pièce de couplage et de la rainure couplée (22a, 23a), et lorsque le pièce de couplage et la rainure couplée sont couplées l'une à l'autre, les bagues de la pluralité de bagues de concassage sont fixées de manière externe sur l'arbre de telle sorte que la pluralité de bagues de concassage ne peuvent pas être déplacées par rapport à l'axe dans la direction circonférentielle,
la pluralité de bagues de concassage comporte une première bague de concassage (22) et une seconde bague de concassage (23),
la première bague de concassage comporte une première dent de référence (24d) qui est l'une de la pluralité de dents de concassage,
la seconde bague de concassage comporte une seconde dent de référence (27e) qui est l'une de la pluralité de dents de concassage,
la première dent de référence est positionnée sur une ligne qui relie un centre de la première bague de concassage et un centre de l'autre de la pièce de couplage et de la rainure couplée, et la seconde dent de référence est disposée de telle sorte que la seconde dent de référence est décalée dans la direction circonférentielle par rapport à la première dent de référence de 360/(n * N) degrés (où N est le nombre de dents de la seconde bague de concassage).

4. Concasseur à cylindres de dispositif de refroidissement selon la revendication 1, dans lequel la pluralité de dents de concassage (24, 27) comporte une dent haute (24a, 27a) et une dent basse (24c, 27c), la dent haute étant la dent de concassage avec une première hauteur, la dent basse étant la dent de concassage avec une seconde hauteur inférieure à la première hauteur.

5. Concasseur à cylindres du dispositif de refroidissement selon la revendication 4, dans lequel des parties de formation de dents hautes (25, 28), dans chacune desquelles une pluralité de dents hautes (24a, 27a) sont agencées dans la direction circonférentielle, et des parties de formation de dents basses (26, 29), dans chacune desquelles une pluralité de dents basses (24c, 27c) sont agencées dans la direction circonférentielle, sont présentes sur une surface périphérique externe du cylindre de réduction de charge (15), et les parties de formation de dents hautes et les parties de formation de dents basses sont agencées d'une manière étagée.

6. Concasseur à cylindres du dispositif de refroidissement selon la revendication 5, dans lequel

le cylindre de réduction de charge (15) comporte un arbre (21) qui s'étend dans une direction axiale dans laquelle s'étend l'axe du cylindre de réduction de charge, l'arbre étant entraîné en rotation autour de l'axe par l'unité d'entraînement en rotation (17) correspondante,
les dents de la pluralité de dents de concassage (24, 27) sont agencées à intervalles réguliers sur la surface périphérique externe de chaque bague de concassage (22, 23) suivant un pas prédéterminé, de telle sorte que les dents de la pluralité de dents de concassage de chaque bague de concassage sont décalées de 1/2 pas dans la direction circonférentielle vers un premier côté par rapport à la pluralité de dents de concassage de la bague de concassage qui est adjacent à chaque bague de concassage dans la direction axiale, l'arbre comporte, sur sa surface périphérique externe, l'une d'une pièce de couplage (21a) et d'une rainure couplée qui s'étendent dans la direction axiale et qui peuvent être couplées l'une à l'autre,
chacune de la pluralité de bagues de concassage (22, 23) comporte, sur sa surface périphérique interne, l'autre de la pièce de couplage et de la rainure couplée (22a, 23a), et lorsque la pièce de couplage et la rainure couplée se couplent l'une à l'autre, les bagues de la pluralité de bagues de concassage sont fixées de manière externe à l'arbre de telle sorte que la pluralité de bagues de concassage ne peuvent pas être déplacées par rapport à l'arbre dans la di-

rection circonférentielle,

les parties de formation de dents hautes (25, 28), dans chacune desquelles au moins deux des dents hautes (24a, 27a) sont agencées, et les parties de formation de dents basses (26, 29), dans chacun desquelles au moins deux des dents basses (24c, 27c) sont agencées, sont présentes sur la surface périphérique externe de chaque bague de concassage,

la pluralité de bagues de concassage comporte une première bague de concassage (22) et une seconde bague de concassage (23),

la première bague de concassage comporte une première dent de référence (24d) qui est l'une de la pluralité de dents de concassage et qui est positionnée sur une ligne qui relie un centre de la première bague de concassage et un centre de l'autre de la pièce de couplage et de la rainure couplée, et sur la surface périphérique externe de la première bague de concassage, les parties de formation de dents hautes et les parties de formation de dents basses sont agencées de manière alternée dans la direction circonférentielle par rapport à la première dent de référence,

la seconde bague de concassage comporte une seconde dent de référence (27e) qui est l'une de la pluralité de dents de concassage et qui est disposée de telle sorte que la seconde dent de référence est décalée par rapport à la première dent de référence dans la direction circonférentielle de 1/2 pas vers le premier côté, et sur la surface périphérique externe de la seconde bague de concassage, les parties de formation de dents hautes et les parties de formation de dents basses sont agencées de manière alternée dans la direction circonférentielle par rapport à la seconde dent de référence, et

la première bague de concassage et la seconde bague de concassage sont formées de telle sorte que chacune de la première bague de concassage et de la seconde bague de concassage présente une symétrie de rotation par rapport à l'axe.

