# United States Patent [19]

**Wakabayashi et al.**

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[54] **METHOD FOR DIVIDING AN ELONGATED BODY INTO SEPARATE PIECES**


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[51] **Int. Cl.** ........................................ **B21d 51/00**

[58] **Field of Search** ......... 225/94, 96, 96.5; 29/413; 72/70, 71, 72, 98, 99, 100



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[57] **ABSTRACT**

A method of dividing an elongated body of circular section into at least a pair of pieces. Initially the body has a circumferential groove formed in its exterior surface between its ends, and then the body is simultaneously rotated while being bent at the region of the groove so that the body breaks at the location of the groove to become thereby divided into at least a pair of pieces.

**17 Claims, 7 Drawing Figures**

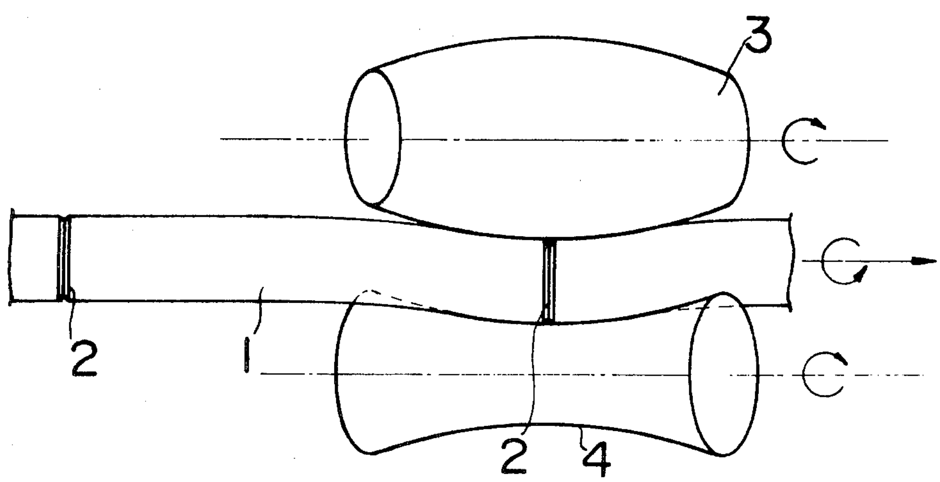



FIG.1

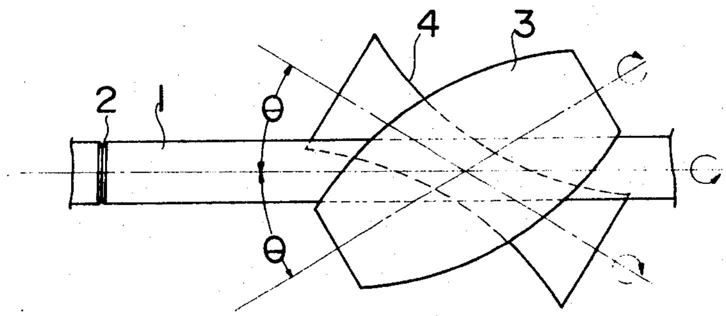
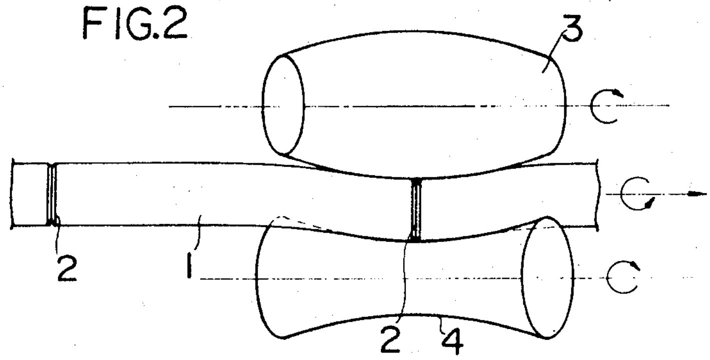



