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(54) **Device for rolling metal bands**

(57) A device for rolling a self-contained endless band (10) for a metal push belt, which is provided with a first and a second rotatable bearing roller (6, 7) around which the band (10) is intended to be placed and held in an elongated form, the second bearing roller (6) being accommodated in a movable manner in the device, with a rolling roller (11) that is in contact with the band (10) and with a central roller (7) that is in contact with the band (10) opposite to the rolling roller (11), in which device a pushing force (Fu) can be generated between the rolling roller (11) and the central roller (7), to which pushing force the band (10) is subjected, wherein one or both of the rolling roller (11) and the central roller (7) is provided with a concave, hourglass-like shape such that the respective roller (7; 11).

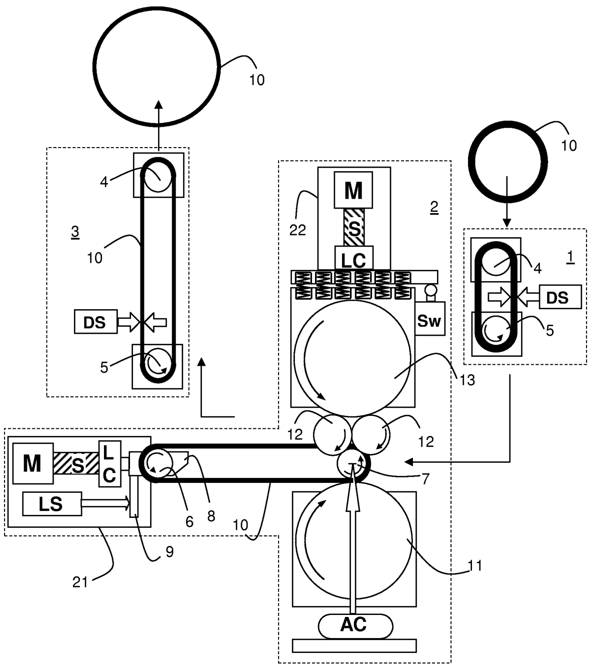

FIG. 1

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Description

[0001] The present invention relates to a device for rolling endless metal bands as defined in the preamble of claim 1.

[0002] Such bands form part of a generally known metal push belt, such as that for use in a continuously variable transmission, and is known, for example, from EP-A 0 950 830. Such a transmission is generally known and is used, inter alia, in passenger vehicles. In such a push belt a band is used as part of a pulling element comprising a number of such bands nested concentrically. The bands here are formed by rolling up a sheet part to form a tube and closing said tube by welding, from which tube a ring is subsequently separated off or cut. Finally, the ring is then rolled to a relatively low band thickness, which is desirable in order to obtain flexibility of the band and relatively low internal material stress when said band is subjected to a rotating movement over a bearing with a relatively small diameter. On account of the crucial importance of this property for the quality of a push belt, the desired shape of the band is achieved specifically in a very accurate manner for each individual band of the pulling element. After the rolling operation, the band generally undergoes a further number of processing or treatment steps before said band is ready for use in a push belt.

[0003] The Applicant has been rolling the metal bands by a method which has not changed since the Applicant's invention of the push belt in 1970, and the principle of which method was recently published in Japanese patent publication JP-11-290908. With the development of the insight into the properties of the push belt and the bands in it, and with the increase in popularity of the continuously variable transmission, the necessity has arisen for an improvement in the principle of the rolling process and the rolling device, not least with a view to the quality requirements of a band in accordance with the present state of the art, but also in order to achieve an entirely modern process and corresponding device in which the years of experience of the Applicant, the requirements of a modern push belt and the advance in general development of the art are reflected. Amongst other things, the advance in the art of the push belt requires that the power to be transmitted per unit mass of the push belt be increased, so that for this also a technologically very advanced execution of each part of the production process of a push belt is desired.

[0004] One of the objects of the invention is therefore to achieve a high-grade process and device for producing rolled bands of relatively high quality, or at any rate of relatively great uniformity.