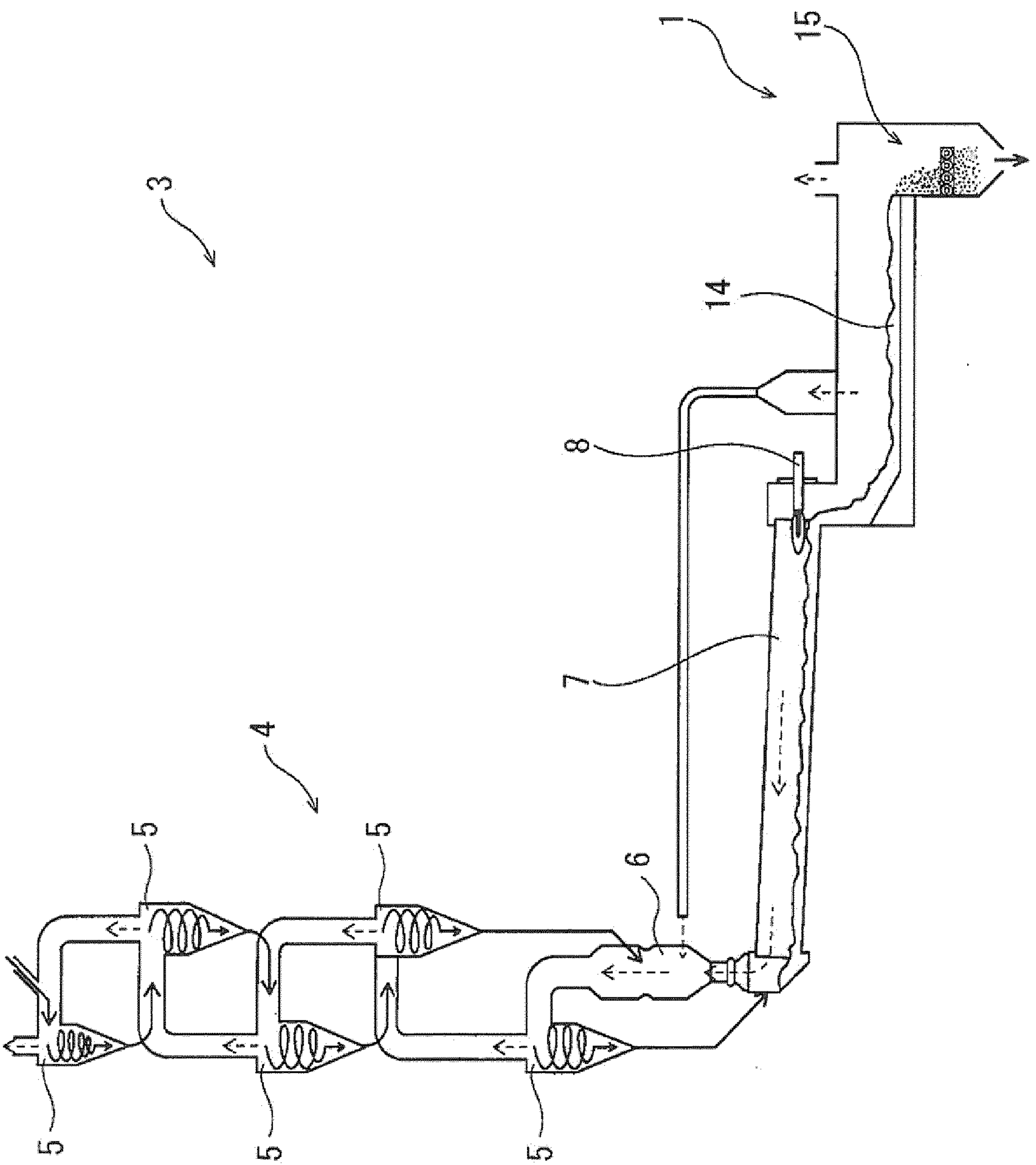


Fig. 1

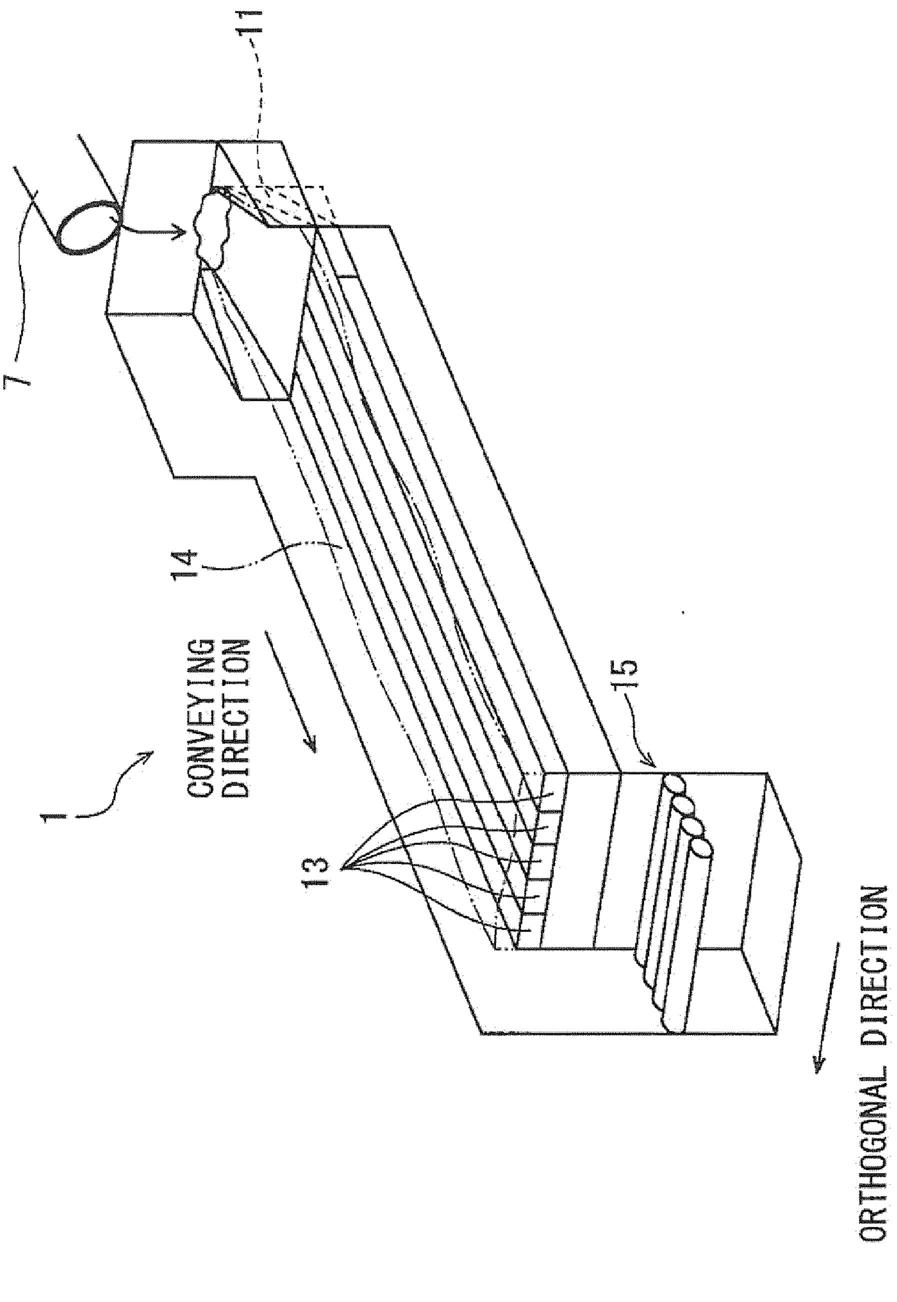


Fig. 2

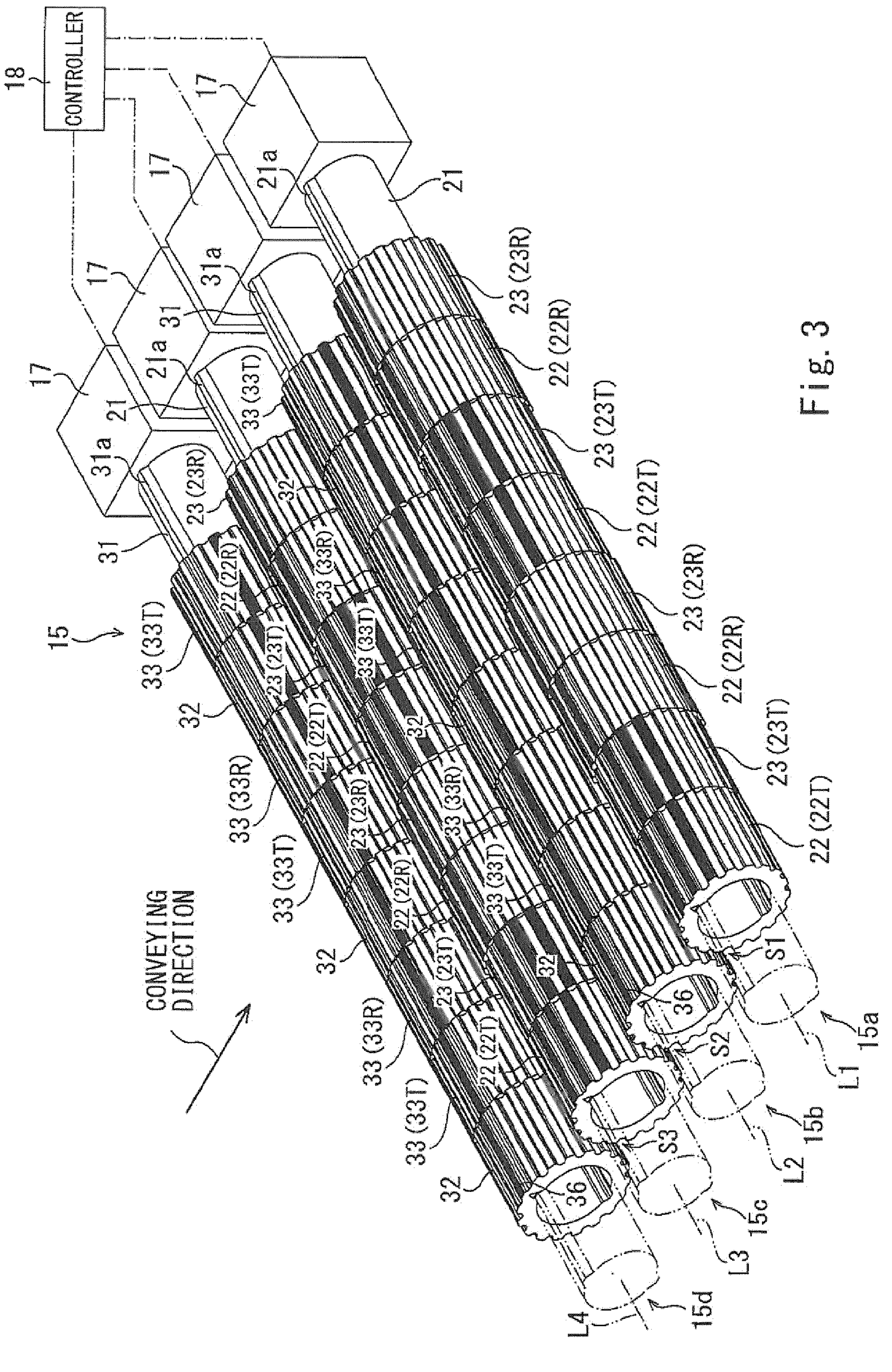

CONTROLLER
18
17
21a
21
31a
31
23 (23R)
22 (22R)
23 (23T)
22 (22T)
33 (33T)
33 (33R)
32
15
CONVEYING DIRECTION
36
S1
S2
S3
15a
15b
15c
15d
L1
L2
L3
L4