FIG.2



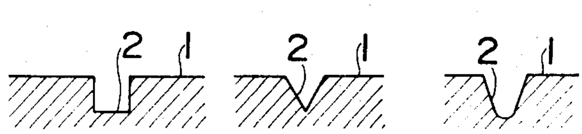




FIG.3A FIG.3B FIG.3C

FIG.4

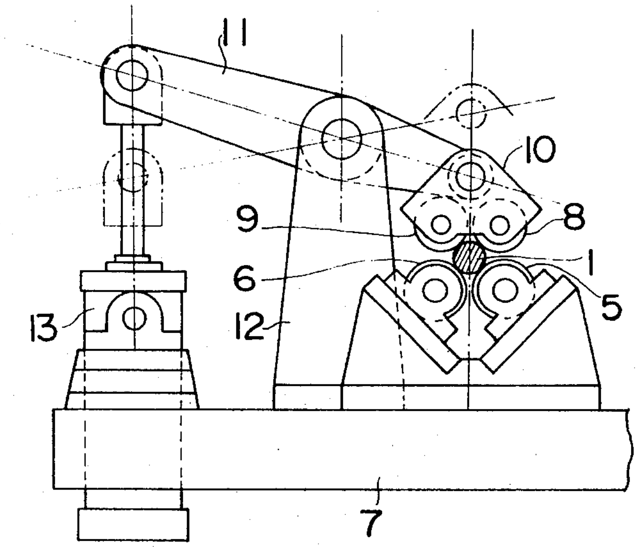
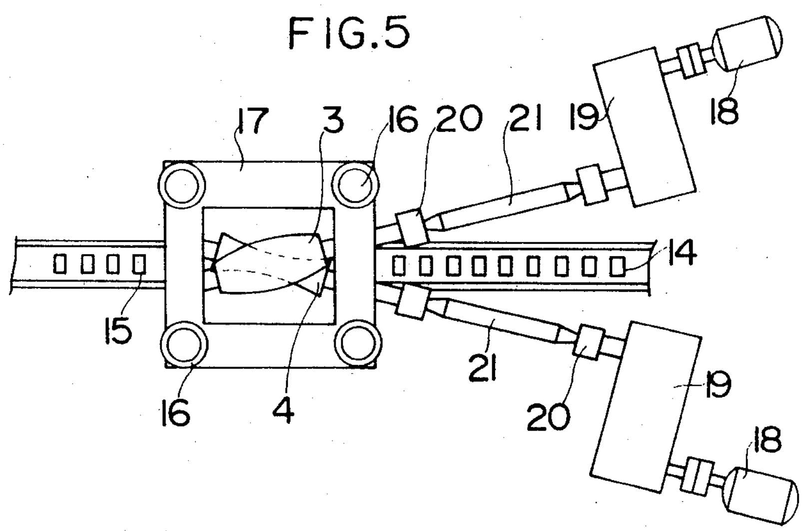



FIG.5



# METHOD FOR DIVIDING AN ELONGATED BODY INTO SEPARATE PIECES

## BACKGROUND OF THE INVENTION

The present invention relates to methods for dividing elongated bodies into a plurality of pieces.

For example, it is known that blooms or billets of circular section can be rolled from ingots in suitable rolling mills such as mills for rolling such ingots into elongated steel bodies of circular section. Such blooms or billets must then be divided into pieces of suitable length for further treatment. Of course, the example of steel blooms or billets from a rolling mill is only illustrative. Thus it is possible also to achieve circular bar stock from a continuous casting machine, and in addition instead of solid bar stock it is necessary also to break elongated relatively thick-walled tubular stock into pieces having lengths rendering the pieces convenient for further treatment.

At the present time the methods utilized for dividing elongated bodies of the above type into smaller pieces have a number of drawbacks. For example it is known to cut the elongated bodies into pieces of desired length. Such cutting may be carried out according to a hot sawing process during which the elongated metal bodies such as billets are at an elevated temperature while acted upon by rotating circular saws. It is also possible to cold saw the elongated body at room temperature, utilizing a rotating circular saw for this purpose. It is also known to utilize a shearing process for cutting the elongated body by the shearing action of suitable cutting tools, and in addition it is known to cut the elongated body into predetermined lengths by a gas cutting process where oxygen and a suitable combustible gas are utilized to cut through the body.

All of these known methods have serious disadvantages not the least of which includes the fact that such known methods unavoidably result in pieces which have rough ends provided with burrs, fins, and the like which must be removed subsequent to the separating of the elongated body into the shorter pieces. In addition, most of the cutting methods will result in the formation of chips or shavings which must be removed and which waste the material. Thus, the conventional cutting methods such as the hot sawing process results in the formation of burrs and in addition creates a short operating life for the saw itself, while at the same time creating undesirable noise of operation and a considerable amount of chips, the latter being determined by the thickness of the saw blade. Of course, the formation of the chips results in a decrease in the lengths of the pieces which can be achieved from a given body.