[0005] This object is achieved according to the invention with a rolling process to which the measures according to the characterizing part of claim 1 are added. The invention will now be explained in greater detail with reference to an example, in which:

Figure 1 relates to an overview of the rolling process according to the invention and provides a diagrammatic insight into the corresponding rolling device;

Figures 2, 3 and 4 show a part of the rolling process;

Figure 5 is an illustration of phases to be distinguished in the speed of revolution applied and rolling force, which phases are used in the rolling process according to the invention for shortening the cycle time in an optimum manner; and

Figure 6 is a side view and a cross section of a band such as is formed in an excellent manner by the process and the device according to the invention.

[0006] In the figures corresponding structural parts are indicated by the same reference numerals.

[0007] Figure 1 shows a rolling device that is illustrated diagrammatically in such a way that the rolling process used can also be seen from it. The device comprises three rolling device parts or modules. The figure shows for this purpose, from right to left, a first measuring module 1, a roller module 2, and a second measuring module 3. The rolling device and the rolling process are controlled by an electronic control unit, which is not further shown in the figure.

[0008] The band 10 in its initial state, in other words before the rolling, is also sometimes indicated by the term ring, on account of its round, relatively rigid character. After rolling, the band is also sometimes indicated by the term belt because of its flexible character.

[0009] The measuring modules 1 and 3 comprise measuring rollers 4, 5 around which the band 10, rolled or otherwise, can be placed, in such a way that a measurement of the thickness D of band 10 can be carried out. At least one of the rollers 4 or 5 is preferably drivable, so that the thickness measurement can be carried out at a number of positions around the circumference of the band 10 and an average value can be determined for it. The abovementioned drivable roller 4 or 5 can preferably be moved away from the respective other roller 5 or 4, in which case the band is subjected to a tensile stress, which benefits the accuracy and in particular the reproducibility of the thickness measurement. The thickness measurement can be carried out by means of a movement sensor DS accommodated between the measuring rollers 4, 5. The thickness, or the average thickness, according to the invention is a decisive measurement for the material volume of the band 10 to be rolled, and consequently for the process settings of the rolling process. The abovementioned measurement for the material volume can be determined more accurately if the length and possibly also the width of the band to be rolled are likewise determined. In the present production process of the band it is sufficient according to the invention to carry out the thickness measurement alone, because the length and width of the band 10 are assumed to be constant, which is quite possible in combination with the known method by which the bands to be rolled are produced. In this known production method a band is produced by rolling up sheet material to form a cylinder, welding together the sides of the sheet material that are then resting against each other, and cutting the tube created in this way into rings.

[0010] The roller module 2 comprises two rotatable bearing rollers 6, 7, a first roller 7 of which is placed centrally in the roller module 2, and a second roller 6 of which is accommodated in the roller module 2 in such a way that it is movable by the application of a pulling force Fm, Fl and around which the band 10 to be rolled can be placed. For the application of the abovementioned pulling force Fm, Fl the roller module 2 comprises first activation means 21, which in this exemplary embodiment comprise a motor M and a screw spindle S and can move a roller holder 8 with the second bearing roller 6 rotatably mounted on it relative to the first bearing roller 7.

[0011] A movement sensor LS is shown, by means of which sensor by way of a reference part 9 of the roller holder 8 the movement of the latter can be determined, and by means of which the length L of the rolled band 10 can also be determined. The pulling force actually exerted can be measured by means of the load cell LC also shown. After the rolling has been completed, the band length L obtained can be determined accurately with the aid of the movement sensor LS from the measured distance between the bearing rollers 6 and 7 and their diameters, by making said sensor rotate about the bearing rollers 6 and 7 without a rolling force Fu or pushing force Fu being exerted between the rolling roller 11 and the first bearing roller 7 in the process. The measured band length L according to the invention can be advantageously used to optimize the rolling process settings by way of feedback, but can also serve as a control parameter for subsequent process steps to be carried out on the rolled band 10.