Fig. 3

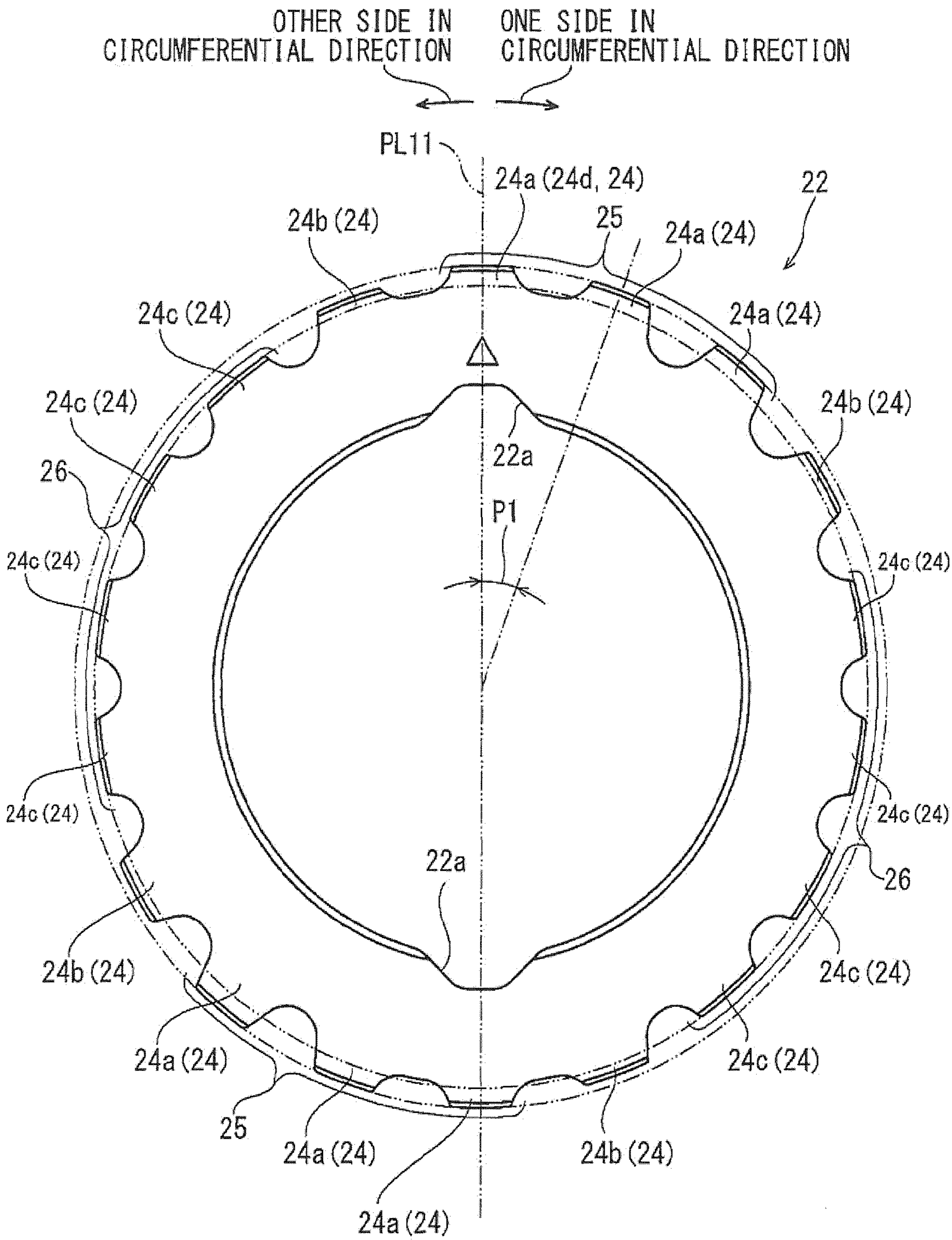

OTHER SIDE IN CIRCUMFERENTIAL DIRECTION
ONE SIDE IN CIRCUMFERENTIAL DIRECTION
PL11
24a (24d, 24)
22
25
24a (24)
24b (24)
24c (24)
24a (24)
24c (24)
24b (24)
22a
26
P1
24c (24)
24c (24)
24c (24)
24c (24)
22a
26
24b (24)
24c (24)
24a (24)
24c (24)
25
24a (24)
24b (24)
24a (24)