Of course, the cold sawing process has the same disadvantages as the hot sawing process in addition to requiring a greater length of time for the cutting operation, as compared with hot sawing. With respect to the method of cutting elongated bodies on a shearing machine, this method has the drawback of causing distortions as well as creating burrs, fins, or undesirably shaped ends on the resulting pieces. In this latter connection, the shearing meachines very often compress the ends of the pieces undesirably so that they have a tapered configuration which must be eliminated.

Utilization of gas for cutting through the body with a flame has the disadvantage of requiring a longer time than other methods while such a method also results in considerable waste of the metal which melts away from



the original body with this method also resulting in rough ends having burrs or the like which must be eliminated.

## SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide a method which will avoid the above drawbacks.

In particular it is an object of the present invention to provide a method for dividing an elongated body of circular section into separate pieces in such a way that there will be no burrs, fins, or the like which must be removed and also in such a way that the separation of the elongated body into the separate pieces can take place rapidly and conveniently with a minimum amount of noise and with a high degree of efficiency.

A more specific object of the present invention is to provide a method of this type which is capable of dividing the elongated body into separate pieces while continuously feeding the body longitudinally.

A specific object of the present invention is to provide a method which makes it possible to break the body into the pieces of predetermined length.

According to the method of the invention, an elongated body of circular section is divided into at least a pair of pieces by first forming a circumferential groove in the exterior surface of the body between the ends thereof and thereafter rotating the body around its longitudinal axis while simultaneously bending the body at the region of the circumferential groove so that the body breaks at the location of the groove, thus achieving in this way pieces of predetermined length.

## BRIEF DESCRIPTION OF DRAWINGS

The method of the invention is illustrated by way of example in the accompanying drawings which form part of this application and in which:

FIG. **1** is a top plan view of a method according to the invention;

FIG. **2** is a side elevation of the method illustrated in FIG. **1**;

FIGS. **3A–3C** respectively illustrate different configurations of circumferential grooves;

FIG. **4** is a schematic illustration of an apparatus for forming circumferential grooves; and

FIG. **5** is a schematic plan view of the apparatus for operating the rolls of FIGS. **1** and **2**.

## DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. **1** of the drawings, it will be seen that an elongated body **1** is illustrated fragmentarily. This elongated body **1** is of a circular cross section and may, for example, take the form of a billet received from a rolling mill. Prior to reaching the stage of the method which is illustrated in FIG. **1**, the elongated body **1** is formed at its exterior surface with a series of circumferential grooves **2**, one of which is illustrated at the left portion of FIG. **1**. These circumferential grooves may be formed in the body **1** in a manner described in greater detail below. The series of grooves **2** are longitudinally spaced from each other along the body **1** in accordance with the length of the pieces desired. In other words the distance from one groove **2** up to the next groove **2** will correspond to the length of a desired piece which is to be broken from the elongated body **1**.

When the elongated body reaches the stage of the method illustrated in FIG. 1 it travels between a pair of rotating rolls 3 and 4. The rolls 3 and 4 are of an elongated configuration with the roll 3 having a convex curved configuration between its opposed ends while the roll 4 has a concave curved configuration between its opposed ends, and the curvature of the exterior surface of the roll 4 is approximately the same as the curvature of the exterior surface of the roll 3. In other words while the roll 3 is convex and the roll 4 is concave, in a plane which contains the axis of the roll 3, the outer surface thereof will have a radius of curvature which will be approximately the same as the radius of curvature of the exterior surface of the roll 4 in a plane which contains the axis of the latter. Thus, the radii of curvature of the concave and convex rolls can be identical.

Moreover, it will be seen from FIG. 1 that the rolls 3 and 4 are oppositely inclined with each roll extending across the elongated body 1. When projected on to the plane of FIG. 1, the axes of the rolls 3 and 4 respectively form with the axis of the body 1 equal angles $\theta$. The axis of the elongated body 1 coincides with the direction of feed thereof. However, in so far as the elongated body 1 is fed smoothly, it is not always necessary that the axes of the rolls 3 and 4 form equal angles with the axis of the body 1.