[0012] The roller module 2 further comprises a pair of supporting rollers 12, which act upon the first bearing roller 7, a rolling roller 11, and a pressure roller 13 acting upon the supporting rollers 12. The supporting rollers 12 are each provided around their circumference with an opening through which they act upon the first bearing roller 7 only on either side next to the band 10. The pressure roller 13 is accommodated in the roller module 2 in a movable manner under the influence of second activation means 22, which in this exemplary embodiment comprise a motor M and a screw spindle S, in such a way that a pushing or rolling force Fu can be exerted upon the supporting rollers 12, which pushing force Fu can be measured by way of a so-called load cell LC. As a result of the double support of the first bearing roller 7 by the supporting rollers 12, the pushing force exerted by the pressure roller 13 during the rolling operation is transmitted in a balanced and stable manner by way of the supporting rollers 12 to the bearing roller 7. Said bearing roller 7 is subsequently supported again by way of a part of the band 10 on the rolling roller 11, which is supported by the pushing force Fu during the rolling operation by way of a reaction force Fr. The band here is accommodated so that during the rolling process it rotates between the first bearing roller 7 and the rolling roller 11. The rotating movement of the band 10 is achieved here by driving one or more of the abovementioned rollers 6, 7, 11, 12 and 13, as indicated by the arrows shown in them. As a result of the rotating movement of the band 10 and the pushing force Fu exerted upon it, material flow occurs over the entire circumference from the thickness dimension of the band 10 to its length and width dimension. The direction of movement or of rotation of the band 10 is important for the quality of the rolling process, which apart from that is carried out with a continuous supply of a lubricant and cooling agent to the contact between the band 10 and the rollers 11 and 7, in such a way that the bearing roller 7 takes the band 10 off the rolling roller 11, the actual deformation of the band 10 occurring in a stretched part of said band.

[0013] Depending on the thickness D measured for each band 10 prior to the rolling process, the control unit determines a desired pulling force Fl and pushing force Fu for the band 10 concerned, which forces are to be applied during the rolling process by way of the activation means 21 or 22.

[0014] Figures 2, 3 and 4 show diagrammatically the movement towards each other or, conversely, the movement away from each other of the respective rollers 6, 7, 11, 12 and 13, for placing the band 10 in or removing it from the rolling device. For this purpose, electronically controllable movement units (not further shown in the figure) are present in the rolling device, according to the invention, for example in the form of electro-hydraulic units or the electronically activated air cylinder AC shown in Figure 1. One of these in the present embodiment acts by way of a bearing arm upon the first bearing roller 7, so that the latter can move towards the supporting rollers 12, which is shown in Figure 2. In another embodiment of the device it is, however, also possible to move the pressure roller 13 together with the supporting rollers 12 towards the first bearing roller 7. This movement towards each other takes place after the band 10 to be rolled has been placed around the first and second bearing rollers 6 and 7 and with the exertion of a relatively low clamping or pulling force Fm upon the band 10.

[0015] When the first bearing roller 7 is in contact with the supporting rollers 12 a force Fp is applied to the shaft of the rolling roller 11, as shown in Figure 3. This also brings the rolling roller 11 into contact with the band 10, as is shown in Figure 4. If the rolling roller 11 is energized in the rotating sense, the abovementioned force Fp ensures that the band 10, the supporting rollers 12 and the pressure roller 13 take over its rotation. The clamping force Fm ensures that the second bearing roller 6 takes over the rotation of the band 10 and that the band 10 moves over the bearing rollers 6 and 7 in a correct or centered manner.

[0016] During the actual rolling process, after the band 10 has been accommodated fully in the rolling device and the rollers 6, 7, 11, 12 and 13 have reached the required speed of rotation, a pulling force Fl is imposed by way of the second bearing roller 6 and a pushing force Fu is imposed by way of the pressure roller 13 upon the band 10. In this case the pulling force Fl is supported by the first bearing roller 7 and the pushing force Fu is ultimately supported by the reaction force Fr exerted by the rolling roller 11.