Fig. 4

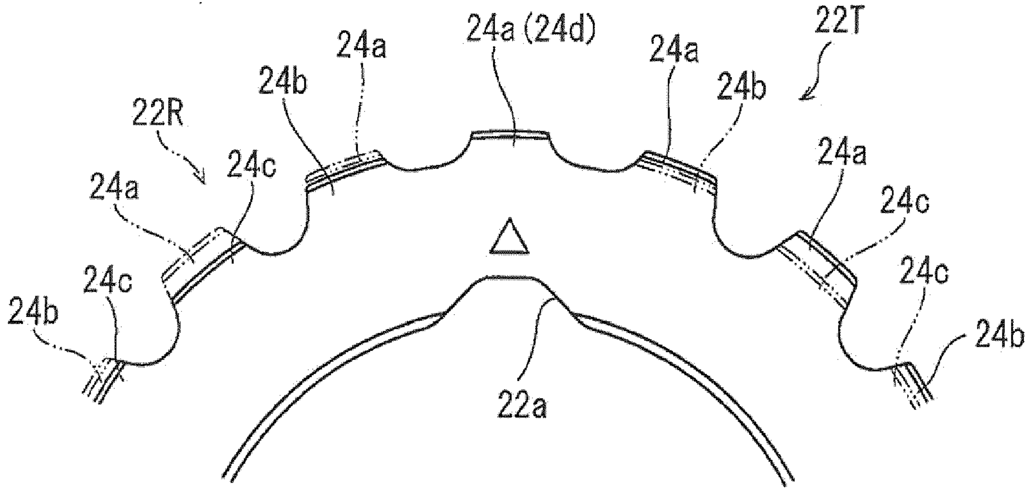

24a (24d)
22T
24a
24a
24b
24b
22R
24a
24c
24a
24c
24a
24c
24c
24b
24b
22a

Fig. 5

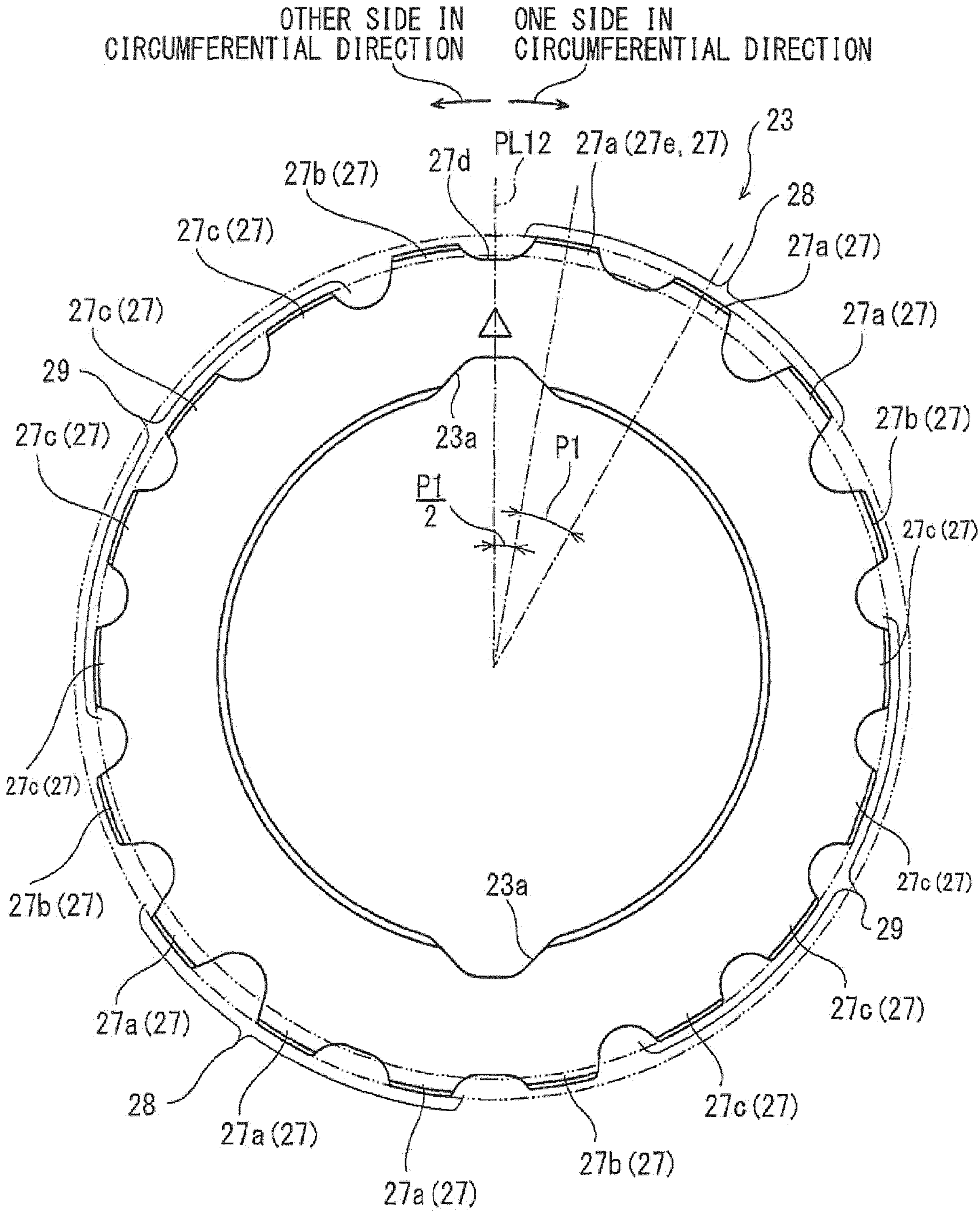

OTHER SIDE IN
CIRCUMFERENTIAL DIRECTION
ONE SIDE IN
CIRCUMFERENTIAL DIRECTION
23
PL12
27d
27a (27e, 27)
27b (27)
28
27a (27)
27c (27)
27a (27)
27c (27)
29
27b (27)
23a
P1
P1/2
27c (27)
27c (27)
27c (27)
27c (27)
23a
27b (27)
29
27a (27)
27c (27)
28
27a (27)
27c (27)
27b (27)
27a (27)

