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(54) Method and device for shaping a continuous metal belt

(57) The invention relates to a method for processing a continuous metal belt (10) having two radially oriented main surfaces (14) and having two axially oriented side faces (15), in particular for processing the side faces (15) thereof, in which a radial or thickness dimension of the belt (10) is reduced in what is known as a rolling process, and in which the belt (10), at least for part of the rolling process, at the location of at least one of the two side faces (15), at least of a transition edge between the side face and a main surface (14), is subjected to a shaping treatment, carried out with the aid of a processing element (26, 27) which acts on the side face (15).

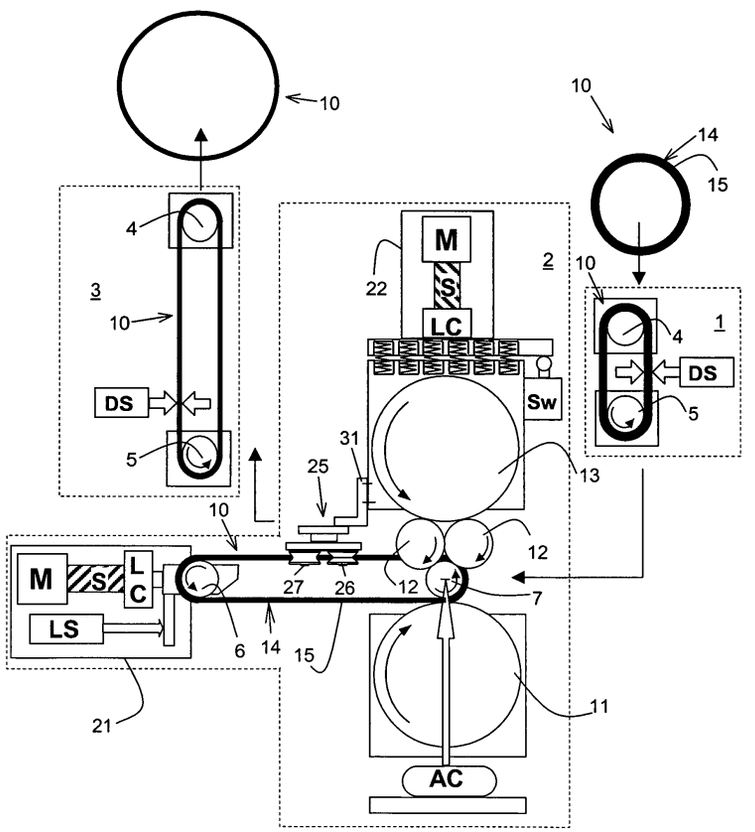

FIG. 1

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Description

[0001] The present invention relates to a method and a device for shaping a continuous metal belt, and to a belt of this type and also to a push belt in which the metal belt is used, as described, inter alia, in the preamble of Claim 1.

[0002] A push belt of this type, and also the continuous metal belt used therein, is generally known, for example from European Patent Publication EP-A 0 181 670 and from Dutch Patent Application No. 1022043, which was not published before the priority date of the present application, both in the name of the present applicant. The latter document also describes a rolling process and device for shaping a belt of this type. The metal belt is generally incorporated in the push belt in the form of one or two sets comprising a number of nested metal belts.

[0003] Hitherto, a metal belt of this type, at least on an industrial scale, is formed by cutting off a ring from a metal tube formed from a material in sheet form and then deforming this ring to produce a desired radial thickness and tangential or circumferential length with the aid of a rolling process, optionally preceded and/or followed by a heat treatment of the belt. Up until the belt undergoes the rolling treatment, it is also referred to as the ring. Before the ring is rolled, it is subjected to a tumbling process which is known per se and in which the ring is held for a certain time in a receptacle containing suitable moving tumbling blocks. This serves to remove burrs formed when the ring was being cut from the tube from the axially oriented side faces of the ring. In the process, at least the edges between the said side faces and radially oriented main surfaces of the ring are also rounded slightly.

[0004] However, it has been found that this known shaping process is not optimum, since the said side faces of the belt which is ultimately formed may still have an undesirable irregularity, for example in the form of scratches therein, which may have an adverse effect on the service life of the belt and therefore on that of the push belt and, moreover, are undesirable for optical reasons. In addition, the known tumbling process is a relatively expensive and labour-intensive process.

[0005] The object of the present invention is to improve the quality or at least the appearance of the axially oriented side faces of the belt considerably and to provide an alternative to the known tumbling process, or at least to reduce the intensity with which it is necessary to employ this process. According to the invention, this object is achieved by a method which comprises at least the characterizing features of Claim 1 below.