[0017] The rolling process itself according to the invention is primarily aimed at achieving a desired uniform band thickness D. The rolling process according to the invention is conceived as a displacement process in the case of which a material flow from the thickness D of the ring 10 is directed towards the length L and the width B of said ring. To this end, the electronic control unit, on the basis an algorithm suitable for the purpose and depending on the measurement for the volume of the band, determines the pushing force Fu and pulling force Fl exerted by the device upon the band 10.

[0018] In the rolling process according to the invention, apart from an accurate band thickness D, it is also aimed to achieve a high degree of accuracy as regards the length L of the band 10. The stability of the band widths B obtained after the rolling operation is therefore to a large degree dependent upon the stability of the material volume of the bands 10 yet to be rolled. In order to reduce the effect of a spread in the band widths B obtained after rolling as a result of the finite stability of the size of the material volume of the bands 10 to be rolled, an effect which is a disadvantage in practice and is therefore undesirable, according to a special embodiment of the invention the measure is taken to divide the bands 10 to be rolled into at least two rolling groups, which are distinguished by the band length L aimed at after rolling and for which the rolling process settings differ per rolling group.

[0019] In practice, this means that bands 10 with a relatively great thickness D are placed in a first rolling group that is rolled out to a relatively great length L, and that bands 10 with a relatively low thickness D are placed in a second rolling group that is rolled out to a relatively small length L. More particularly, the rolling process settings are characterized in that for the first rolling group the ratio between the pulling force Fl and the pushing force Fu is selected at a higher level than is the case for the second rolling group. As a result of the spread in the length L of the rolled bands 10 thus permitted and even striven for, the band width B obtained after rolling will in fact exhibit less spread between the individual bands 10.

[0020] In this special embodiment of the invention there is advantageous use of the rolled bands in the pulling element of the push belt in which a number of bands 10 are nested concentrically in relation to one another, for which purpose said bands must be of different lengths. Bands 10 from the second rolling group are then eminently suitable for nesting in the bands 10 of the first rolling group. Different lengths L between the rolled bands 10 of the pulling element are therefore advantageous for nesting of said bands and according to the invention can also advantageously be used to reduce a variation in the width B of the bands 10 in the pulling element. The number of different rolling groups to be defined is, of course, dependent here upon an envisaged maximum variation in the width B of said bands and on the number of bands 10 per pulling element.

[0021] The pushing force Fu and pulling force Fl to be exerted during the rolling process are regulated by the control unit by feedback from the actual forces exerted that have been measured with the aid of the load cells. In addition, according to the invention, the quality of the rolling process is largely determined by the fact that it is controlled on the basis of the abovementioned forces Fl and Fu. This contrasts with a possible process control on the basis of the mutual position of the bearing rollers 6 and 7 and the of the rolling roller 11 and the central roller 7.

[0022] As shown in Figure 1, the band thickness D obtained after rolling can be measured with the aid of the second measuring module 3. A thickness measurement is preferably carried out outside the roller module 2, in order to make efficient use of the device. By means of such a measurement it can be checked whether the selected rolling process setting is actually leading to the desired rolling result, and wear of, for example, the first bearing roller 7 can be detected.

[0023] According to the invention, it is further possible greatly to shorten the speed of the rolling process, or the cycle time needed for rolling one band 10, thereof, which is achieved by selecting the speed of rotation of the first bearing roller 7 and consequently also of the band 10 at a relatively high level during a main phase HF of the rolling process. According to the invention, it is necessary here that after the abovementioned main phase HF a slow-down phase UF be added to the rolling process, in which latter phase the rolling forces Fu and Fl, and preferably also the abovementioned speed of rotation, are considerably lower than is the case in the main phase HF. Such a rolling process is illustrated in the diagram of Figure 5, in which, depending on the cycle time t, the speed of rotation rpm of the band 10 and one of the two rolling forces, in this case Fu, given as an example. In Figure 5 the dashed lines indicate for purposes of comparison a rolling process with a single rolling phase WF.

