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(54) Title: BELT

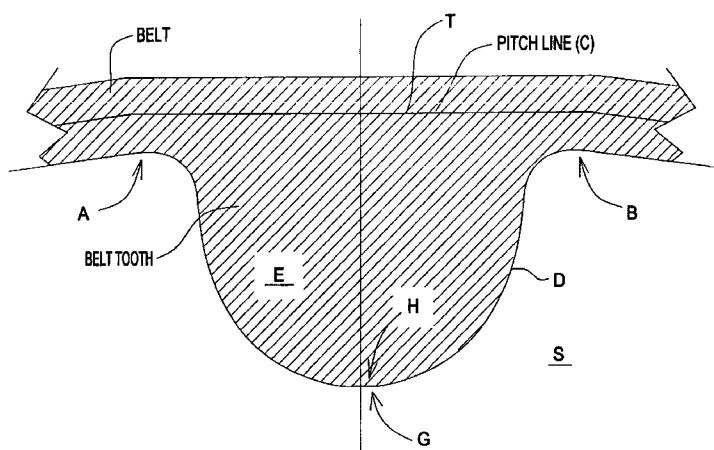


FIG.1

(57) Abstract: A belt and sprocket system comprising a tensile cord disposed within a belt body, a tooth projecting from the belt body, the tooth having a profile having at least two unequal radii connected in series and disposed between a tooth tip and a tooth root, a sprocket having a groove for receiving the tooth, the groove profile comprising at least one substantially linear portion disposed between the at least two unequal radii, a tooth tip engaging a predetermined portion of the sprocket groove such that the tensile cord is supported in a manner to cause the tensile cord to have a substantially arcuate form between the tooth roots.

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Title

Belt

5 Field of the Invention

The invention relates to a belt having a tooth tip engaging a predetermined portion of the sprocket groove such that the tensile cord is supported in a manner to cause the tensile cord to have a substantially arcuate
10 form between the tooth roots.

Background of the Invention

The prior art belt and sprocket system is based on a mold groove profile and requires clearance between the
15 belt tooth tip and the bottom of the pulley groove. There is also some shrinkage in the belt tooth height after curing that increases this clearance between the belt tooth tip and pulley groove bottom. This clearance causes the pitch line of the belt to become chordal over
20 the pulley groove as the belt teeth in rack form mesh with the sprocket grooves. As the belt pitch line is repeatedly raised and lowered by the driver and driven sprocket teeth, the angular velocity of the driven sprocket alternately increases and decreases. This
25 cogging action can be amplified by a bicycle peddle crank arm and then can be felt as a vibration, for example, by a bicycle rider.

Representative of the art is US patent no.3,756,091 to Miller which discloses a toothed power transmission
30 belt and pulley system is disclosed wherein the belt has an endless substantially inextensible tensile member with teeth secured thereto, the teeth having a cross-sectional configuration composed of two circular intersecting arcs for meshing with mating, conjugate, curvilinear pulley

teeth. The size of teeth, length of radii of curvature, and the angles and point of intersection are determined by a set of design criteria and formulas as recited therein.

5 What is needed is a belt having a tooth tip engaging a predetermined portion of the sprocket groove such that the tensile cord is supported in a manner to cause the tensile cord to have a substantially arcuate form between the tooth roots. The present invention meets this need.

10

Summary of the Invention

 The primary aspect of the invention is to provide a belt having a tooth tip engaging a predetermined portion of the sprocket groove such that the tensile cord is supported in a manner to cause the tensile cord to have a substantially arcuate form between the tooth roots.

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 Other aspects of the invention will be pointed out or made obvious by the following description of the invention and the accompanying drawings.

20

 The invention comprises a belt and sprocket system comprising a tensile cord disposed within a belt body, a tooth projecting from the belt body, the tooth having a profile having at least two unequal radii connected in series and disposed between a tooth tip and a tooth root, a sprocket having a groove for receiving the tooth, the groove profile comprising at least one substantially linear portion disposed between the at least two unequal radii, a tooth tip engaging a predetermined portion of the sprocket groove such that the tensile cord is supported in a manner to cause the tensile cord to have a substantially arcuate form between the tooth roots.

25

30

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate preferred embodiments of the present invention, and together with a description, serve to explain the principles of the invention.

Fig. 1 is a profile of a prior art belt and sprocket showing the chordal effect.

Fig. 2 is a side view of the inventive sprocket groove.

Fig. 2a and Fig. 2b are each a table of example dimensions.

Fig. 3 is a side view of the inventive belt tooth.

Fig. 3a and Fig. 3b are each a table of example dimensions.

Fig. 4 is a side view of the inventive belt tooth in a groove.