As is apparent from the acurate arrows illustrated in FIGS. 1 and 2, the pair of rolls 3 and 4 rotate in the same direction while the elongated body 1 which travels between the rolls 3 and 4 rotates in a direction opposite from the direction of rotation of the rolls 3 and 4.

As a result of the above-described configuration of the rolls 3 and 4, they act not to axially feed or advance the body 1 to the right, as shown by the horizontal arrow at the right of FIG. 2, but in addition while the body 1 travels longitudinally between the rolls 3 and 4, the body 1 is rotated about its axis and is bent in the manner indicated in FIG. 2. Thus, the rotating rolls 3 and 4 serve to pull the body 1 to the right, as viewed in FIG. 2, while simultaneously bending and rotating the body 1.

With this arrangement if the peripheral rotary speed of the rolls 3 and 4 is Vm/min and the body 1 has a rotating speed of $V_1$, then:

$$V_1 = V \cos \theta \, .$$

If the axial feed speed of the body 1 is $V_2$, then:

$$V_2 = V \sin \theta \, .$$

When part of the body 1 formed with the circumferential groove 2 is situated between the rolls 3 and 4 in the above manner, the action of rotation and bending to which the body 1 is subjected at this time results in stresses due to rotation and bending with these stresses being concentrically imposed at the innermost part of the circumferential groove 2 so that the body 1 breaks apart at the location of the groove 2.

Of course, the actual breaking off of a piece from the body 1 occurs when the breaking location has advanced somewhat beyond the centers of the rolls 3 and 4, so that the next portion of the body 1 is already pressed between the rolls 3 and 4 to be axially fed thereby, and in this way the body 1 is continuously fed in an axial or longitudinal direction by the rolls 3 and 4 so that the next circumferential groove 2 will automatically progress up to the location between the rolls 3 and 4 where the next breaking will occur as a result of the above action.

FIGS. 3A–3C respectively illustrate various possible cross-sectional configurations for the circumferential grooves 2. Thus, FIG. 3A illustrates that the circumferential groove 2 may have a rectangular cross section while FIGS. 3B and 3C respectively illustrate that the circumferential groove 2 may have a V-shaped cross section. However it will be noted that in FIG. 3B the circumferential groove 2 is defined by a pair of side surfaces which sharply intersect each other while in the case of FIG. 3C the oppositely inclined side surfaces of the circumferential groove 2 intersect at an inner rounded end surface of the circumferential groove 2.

The circumferential grooves can be formed in the exterior surface of the body 1 in a number of different ways. For example, rotary dies similar to those used in roll-threading methods may be used. Also it is possible to cut the grooves with a suitable cutting tool or milling cutter. In addition it is possible to form the circumferential grooves with a saw or a flame from a gas-operated cutting apparatus may be used to form the grooves. Again, it is more preferable to form grooves in the exterior surface of the body 1 without giving a rotary motion thereto by pressing at least one rotary die or cutter into the surface of the body 1 or by moving a cutter in reciprocating motion around the circumference of the body 1.

However, of all of the above different possible methods for forming the grooves, the use of rotary dies is superior with respect to the output, length of operating life of the tools, and the like.

It has been found from experience that a circumferential groove of V-shaped cross section as illustrated in FIGS. 3B and 3C will produce very good results, and while the angle of the V-groove should be taken into consideration, a depth of the groove on the order of 0.5 mm has proved to be sufficient to result in the breaking off of the piece from the elongated body 1.

One of the structures for forming each of the circumferential grooves is schematically represented in FIG. 4. Thus, referring to FIG. 4 it will be seen that a suitable supporting structure or base 7 carries a pair of rotary driving rolls 5 and 6 on which the elongated body 1 is supported. Thus, in response to rotation of the rolls 5 and 6 the body 1 will be rotated about its axis. The rolls 5 and 6 are of course parallel to each other. The base 7 carries a standard 12 on which a lever 11 is pivoted, the lever 11 being pivoted intermediate its ends as illustrated. At its right end, the lever 11 swingably carries a bracket 10 on which a pair of dies 8 and 9 are supported for rotary movement. Thus, the pair of dies 8 and 9 are located in a common plane and have peripheral edges of V-shaped cross section, for example. The base 7 carries a hydraulic mechanism 13 in the form of a cylinder having in its interior a piston whose piston rod is pivotally connected to the left end of the lever 11, as illustrated in FIG. 4. Thus, when the piston is retracted downwardly to the dot-dash line position shown for its upper end in FIG. 4, the lever 11 is raised at its right end so that the dies 8 and 9 do not engage the body 1. On the other hand, when the hydraulic fluid is introduced under pressure into the cylinder of the system 13, the lever 11 will be pushed to the solid-line position where the peripheries of the dies 8 and 9 press into the exterior surface of the rotating body 1 to form the circumferential groove 2 therein. Of course, after one groove is completed the dies 8 and 9 are raised and the body 1 is axially advanced through the desired axial distance and then the next groove is formed.