[0024] According to the invention, the abovementioned reduction should be at least 10%, but should preferably be between 25% and 50%. Such a rolling process has the advantage that in the main phase a considerable initial reduction in thickness of the band 10 can be achieved relatively quickly, although to some extent at the expense of the accuracy or stability of the end result of the process, while in the slow-down phase the desired thickness D of the band 10 is achieved accurately and in a stable manner, also uniformly distributed over the band length L.

[0025] Apart from the abovementioned measures, it was found on the basis of practical experience that the features of the rolling process, including the reproducibility of the rolling result and the shortening of the cycle time t discussed above, are improved by a specific diameter ratio between the rolling roller 11 and the first bearing roller 7 between which the band 10 is rolled, with one of the rollers having to be considerably larger than the other, as shown in Figure 1. In particular, the diameter of the rolling roller 11 should be at least 3 times, but preferably approximately 4 times, the size of that of the first bearing roller 7. Such diameter ratios have the additional advantage that the rolling roller 11 wears significantly less quickly, so that during operation in most cases only the bearing roller 7, which is relatively easy to remove and overhaul, needs to be replaced because of wear. There is consequently an advantageous effect on the production capacity and the maintenance costs of the rolling device.

[0026] Figure 6 shows diagrammatically a side view and a cross section of a rolled band 10. In this figure the abovementioned parameters of the band 10, i.e. the length L, the width B and the thickness D, is are illustrated again. It is also shown that the rolled band 10, viewed in cross section, can be provided with an arch shape with a radius R. The figure also shows that the rolled band 10, viewed in cross section, can be provided with a barrel shape, in other words a thickness D measured centrally on the band 10 is greater than a thickness A measured near the edges of the band 10.

[0027] The configuration of the present rolling device, in particular the specified diameter ratio of the rolling roller 11 and the first bearing roller 7, is eminently suitable for obtaining the desired band shapes. It is also possible according to the invention to obtain a desired shape of the cross section of the band 10 depending on the shape of at least one of the rollers 7, 11. For instance, according to the invention it is advantageously possible, in particular in order to obtain the abovementioned barrel shape, to provide the respective roller 7 or 11 with a non-cylindrical shape, for example by narrowing said roller slightly from its edges towards a central point on the roller, in other words providing it with a concave, hourglass-like shape.

[0028] Apart from what has been described above, the invention also relates to all details in the figures, at any rate in so far as such details can be immediately and unequivocally deduced by a person skilled in the art, and to all that is described in the following set of claims.

Claims

1. A device for rolling a self-contained endless band (10) for a metal push belt, which is provided with a first and a second rotatable bearing roller (6, 7) around which the band (10) is intended to be placed and held in an elongated form, the second bearing roller (6) being accommodated in a movable manner in the device, with a rolling roller (11) that is in contact with the band (10) and with a central roller (7) that is in contact with the band (10) opposite to the rolling roller (11), in which device a pushing force (Fu) can be generated between the rolling roller (11) and the central roller (7), to which pushing force the band (10) is subjected, **characterized in that** one or both of the rolling roller (11) and the central roller (7) is provided with a concave, hourglass-like shape that narrows in a direction from either side towards a central point of the respective roller (7; 11).

2. The rolling device as claimed in claim 1, **characterized in that** the diameter of the rolling roller (11) is considerably larger than the diameter of the central roller (7).

3. The rolling device as claimed in claim 2, **characterized in that** the **in that** the diameter of the rolling roller (11) is at least 3 - and preferably approximately 4 - times the size of the diameter of the central roller (7).

4. The rolling device as claimed in claim 2 or 3, **characterized in that** the diameter of the rolling roller (11) lies in the range from 120 to 200 mm and the diameter of the central roller (7) lies in the range from 30 to 50 mm.