[0006] With the method according to the invention, the belt is processed in a tensioned state at the same time as the rolling process is being carried out on it, i.e. in the state and during the period in which the ring is being rolled under pressure from what are known as the rolling rolls in the thickness direction and, at the same time, is being stretched in the circumferential direction. The invention makes use of a specifically shaped and dynamically operating processing element in the form of a shaping roll which acts on an axially oriented side face of the belt. A processing operation of this type produces a permanent shaping, which is readily visible in the end product, of the said side faces. The processed side face can be of very even shape and structure and, on account of a specific shaping of the shaping roll, can be very successfully influenced in the desired way.

[0007] In particular, the method according to the invention can successfully be used to obtain a controlled, rounded and permanent shape of the side faces of the belt, with the abovementioned burrs or any remainders advantageously being removed therefrom, deformed or pressed into the bulk of the belt after a shortened tumbling process. These effects are boosted by arranging the shaping roll or rolls in such a way that, during the rolling process, they simultaneously act on the belt for as long as possible. The assumed reason for this is that the shaping of the side faces can then take place uniformly, and therefore without sudden and/or major deformation of material being required.

[0008] In addition, one important effect of the method according to the invention is that the side faces are shaped to be so even and smooth that any remaining deformations therein, such as a relatively large indentation or any irregularity in the structure of the material, will be noticed very reliably and, in particular, more quickly than hitherto, both during a visual inspection and if automated optical detection means are deployed.

[0009] The method and device according to the invention also realize a process in which the need to round the side faces of the rings prior to the rolling process is eliminated or at least reduced. Consequently, the need to tumble rings is at least limited to a shortened tumbling process in which, for example, the said burrs are removed but there is no significant rounding of the said edges. This fact has a beneficial effect on the speed and flexibility of the production process for the belts and considerably reduces the costs thereof.

[0010] It should be noted that processing of the side face of the ring or belt using the shaping roll which takes place only before or after the rolling process does not result in the same quality as if, in accordance with the present invention, this processing of the side face of the ring or belt using the shaping roll is carried out at least partially simultaneously with the said rolling process. Carrying out the abovementioned processing of the side faces simultaneously with the rolling process, i.e. during a uniform reduction in the thickness of the belt, in particular with simultaneous lengthening thereof, therefore forms a significant component of the invention.

[0011] In the method and device according to the invention, the belt is processed in the tensioned state, i. e. held around two so-called guide rolls, which are moved with a relative movement away from one another in order to apply a tensile stress to the belt. As a result,

the belt is brought into a more or less rigid state, at least into a state in which the belt can absorb a force exerted on its side face by the shaping roll. The belt is then rotated around and by means of the tensioning rolls, with the side face of the belt being guided onto the shaping roll. It is preferable for the shaping roll to be made from a material which is similar to or harder than the metal from which the belt is made.

[0012] In one preferred embodiment of the method and device according to the invention, the device is provided with at least two shaping rolls, which are positioned on either side of the belt and act on a side face thereof, these shaping rolls each having an axis of rotation which is oriented substantially perpendicular to the main surfaces and parallel to the side faces. The rolls are preferably provided with a groove with a substantially V-shaped contour which is applied over the cylindrical outer circumference of the roll, at least as seen in the tangential direction in a cross section through the roll. The shaping rolls are positioned opposite one another with respect to the circumferential direction of the belt and are pressed towards one another with a certain force, with the belt being held in the grooves in the said rolls at least at the location of its side faces.

[0013] In yet another preferred embodiment of the method and device, the device comprises two pairs of shaping rolls of this type positioned opposite one another, with the substantially V-shaped groove of a first pair being provided with a more acute vertex angle than that of the second pair. In a more detailed refinement, at least a centre part of the V-shaped groove of the second pair is rounded in shape, with the abovementioned vertex angle being defined by an imaginary lengthening of the sides of the contour of the V-shaped groove, at least as seen in the said tangential direction.

[0014] It should also be noted that the abovementioned publication EP-A 0 181 670, apart from the metal belt for a push belt to which the present application partly relates, also shows a method for processing a belt of this type with the aid of two cylindrical shaping elements, in particular shaping elements aimed at introducing a compressive stress into the axial sides of the belt by means of plastic deformation thereof. The shaping elements in this case act on the main surfaces of the belt, with the axis of rotation of shaping elements oriented parallel thereto and perpendicular to the side faces. However, this known method does not offer the option of specific shaping of the side faces of the belt or of removal of the said burr (residues), and moreover is aimed at achieving a different object from the present invention.