Fig. 6

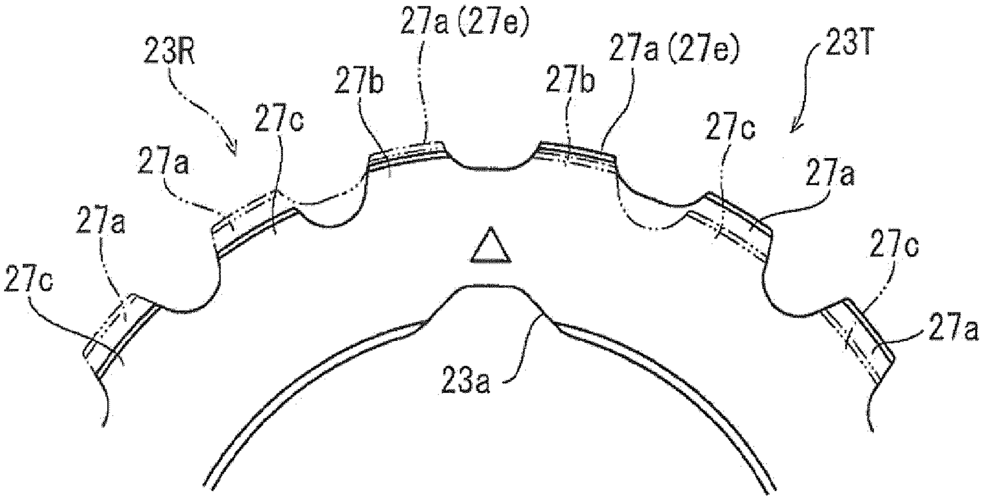

27a (27e)
27a (27e)
23R
23T
27b
27b
27c
27c
27a
27a
27a
27c
27c
27a
23a

Fig. 7

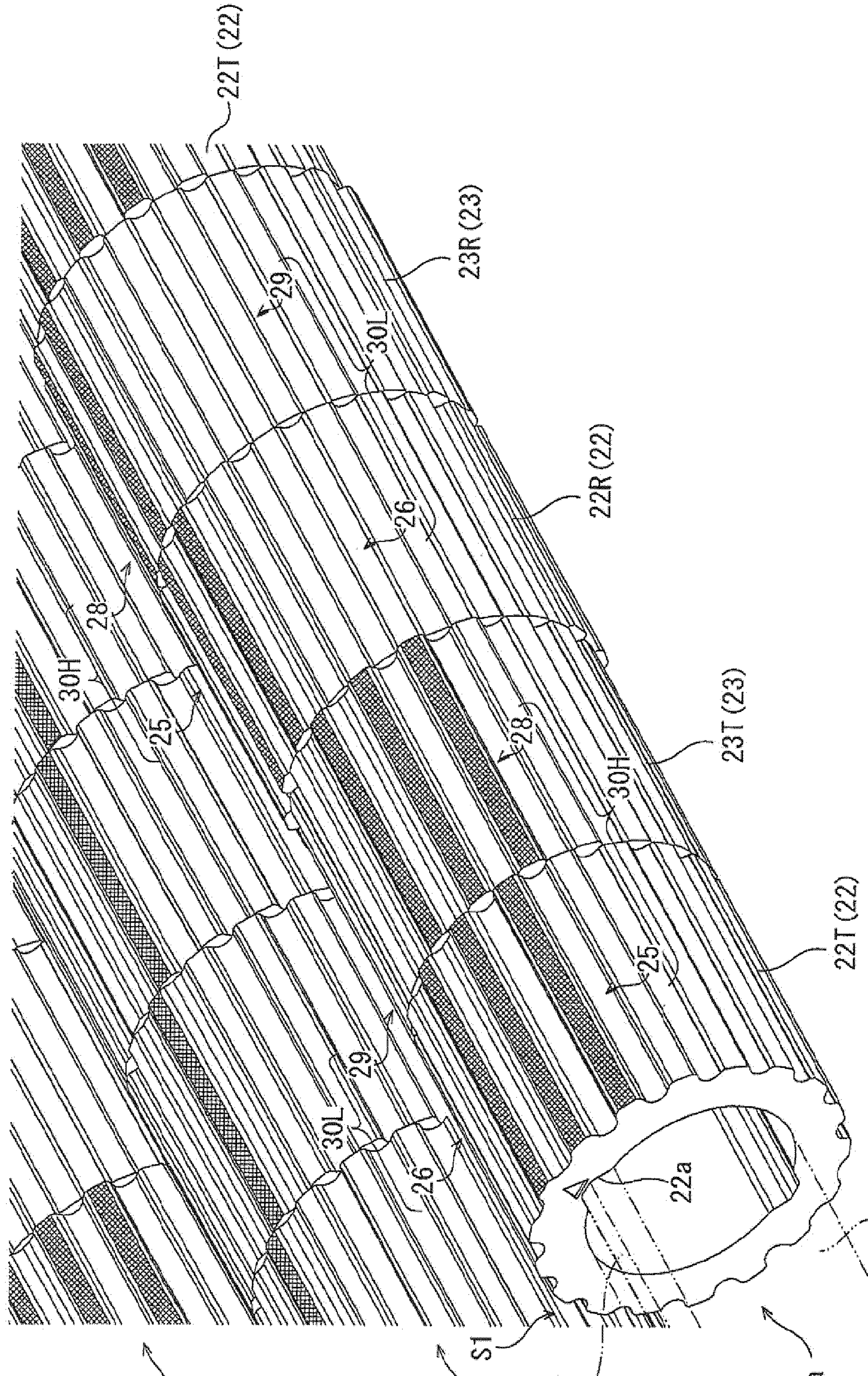

22T (22)
23R (23)
29
30L
22R (22)
26
28
30H
25
23T (23)
28
30H
22T (22)
25
29
30L
26
22a
21
S1
15c
15b
21a
15a