Fig. 5 is a side view of an alternate embodiment of the inventive belt tooth and sprocket.

Detailed Description of the Preferred Embodiment

Fig. 1 is a profile of a prior art belt and sprocket showing the chordal effect. A prior art toothed belt system comprises a belt having a pitch line (C). The pitch line generally coincides with the tensile cord T location in the belt body, but this is not always the case. The tensile cord carries the belt load during operation of the belt in a belt drive system. Fig. 1 is a side view of the belt and sprocket. In the art, a "tooth" is disposed across the width of a belt and typically arranged on a normal to the tensile cords.

The toothed belt typically engages a sprocket (S) having a groove (D). A belt tooth (E) engages a sprocket groove (D). Fig. 1 is a depiction of a portion of the

sprocket engaged with one belt tooth. Typically a number of teeth will engage each sprocket.

The belt bears upon the outer surface of the sprocket which includes portion (A) and (B). A sprocket
5 generally comprises a mechanical device which engages a toothed belt. Each groove on the sprocket extends parallel to the axis of rotation.

In operation the pitch line "spans" between A and B causing the pitch line (C) and hence tensile cord T to be
10 substantially linear between A and B. This is because during production there is some shrinkage of the tooth or a clearance may be required. This can result in a gap or non-loaded condition between the groove bottom G and the tooth tip H. This in turn causes the pitch line of the
15 belt to become chordal (linear) over the pulley groove portions (A and B) as the belt teeth in rack form mesh with the sprocket grooves. Points A and B are approximately where the sprocket engages the tooth root.

Consequently, as the belt pitch line is raised and
20 lowered by the sprocket teeth, the angular velocity of the sprocket alternately increases and decreases. This can cause an undesirable vibration in a belt drive system that can be detected by a user, for example, on a bicycle.

25 Fig. 2 is a side view of the inventive sprocket groove. The inventive system comprises a belt and sprocket.

An example sprocket groove is dimensioned as shown in Fig. 2a. The values in Fig. 2a and Fig. 3a are given
30 as examples only and are not intended to limit the breadth of the invention.

The groove comprises two halves jointed together, 10 and 20, about a centerline CL. Each half comprises three radii R1, R2, R3 connected in series. A substantially

linear segment S1 is connected between R3 and R4. Each radii described in this specification is a segment of a circle, meaning each radii is substantially constant. In an alternate embodiment, each radius R1 or R2 or R3 may
5 vary as a function of dR/dx as may be required by the operational conditions.

Further each radius R1 for each half of the groove is connected by a linear segment S2. Each segment S1 and S2 provide a predetermined clearance between the groove
10 and tooth in order to facilitate engagement of the tooth with the groove during operation.

The inventive belt body may comprise any conventional and/or suitable cured or thermoplastic elastomer composition. Suitable elastomers that may be
15 utilized for this purpose include for example polyurethane elastomers (including as well polyurethane/urea elastomers) (PU), polychloroprene rubber (CR), acrylonitrile butadiene rubber (NBR), hydrogenated NBR (HNBR), styrene-butadiene rubber (SBR),
20 alkylated chlorosulfonated polyethylene (ACSM), epichlorohydrin, polybutadiene rubber (BR), natural rubber (NR), and ethylene alpha olefin elastomers such as ethylene propylene copolymers (EPM), ethylene propylene diene terpolymers (EPDM), ethylene octene copolymers
25 (EOM), ethylene butene copolymers (EBM), ethylene octene terpolymers (EODM); and ethylene butene terpolymers (EBDM); and silicone rubber, or a combination of any two or more of the foregoing. The tensile cord may comprise polyester, carbon fiber, metal wire, nylon, aramid, glass
30 or any combination of two or more of the foregoing in any suitable and/or conventional configuration such as plied or braided, and generally may comprise one or a plurality of strands which may themselves be of any suitable and/or conventional configuration such as plied or braided, and

generally may comprise one or a plurality of yarns. "Yarn" refers to a bundle of filaments or fibers in the form as received from a yarn manufacturer, which may include twisted yarn or yarn with no twist. "Strand" refers to a yarn or yarns that have been twisted, plied or braided as an intermediate step in forming a cord.

Fig. 3 is a side view of the inventive belt tooth. The tooth profile comprises radii R5, R6 and R7, each radii being joined in series between points P4 and P1. For reference purposes point P4 is disposed on centerline CL. Point P1 is disposed at a tooth root 50, 51. There are no linear segments included in the tooth profile as is the case for the groove profile in Fig. 2. Example dimensional values for the Cartesian coordinate locations for points P1, P2, P3 and P4 are included in Fig. 3a.