[0015] The invention will be explained in more detail below on the basis of an example, in which:

Figure 1 shows a diagrammatic overview of a rolling device as an overall insight into the method according to the invention which it is to carry out;
Figure 2 diagrammatically depicts a view of a device according to the invention for shaping axially oriented side faces of a continuous metal belt, which view is directed transversely onto a main surface of the belt;
Figure 3 forms a view of the device shown in Figure 2 in the direction indicated by arrow 'B';
Figure 4 forms a view of the device shown in Figure 2 in the direction indicated by arrows 'A';
Figure 5 shows part of a cross section through a belt prior to a generally known rolling process; and
Figure 6 shows the said part after the belt has been processed using the form of shaping in accordance with the invention.

[0016] Figure 1 diagrammatically depicts an existing rolling device for rolling metal rings to form belts, which device is illustrated in such a manner that it also provides an insight into the shaping method and shaping device 25 according to the invention. The rolling device is described in Dutch Patent Application No. 1022043, which was not published before the priority date of the present application, and comprises three modules. In this respect, the figure shows, from the right to the left, a first measuring module 1, a rolling module 2 and a second measuring module 3. The rolling device is controlled by an electronic control unit, which is not shown in more detail in the figure. The measuring modules 1 and 3 comprise measuring rolls 4, 5 around which the belt 10 can be arranged, in such a manner that the thickness of the belt 10 can be measured both before and after the rolling process has been carried out, with the aid of the proximity sensors DS. It is preferable for the said measuring rolls 4, 5 to be moved away from one another, with the belt 10 being subjected to a tensile stress, and for the measurement to be carried out at a number of positions over the circumference of the belt 10, which is of benefit to the accuracy.

[0017] The rolling module 2 comprises two rotatable guide rolls 6, 7, of which a first roll 7 is positioned centrally in the rolling module 2 and around which the belt 10 to be rolled can be arranged. A second roll 6 of the guide rolls 6, 7 is held within the rolling module 2 in such a manner that it can be displaced so as to apply a tensile force, for example under the control of first activation means 21. The rolling module 2 furthermore comprises a pair of support rolls 12 which act on the first guide roll 7, a rolling roll 11, and a pressure roll 13 acting on the support rolls 12. The support rolls 12 are each provided over their circumference with a recess, by means of which they each act on the first guide roll 7 on either side adjacent to the belt 10. The pressure roll 13 is accommodated in such a manner that it can be displaced, under the influence of second activation means 22, in the rolling module 2, in such a manner that a pushing force or rolling force can be exerted on the support rolls 12. During the rolling operation, the support rolls 12 transmit the rolling force to the first guide roll 7, which is then supported on the rolling roll 11 via part of the belt

10.

[0018] During the rolling process, the belt 10 is held rotating between the first guide roll 7 and the rolling roll 11. The rotating movement of the belt 10, the direction of rotation of which is indicated by arrows D, is in this case achieved by driving at least one of the said rolls 6, 7, 11, 12 and 13, with the direction of rotation of the rolls 6, 7, 11, 12 and 13 being indicated by the arrows illustrated therein. After the rolls 6, 7, 11, 12, 13 and the belt 10 have reached a desired rotational speed, a tensile force is applied to the belt 10 between the guide rolls 6, 7, and a pushing force is applied to the belt 10 between the rolling roll 11 and the first guide roll 7. As a result of the rotary movement of the belt 10 and the rolling forces exerted thereon, material flows out of the thickness dimension towards the longitudinal and/or width dimension of the belt 10 over its entire circumference. The said flow of material is partially introduced by being applied, via the rotation of the belt 10, in a number of rolling passes between the rolling roll 11 and the first guide roll 7. The rolling process, it should be noted, is carried out with a continuous supply of a coolant.

[0019] Figure 1 also diagrammatically depicts the shaping device 25 according to the present invention and the way in which it can be held in the known rolling module 2 in order to process side faces 15 of the belt which are oriented in the width direction, i.e. axially oriented, at the same time as the belt 10 is being rolled. The shaping device 25 is preferably coupled to a frame to which one of the rolling rolls is secured, in this case the bearing frame for the pressure roll 13, in such a manner that a correct orientation of the latter with respect to the belt 10 is obtained automatically. A bearing arm 31 is provided for this purpose in Figure 1.