FIG. 5 schematically illustrates the structure operatively connected to and associated with the rolls 3 and 4 described above. This structure associated with the rolls 3 and 4 includes a stand or supporting framework 17 in front of which is located a front table 14 and at the rear of which is located a rear table 15, the body 1 advancing from the front table 14 through the space between the rolls 3 and 4 and the broken off pieces being received by the table 15. These tables may take the form of plates supporting rollers on which the work freely moves.

The framework or support means 17 for the rollers 3 and 4 includes not only bearings for supporting the pair of rollers 3 and 4 but also an adjusting mechanism 16 in the form of vertically extending screw members rotatable in nuts carried by that part of the frame 17 which supports at least one of the rolls 3 and 4, so that in this way the vertical spacing or elevation of the rolls 3 and 4 one with respect to the other can be adjusted. The bearings of the support means 17 are situated in such a way that the rolls 3 and 4 are inclined with respect to each other as illustrated.

The drive means for the rolls includes a pair of reduction gear units 19 respectively connected operatively with driving motors 18. The outputs of the gear reduction units 19 are respectively delivered to the rolls 3 and 4 through rotary drive shafts 21 connected through suitable universal joints 20 on the one hand with the rolls 3 and 4 and on the other hand with the reduction units 19.

Of course, the structure shown in FIG. 4 for forming circumferential grooves is situated in advance of the front table 14 so that the elongated body 1 is already provided with the circumferential grooves 2 when it is delivered to the space between the rolls 3 and 4.

It is thus apparent that with the method of the invention it is possible to break off pieces from an elongated body of circular section in a highly effective manner far superior to what has heretofore been possible. All that is required is to initially form the elongated body 1 with the circumferential grooves 2 at the locations where the breaking is to occur. According to the method of the invention during the axial feeding between the rolls 3 and 4 the elongated body 1 is simultaneously rotated and bent, so that the stresses due to the bending and rotation are concentrated at the innermost part of the circumferential groove to bring about in this way the breaking off of pieces from the body 1. The pieces which break off have smooth ends.

Therefore, in contrast with previously known methods, the method of the invention has the advantage of an improved output inasmuch as there are no chips or shavings which form a waste material, and the pressing of the circumferential grooves further contributes to this advantage. With conventional cutting operations, hot and cold sawing will provide scrap throughout the cross section of the work through a length on the order of 8–10 mm, while with gas cutting methods the waste material also is determined by the thickness of the work and at each cutting operation a length of 15–20 mm of the work material is wasted.

Further advantages resulting from the invention reside in the fact that since the breaking occurs at the location of the initially formed circumferential grooves as a result of the simultaneous rotation and bending, there are no deformed ends on the resulting pieces. Thus, the pieces broken off from the body with the method of the invention do not have fins, burrs, or the like which must be removed, and the ends are not mashed or otherwise tapered or flattened in an undesired manner, as is commonly encountered with conventional methods.

In addition, there is very little noise involved with the method of the invention and sparks or the like are not generated, so that the entire operation is far more comfortable for the personel and far less dangerous.

In addition, since the dies, such as the dies 8 and 9 for forming the circumferential grooves, are required only to make an extremely shallow groove on the work and are not used for cutting through the work, the operating life of the groove-forming dies is extremely long.