Fig. 4 is a side view of the inventive belt tooth in a groove. Due to the slightly differing dimensions between the tooth and the groove, there are two gaps ($\alpha 1$) and ($\alpha 2$) disposed between the flanks of the tooth and the groove. In this embodiment the tip of the tooth contacts the bottom of the groove.

Also disclosed is a capture zone β at the end of the tooth in the groove bottom wherein the tooth is "captured" within the groove. This means that in operation, the tooth tip undergoes compression under load in the groove bottom in a manner which supports the overlying portion of the tensile cord T in a substantially arcuate form, see portion 30. However, the entire tooth is not fully compressed, instead, it is only the portion of the tooth occupying the groove between groove bottom and point P5. This also corresponds to the radius portions R1 on each side of centerline CL.

When the belt and tooth is fully engaged during operation, the tooth material expands to substantially

occupy gaps ($\alpha 1$) and ($\alpha 2$). This occurs simultaneously with the tensile cord portion 30 being supported by the material within the zone β . As a result of the support the tensile cord T takes a substantially arcuate form between roots 50, 51 with a radius R_T , see Fig. 5. This results in significantly reduced vibration of the belt during operation.

Example dimensions are set out in Fig. 2a. Reference to all dimensions is with respect to the origin at (0,0). The approximate position of the upper portion of the zone β is at a distance "x" from coordinate 0,0.

Fig. 5 is a side view of an alternate embodiment of the inventive belt tooth and sprocket. In this embodiment there is a gap or missing material in the bottom of the groove. This results in a free volume ζ into which the tooth tip may be slightly expanded. However, the tooth bears upon the groove at F and G. The portion of the tooth tip surface 100 between F and G approximates a simply supported beam with an equally distributed load. The absence of the tooth tip and free volume ζ can also be achieved by elimination of a portion of the groove bottom, also referred to as a slot.

The width of portion 100 may be adjusted according to the operational conditions of the system. In this embodiment the surface portion 100 is substantially flat. Coordinate 0,0 is disposed a predetermined distance "y" from a tensile cord T.

Although a form of the invention has been described herein, it will be obvious to those skilled in the art that variations may be made in the construction and relation of parts without departing from the spirit and scope of the invention described herein.

Claims

I claim:

1. A belt and sprocket system comprising:
 - a tensile cord disposed within a belt body;
 - 5 a tooth projecting from the belt body;
 - the tooth having a profile having at least two unequal radii connected in series and disposed between a tooth tip and a tooth root;
 - a sprocket having a groove for receiving the tooth,
 - 10 the groove profile comprising at least one substantially linear portion disposed between the at least two unequal radii;
 - a tooth tip engaging a predetermined portion of the sprocket groove such that the tensile cord is supported
 - 15 in a manner to cause the tensile cord to have a substantially arcuate form between the tooth roots.
2. The system as in claim 1, wherein the groove further comprises a second substantially linear portion disposed
- 20 at a groove bottom between adjacent and substantially equal radii.
3. The system as in claim 1, wherein the tooth tip is substantially flat.
- 25 4. The system as in claim 1, wherein a portion of the groove bottom is omitted to form a slot.