[0020] In a preferred embodiment, the shaping device 25 according to the invention is provided with two pairs of shaping rolls 26, 27, the respective rolls 26, 27 of which are moved towards one another, or at least a pushing force is exerted between them, so that they act on the side faces 15 on either side of the belt 10. The shaping rolls 26, 27 are provided over their outer circumference with a concave profile, i.e. a groove, in which the belt 10 is partially accommodated. During the normal rolling process, in which a defined reduction in the thickness of the belt 10 is desired during the said rolling passes, the shaping rolls 26, 27 simultaneously act on the belt 10 in the axial direction, with the side faces 15, and in particular the transition edges 16 (cf. Figures 5 and 6) between these side faces and the radially oriented main surfaces 14 of the belt 10 being provided with a desired shape.

[0021] Obviously, the shaping device 25 should furthermore be provided with means which enable it to be opened and closed, i.e. with means which are responsible for moving the rolls 26, 27 away from one another with a movement component in the axial direction and then bringing them into contact with the belt 10, which can advantageously be achieved in the construction shown by the said means being mechanically coupled to the rolling module 2, it being possible for the latter to follow an opening and closing movement thereof for the purpose of applying and removing the belt 10 to and from the guide rolls 6, 7.

[0022] Figures 2, 3 and 4 diagrammatically depict the arrangement of an embodiment of the shaping device 25 for processing, i.e. shaping, the side faces 15 of the belt 10. In this context, Figure 2 shows a view transversely onto the circumferential direction of the belt 10, as seen in a direction perpendicular to the main surface 14 thereof, and Figures 3 and 4 each show a view of the shaping device 25, respectively as indicated by arrows A and arrow B in Figure 2.

[0023] A carrier 30 which is coupled to the bearing arm 31 is provided, in accordance with a preferred embodiment, with two subframes 33 which are each held moveably, i.e. linearly displaceably, with respect to the carrier 30 and with respect to one another. In the preferred embodiment shown, the subframes 33 are provided with two processing rolls 26 and 27, which are arranged rotatably thereon. Moreover, an intermediate frame 32 is also provided between the subframes 33 and the carrier 30. In this case, the intermediate frames 32 are arranged on the carrier 30 in such a manner that they can be displaced linearly with respect to the latter, for example with the aid of a rectilinear guide which is oriented transversely with respect to the said direction of rotation D, and the subframes 33 are arranged on the respective intermediate frame 32 with the aid of an axle 34, so that they can execute an oscillating or rotary motion with respect to the intermediate frame 32 and therefore also with respect to the belt 10 which is to be shaped.

[0024] Obviously, alternative embodiments are conceivable, for example by using just one pair of shaping rolls 26, 27, by providing each of the subframes 33 directly with one processing roll 26, 27 and not using the said intermediate frame 32, or by the two rolls 26, 27 each being separately secured to the carrier 30 in a linearly displaceable manner. In the latter embodiment, two activation elements 36 are required in order to move the two pairs of shaping rolls 26 and 27 towards one another, at least in order to exert a pushing force F on the side faces 15 of the belt 10 on either side thereof. In the construction shown in Figures 2-4, only one activation element 36 is required (cf. also Figure 4). The activation element 36 may, for example, realize a controlled force F, but according to the invention may also be realized, in a surprisingly simple way, as a more or less constant spring force F produced by a tension spring 36 arranged between the subframes 33.

[0025] Figures 2-4 illustrate the possibility of processing a side face 15 using two pairs of shaping rolls 26 and 27. The shaping rolls 26, 27 are provided over their outer circumference with a concave profile, i.e. a groove, in which the belt 10 is partially accommodated and via which groove the shaping rolls 26, 27 each act

on the side faces 15 of the belt from the axial sides thereof, and in particular act on the transition edges 16 between the side faces 15 and the radially oriented main surfaces 14, shaping them during the known rolling process.

[0026] As is shown in the figures and in accordance with a further refinement of the inventive concept, the grooves in the two pairs of shaping rolls 26, 27 are of different shapes, at least as seen in the tangential direction in a cross section thereof. The two groove shapes are in this case substantially V-shaped, but in a first pair of shaping rolls 26 the V-shaped groove ends in a discrete, acute vertex angle, while in the other, or second, pair of shaping rolls 26 it ends in an evenly rounded transition, at least at the location of a centre part of the groove, which therefore forms a rounded transition between the side faces of the groove on either side of the centre part. This centre part is preferably substantially parabolic in shape. Also, the V-shaped groove of the first pair of shaping rolls 26 is preferably narrower than that of the second pair of shaping rolls 27. A configuration and shaping of the device 25 of this type also ensures that the first pair of rolls 26 is at least substantially aimed at processing and shaping the said transition edges 16, and that the second pair of rolls 27 is at least substantially aimed at processing and shaping the side face 15 itself (cf. also Figures 5 and 6). In this case, it is preferable for the second pair of shaping rolls 27 to be positioned behind the first pair of shaping rolls 26, at least as seen in the direction of rotation D of the belt 10.