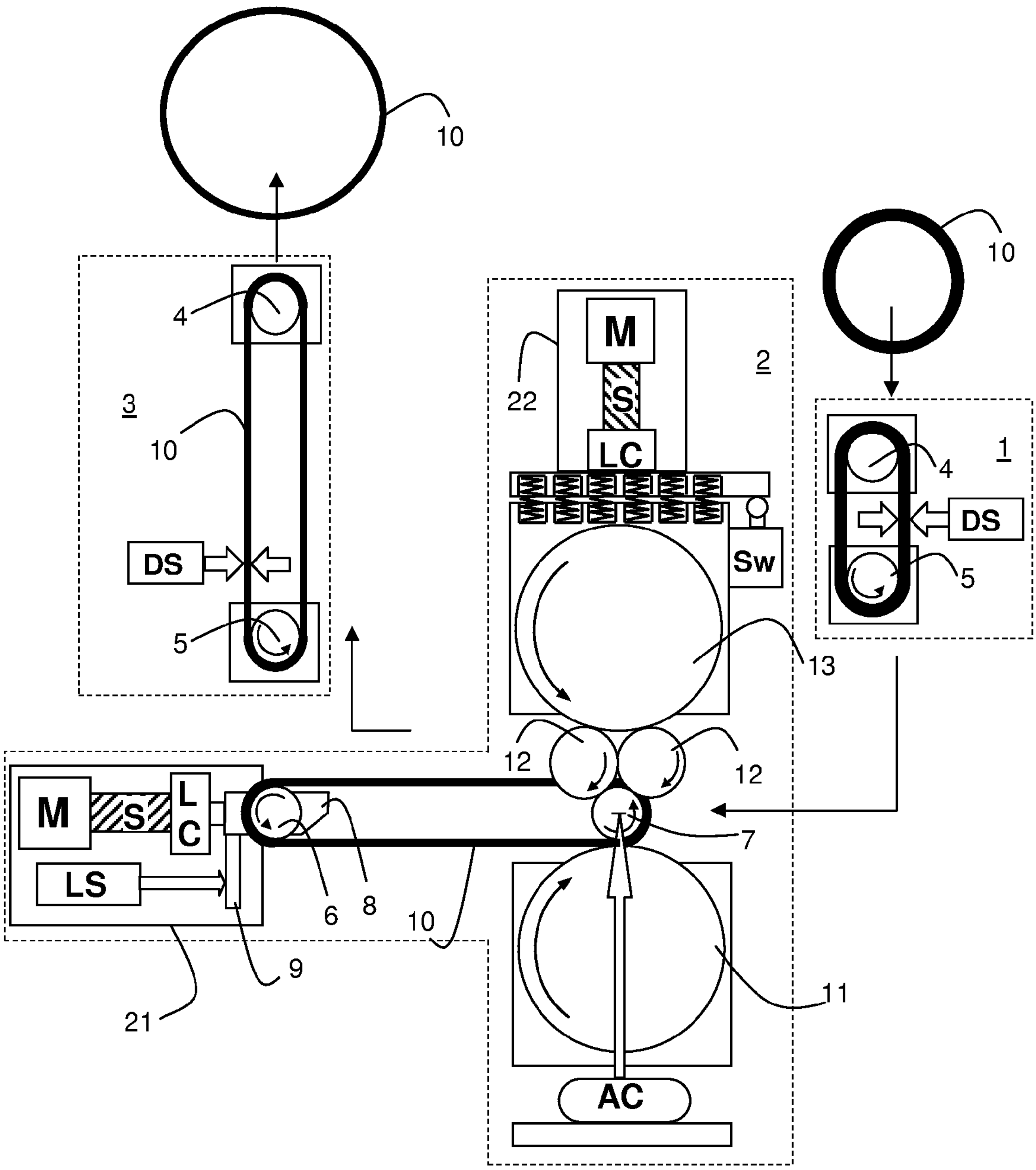

FIG. 1

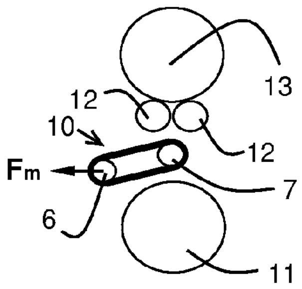

FIG. 2

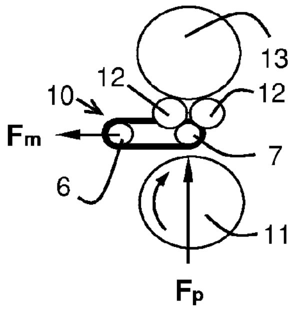

FIG. 3

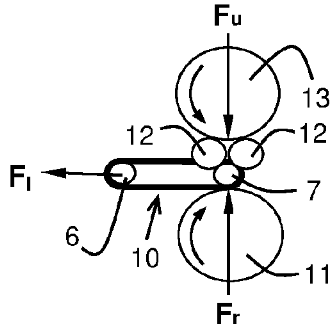