In addition, since it is possible to form these circumferential grooves on the elongated bodies while they are longitudinally fed, both the formation of the circumferential grooves and the breaking operations can go forward during continuous feeding of the work with an exceedingly high output achieved in this way so that a highly effective method is achieved. In this latter connection it is of course a simple matter to mount the base 7 shown in FIG. 4 on suitable guides such as suitable tracks with a spring and stop arrangement being used to determine the initial position of the base 7 while during formation of the circumferential groove it is possible for the base 7 to move with the work as it is axially fed between the rolls 3 and 4, and of course when a circumferential groove is completed the base 7 would be returned by a spring to its initial location and the lever 11 actuated to form the next circumferential groove. In this way, the feeding achieved from the rotary rolls 3 and 4 would be used not only for feeding the circumferential grooves sequentially to the space between the rolls 3 and 4 to bring about the breaking off results referred to above, but in addition this feeding would be used to feed the work with respect to the grooveforming dies. Thus a highly efficient method can be achieved with the invention.

While reference has been made above to elongated bodies 1 in the form of billets or blooms, in the case of relatively large diameter bodies, it is of course to be understood that the body 1 need not be solid. Thus it is also possible to apply the present invention to a tubular elongated body of medium diameter which has a relatively thick wall.

What is claimed is:

**1.** In a method of dividing an elongated body of circular section into a plurality of pieces, the steps of forming a plurality of circumferential grooves in the exterior surface of the elongated body between the ends thereof while spacing the circumferential grooves one from the next in accordance with desired lengths of the pieces into which the elongated body is to be divided, sequentially bending the body at the region of sequential grooves thereof while simultaneously rotating the body around its longitudinal axis for breaking the body at the locations of said grooves, and longitudinally feeding the body while simultaneously rotating and bending the latter so that the body is continuously fed and successively broken at successive grooves.

**2.** In a method as recited in claim 1 and including the step of acting on the body with a pair of rolls one of which has an elongated exterior surface of convex configuration and the other of which has an elongated surface of concave configuration with said rolls respectively having oppositely inclined axes which are respectively inclined with respect to the axis of said longitudinal body, while the latter travels between said rolls to be rotated, bent, and longitudinally fed by the action of said rolls.

**3.** In a method as recited in claim **2** and wherein said rolls have their axes respectively inclined at the same angle with respect to the longitudinal axis of said body.

**4.** In a method as recited in claim **2** and wherein the angles of said rolls with respect to the longitudinal axis of the body are respectively determined with the condition that the body is fed in the longitudinal direction thereof while being rotated by the rotary motion of said rolls.

**5.** In a method as recited in claim **3** and wherein the circumferential grooves are initially formed in the body prior to travel of the latter between the rolls.

**6.** In a method as recited in claim **3** and wherein the circumferential grooves are formed in the body simultaneously with the longitudinal movement of the latter between the rolls.

**7.** In a method as recited in claim **1** and wherein said body is made of metal.

**8.** In a method as recited in claim **1** and wherein the body is solid.

**9.** In a method as recited in claim **1** and wherein the body is tubular.

**10.** In a method as recited in claim **1** and wherein the body is made of steel.

**11.** In a method as recited in claim **1** and wherein said groove is of a rectangular cross section.

**12.** In a method as recited in claim **1** and wherein said groove is of a V-shaped cross section.

**13.** In a method as recited in claim **12** and wherein said groove has a rounded inner end surface area situated between opposed side surfaces of said groove.

**14.** In a method as recited in claim **1** and wherein the body is rotated while at least one die is simultaneously pressed into the surface of the body to form the circumferential groove therein.

**15.** In a method of dividing an elongated body of circular section into at least a pair of pieces, the steps of forming a circumferential groove in the exterior surface of the body between the ends thereof, and rotating the body around its longitudinal axis while simultaneously bending the body at the region of said circumferential groove for breaking the body at said circumferential groove, the body being engaged by only a pair of opposed rotating rolls one of which is of a convex configuration and the other of which is of a concave configuration with said rolls acting on the body to simultaneously rotate and bend the latter, said rolls being inclined with respect to each other and with respect to the longitudinal axis of said body with the angles of said rolls with respect to the axis of the body being respectively determined with the condition that the body is fed in the longitudinal direction thereof while being rotated by the rotary motion of said rolls.

**16.** In a method as recited in claim **15** and wherein said rolls are inclined with respect to each other and with respect to the longitudinal axis of said body with the of said rolls being inclined at the same angle with respect to the axis of said body.

**17.** In a method as recited in claim **15** and wherein said groove has a pair of opposed oppositely inclined surfaces which sharply intersect each other.

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