Figures 5 and 6 illustrate the effect of a processing operation in accordance with a more detailed refinement of the present invention of this nature. Figure 5 shows a cross section through a part 17 of a belt 10 which is yet to be rolled, i.e. a ring, as is typically obtained after the belt 10 has been cut off a tube, i.e. including a burr 18 which is generally present at the location of a transition edge 16. Figure 6 shows the same cross section 17 through the belt 10, but after it has been rolled and, at the same time, processed or shaped in accordance with the invention. It can be seen that the thickness of the belt 10 - i.e. the distance between the two main surfaces 14 - has been reduced by the rolling operation and, moreover, that the transition edges 16 have been considerably flattened in particular by the action of the first pair of rolls 26. The centre part 20 of the side face 15 has clearly been shaped in particular by the second pair of rolls 27 and therefore has a convex profile, at least as seen in cross section 17. The side parts 19 of the side face 15 located on either side of the said centre part 20 have clearly been shaped in particular by the first pair of rolls 26 and consequently have a flat profile, at least as seen in cross section 17.

Claims

1. Method for processing a continuous metal belt (10) with two radially oriented main surfaces (14) and with two axially oriented side faces (15), in particular for processing the side faces (15) thereof, in which a radial or thickness dimension of the belt (10) is reduced in what is known as a rolling process by the belt (10) being rotationally fitted between and around at least two rolls (6, 7) of a rolling module (2) and then being rolled, for a number of rotations and with compressive force being exerted, between two rolling rolls (7, 11) of the rolling module (2), which each act on a main surface (14) of the belt (10), **characterized in that** the belt (10), for part of the rolling process, at the location of at least one of the two side faces (15), at least of a transition edge (16) between this face and a main surface (14), is subjected to a shaping treatment, carried out with the aid of a processing element (26, 27) which acts on the side face (15), at least at the transition edge (16) thereof.

2. Method according to Claim 1, **characterized in that**, during the shaping treatment, the processing element (26, 27) is pushed onto the respective side face (15) with the aid of an activation element (36).

3. Method according to Claim 1 or 2, **characterized in that** the processing element (26, 27) is what is known as a shaping roll (26, 27) with an axis of rotation that is oriented substantially perpendicular to the main surfaces (14) and parallel to the side faces (15) of the belt (10).

4. Method according to Claim 3, **characterized in that**, during the shaping treatment, two identical shaping rolls (26; 27), which are positioned opposite one another with respect to a circumferential direction of the belt (10), on either side of the latter, act on the side faces (15) of the belt (10).

5. Method according to Claim 3 or 4, **characterized in that** the shaping roll (26, 27) is provided, over its circumference, with a groove, preferably with a contour which is substantially V-shaped, as seen in cross section, through which groove the belt (10) is guided during the shaping treatment.

6. Device (2, 25) for rolling a continuous metal belt (10) with two radially oriented main surfaces (14) and with two axially oriented side faces (15), suitable in particular for carrying out the method according to one of the preceding claims, provided with a rolling module (2) having two rolls (6, 7) for tensioning the belt (10) in rotation, and at least one further rolling roll (11) for acting on the main surfaces (14) of the belt (10) with a compressive force being exerted, **characterized in that** the device (2, 25) is provided with a shaping device (25) with at least one shaping roll (26, 27) for processing a side face (15) of the

belt (10), or at least a transition edge (16) between the side face and a main surface (14).

7. Device (2, 25) according to Claim 6, **characterized in that** the shaping device (25) is provided with an activation element (36) for pushing the shaping roll (26, 27) onto the respective side face (15).

8. Device (2, 25) according to Claim 6 or 7, **characterized in that** an axis of rotation of the shaping roll (26, 27) is oriented substantially perpendicular to the main surfaces (14) and parallel to the side faces (15) of the belt (10).

9. Device (2, 25) according to one of Claims 6-8, **characterized in that** the shaping roll (26, 27) is provided, over its circumference, with a groove, preferably with a contour which is substantially V-shaped, as seen in cross section.