Fig. 8

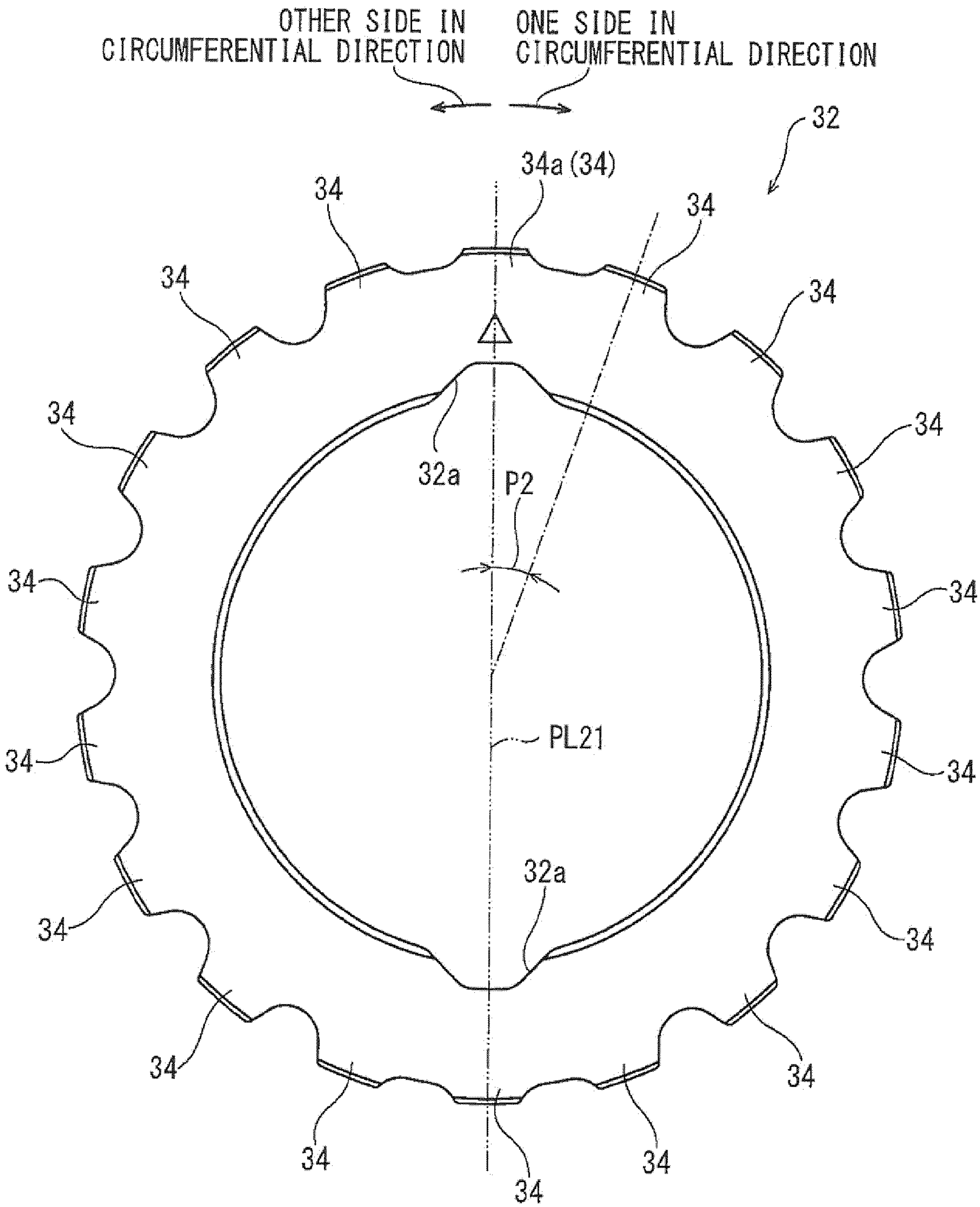
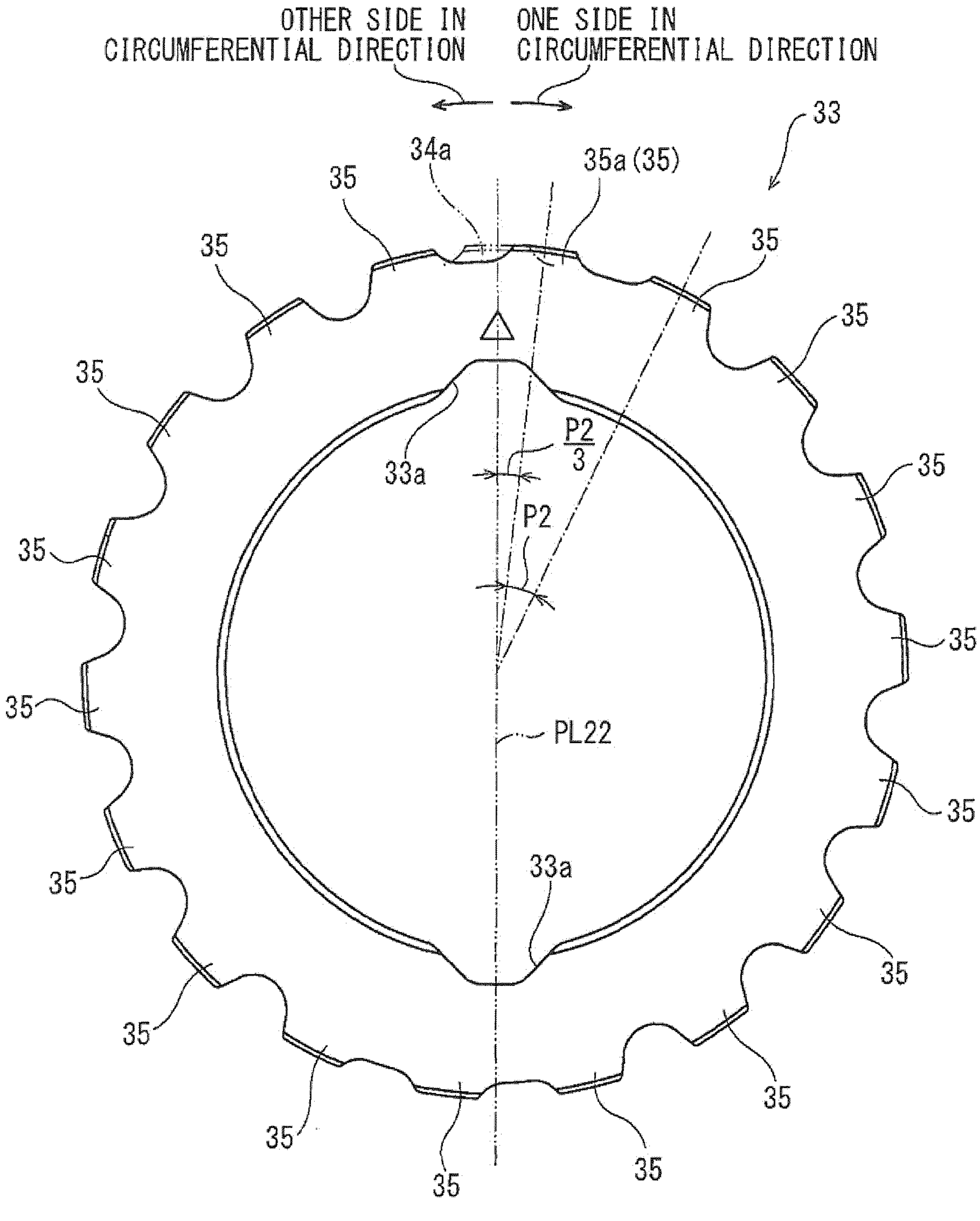