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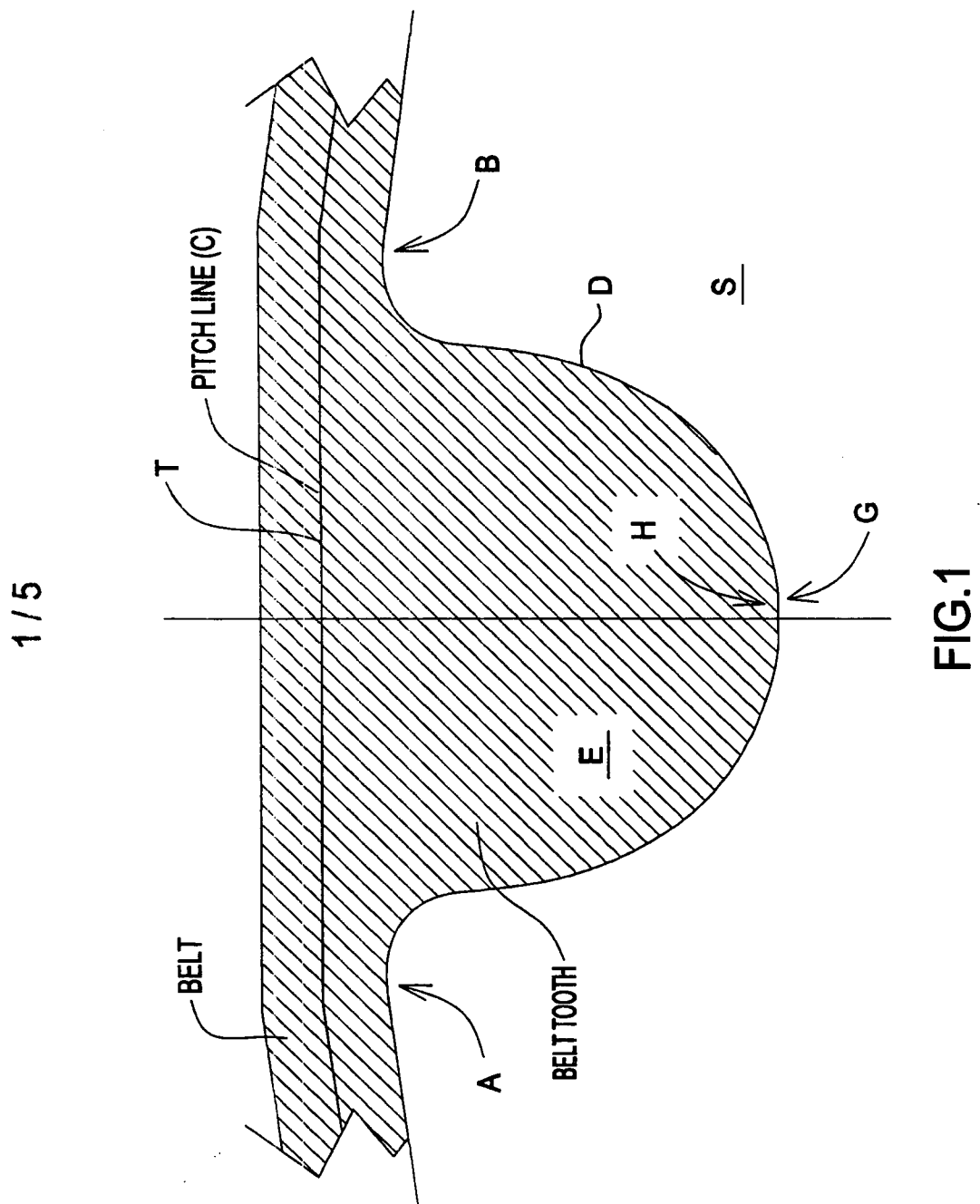


FIG. 1

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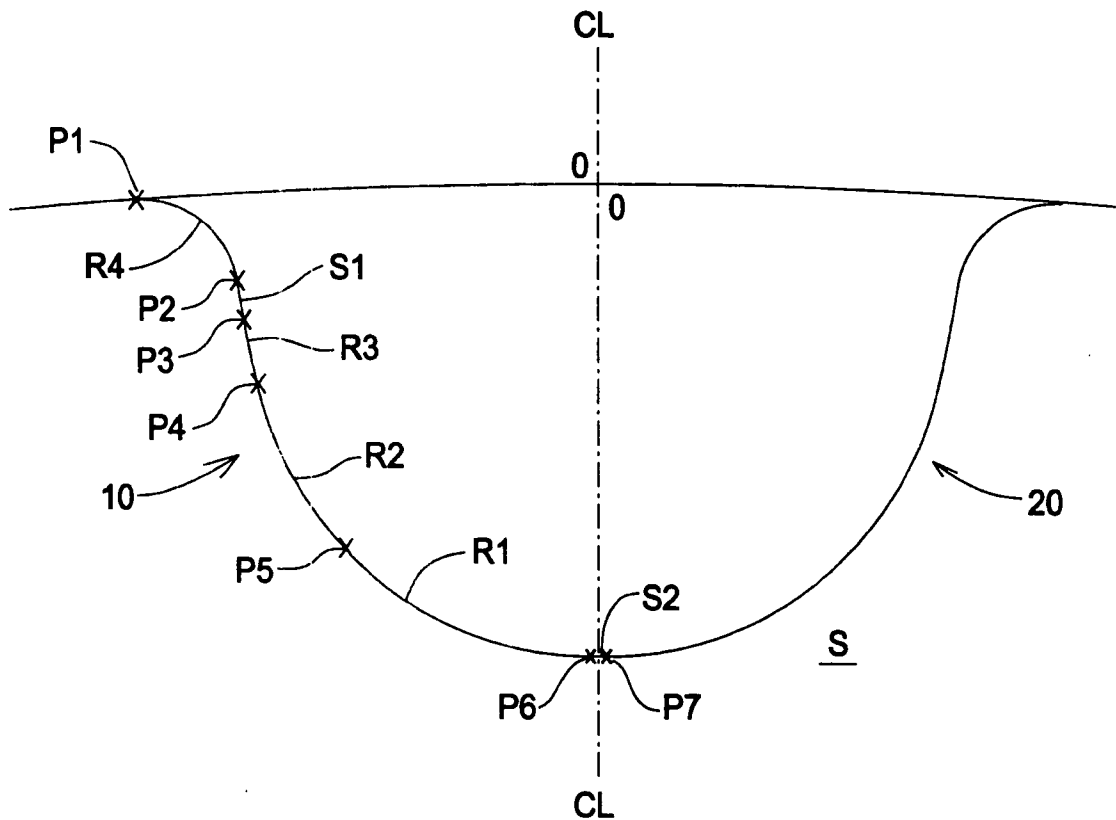