10. Device (2, 25) according to one of Claims 6-9, **characterized in that** the shaping device (25) is provided with at least two identical shaping rolls (26, 27), which are positioned opposite one another with respect to a circumferential direction of the belt (10), on either side of the latter.

11. Device (2, 25) according to one of Claims 6-10, **characterized in that** the shaping device (25) is provided with two pairs (26, 27) of respectively identical shaping rolls (26, 27), which are positioned opposite one another with respect to a circumferential direction of the belt (10), on either side of the latter, a first pair of rolls (26) being provided with a groove with a V-shaped contour provided with a discrete, acute vertex angle, while a second pair of rolls (27) is provided with a groove with a V-shaped contour with a more or less rounded profile, and the groove of the first pair of shaping rolls (26) being narrower than that of the second pair of shaping rolls (27).

12. Device (2, 25) according to Claim 11, **characterized in that** in each case one roll (26, 27) of the two pairs of shaping rolls (26, 27) is accommodated rotatably on one of two subframes (33).

13. Device (2, 25) according to Claim 12, **characterized in that** the subframes (33) are each held with a rotation axle (34) on a separate intermediate frame (32), which intermediate frame (32) is accommodated in a linearly displaceable fashion on a common support (30).

14. Device (2, 25) according to Claim 13, **characterized in that** the shaping device (25) is provided with an activation element (36) for forcing the rolls (26, 27) of a pair of rolls (26, 27) towards one another, in particular with a tension spring (36) secured between the intermediate frames (32).

15. Shaping device (25) intended for the device (2, 25) according to one of Claims 6-14, provided with at least one shaping roll (26, 27) for processing a side face (15) of the belt (10), or at least a transition edge (16) between the side face and a main surface (14).

16. Metal belt (10) produced using the method from one of Claims 1-5 or with the aid of the shaping device (25) from Claim 15.

17. Push belt provided with at least one set comprising a number of metal belts (10) according to Claim 16 which are nested with one another in the radial direction.

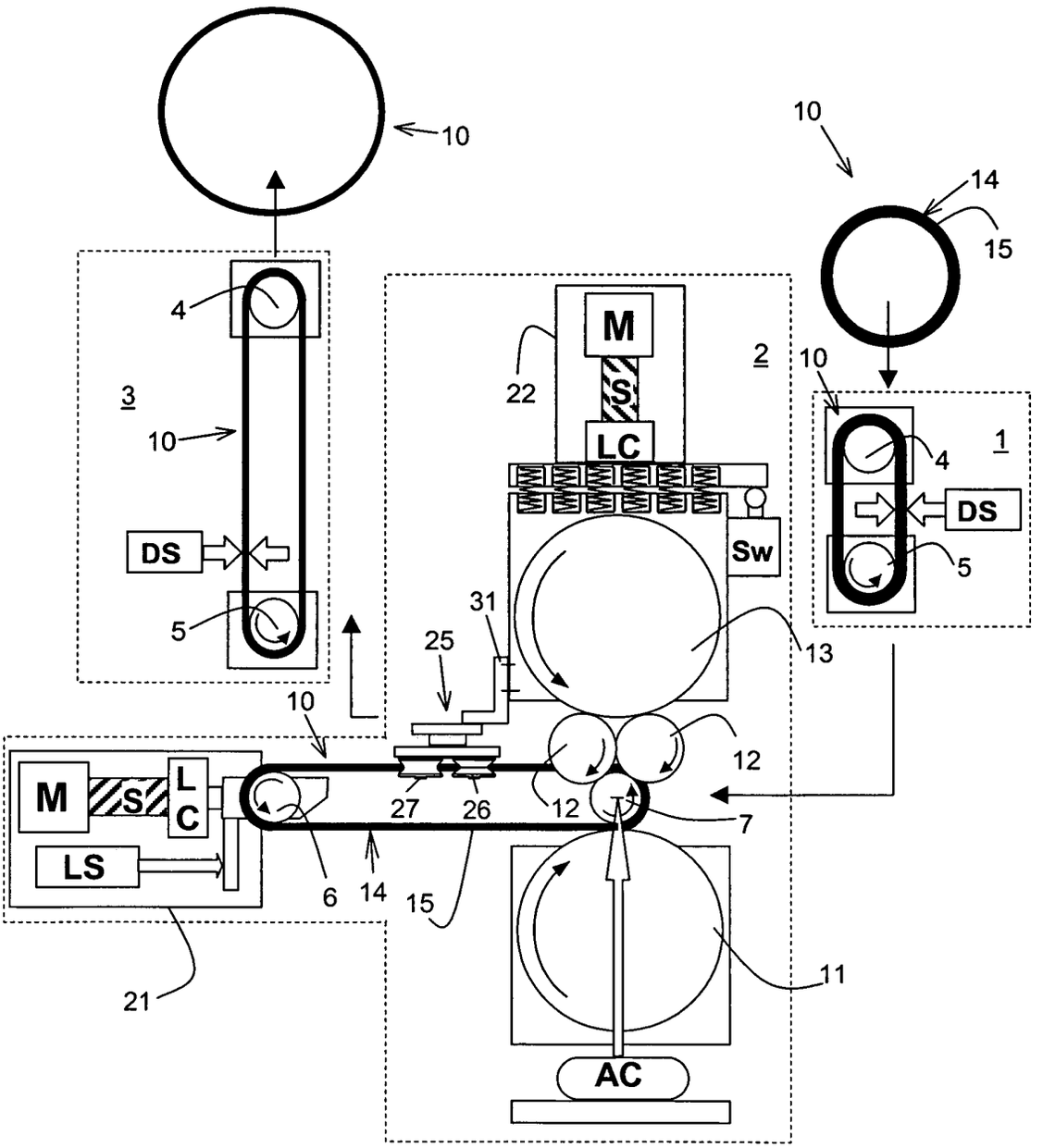
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FIG. 1