OTHER SIDE IN
CIRCUMFERENTIAL DIRECTION
ONE SIDE IN
CIRCUMFERENTIAL DIRECTION
32
34a (34)
34
32a
P2
PL21

Fig. 9



OTHER SIDE IN
CIRCUMFERENTIAL DIRECTION
ONE SIDE IN
CIRCUMFERENTIAL DIRECTION
33
34a
35a (35)
35
33a
P2
3
P2
PL22

Fig. 10

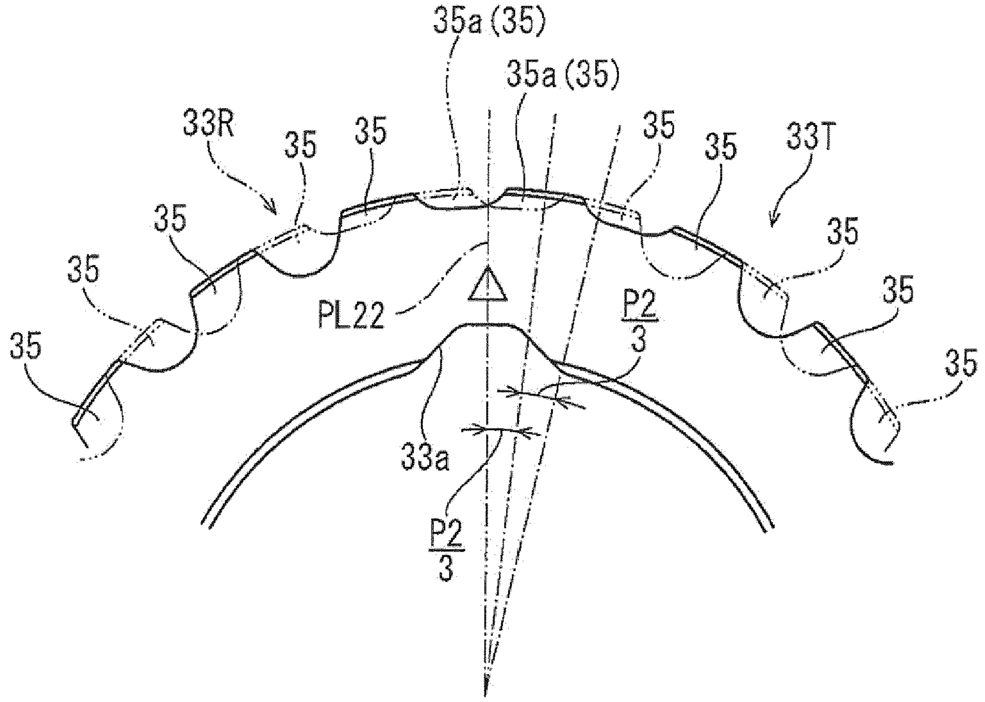


Fig. 11

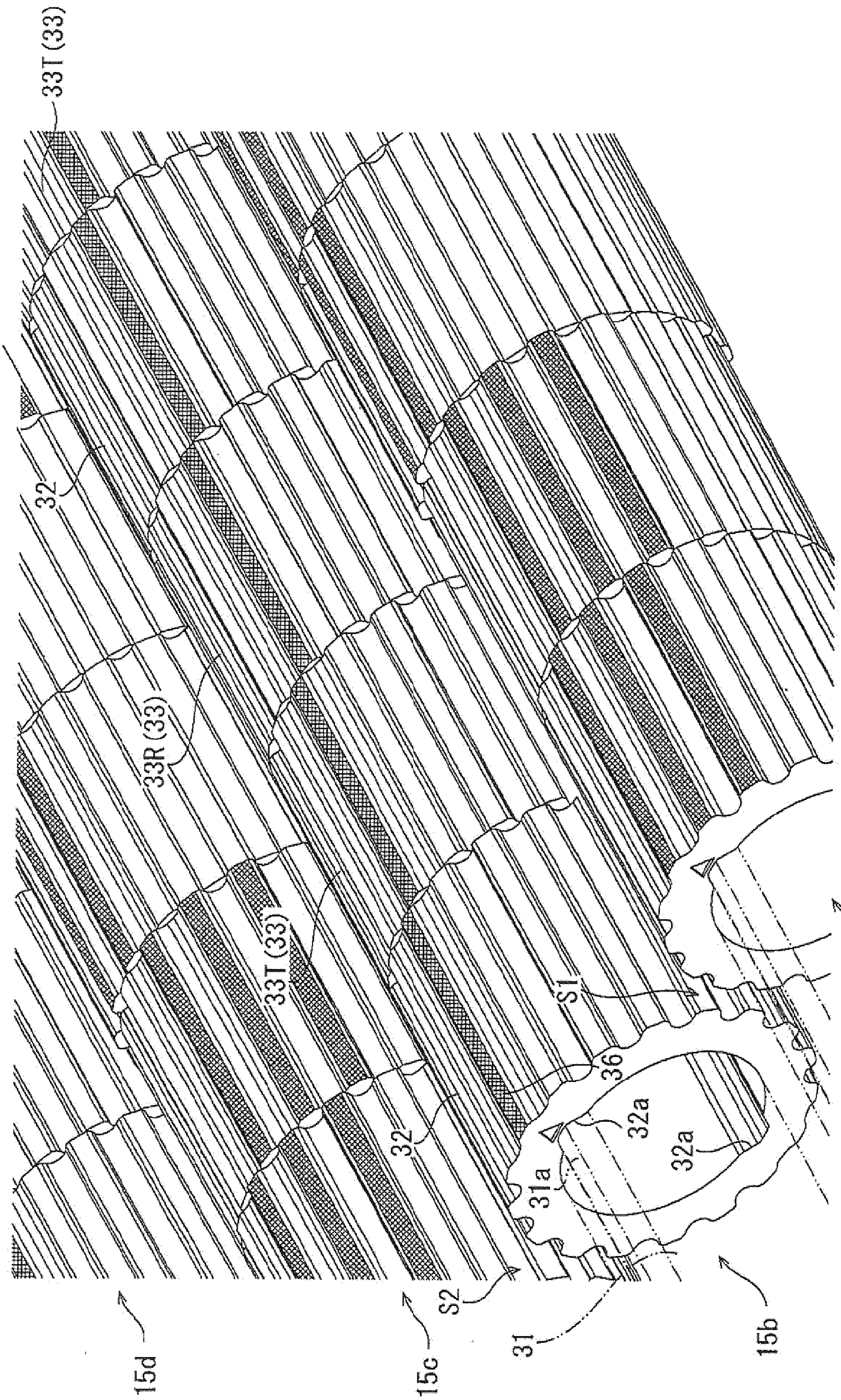


Fig. 12

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 104525310 A **[0002]**
- JP S61295264 A **[0003]**