FIG. 4

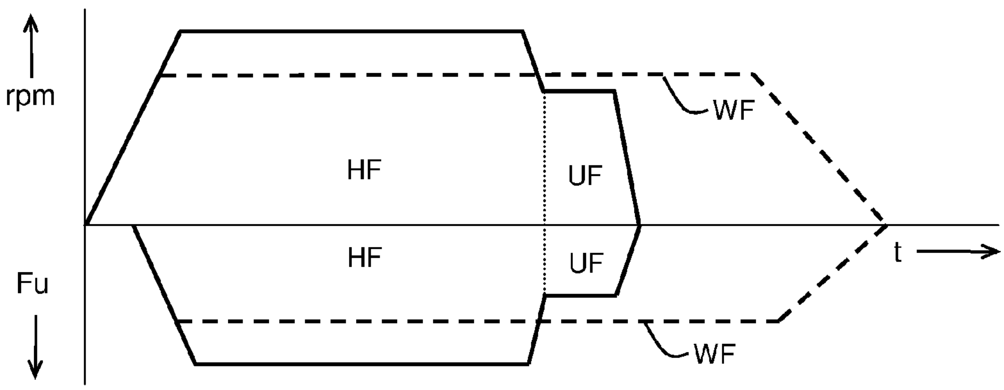

FIG. 5

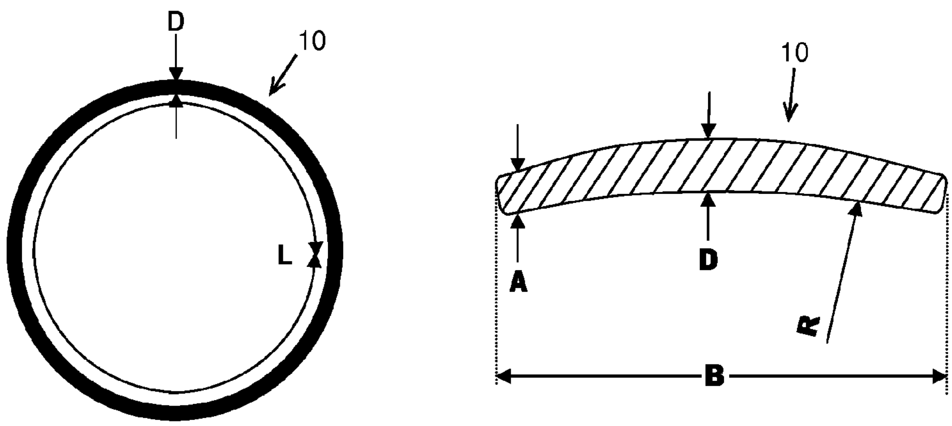

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0950830 A **[0002]**
- JP 11290908 A **[0003]**