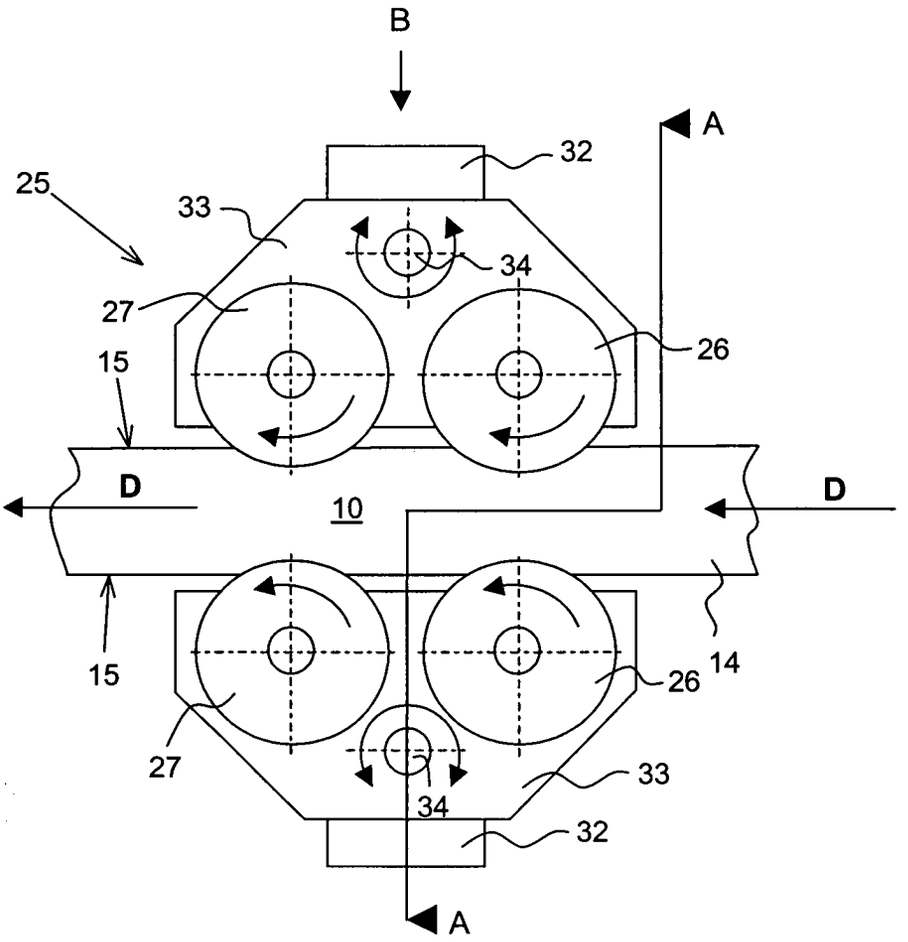
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FIG. 2

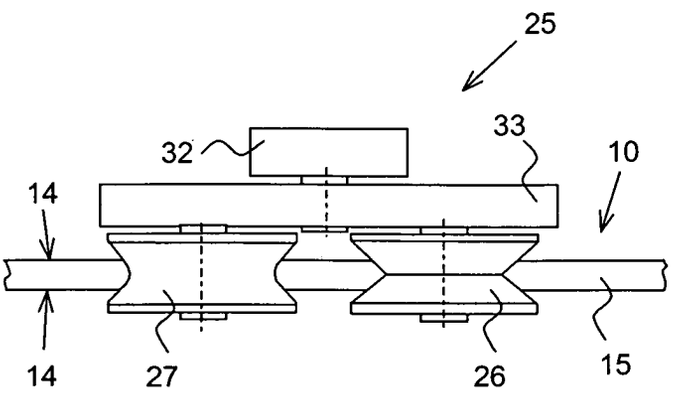
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FIG. 3

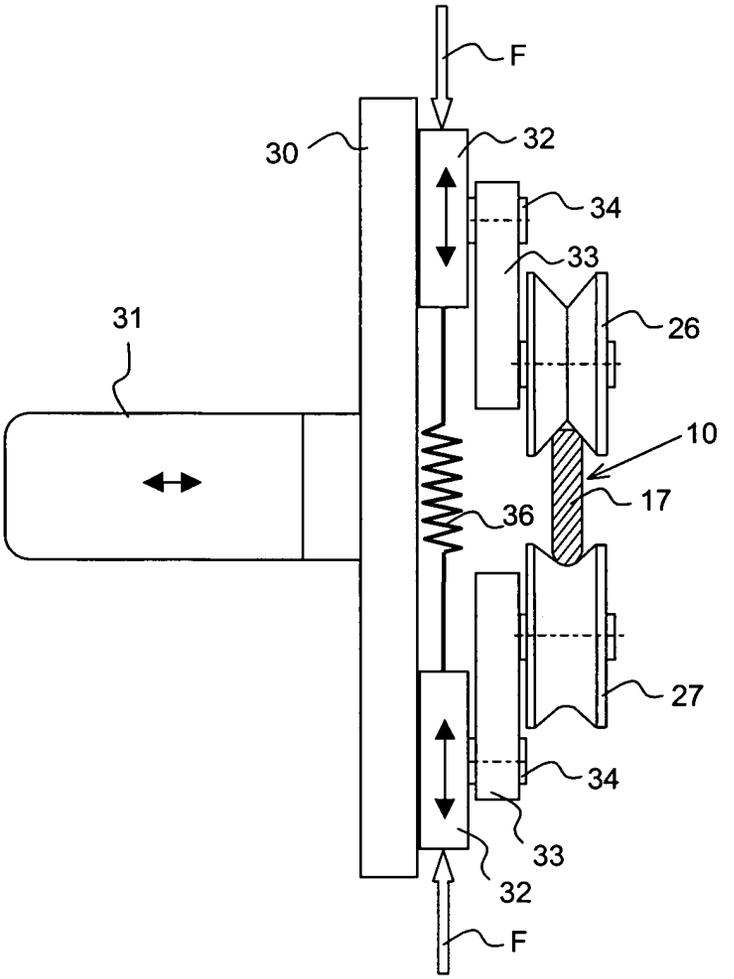

FIG. 4

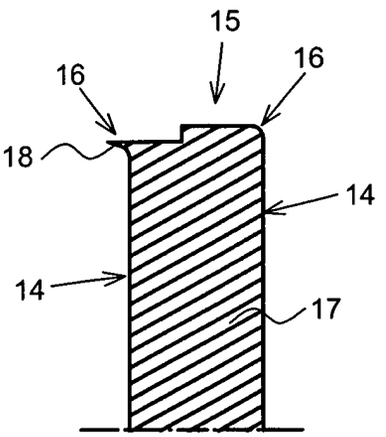

FIG. 5

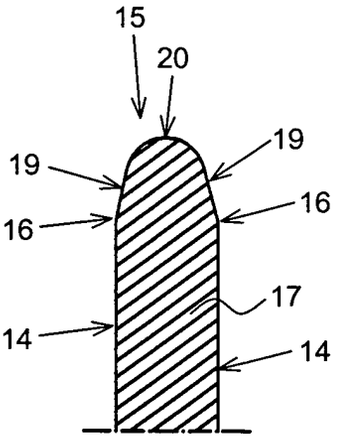

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 01 4542

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	US 4 661 089 A (CUYPERS MARTINUS H) 28 April 1987 (1987-04-28) * the whole document *	1-17	B21D19/00 B21D53/14
A	US 3 400 566 A (WALTER GAUER) 10 September 1968 (1968-09-10)		
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 August 2004	Peeters, L

CATEGORY OF CITED DOCUMENTS

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16-08-2004

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