FIG. 2

SEGMENT INTERSECTIONS		
	X	Y
P1	-0.1880	-0.0067
P2	-0.1469	-0.0384
P3	-0.1436	-0.0559
P4	-0.1386	-0.0813
P5	-0.1028	-0.1498
P6	-0.0040	-0.1935
P7	-0.0000	-0.1935

FIG. 2a

RADIUS DIMENSIONS	
R1	0.1343
R2	0.1550
R3	0.3191
R4	0.0390

FIG. 2b

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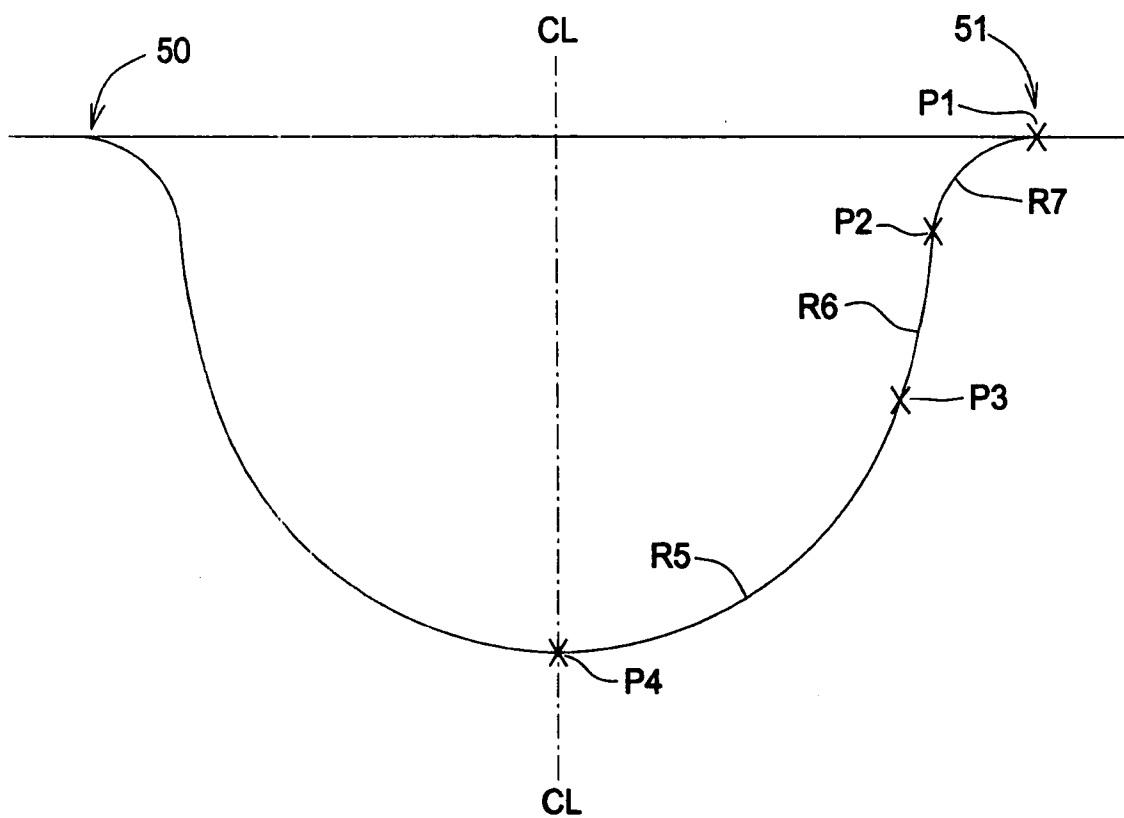


FIG.3

POINT	X	Y
P1	-0.1752	-0.0000
P2	-0.1370	-0.0362
P3	-0.1257	-0.0978
P4	-0.0000	-0.1935

FIG.3a

RADIUS DIMENSIONS	
R5	0.1304
R6	0.2475
R7	0.0383

FIG.3b

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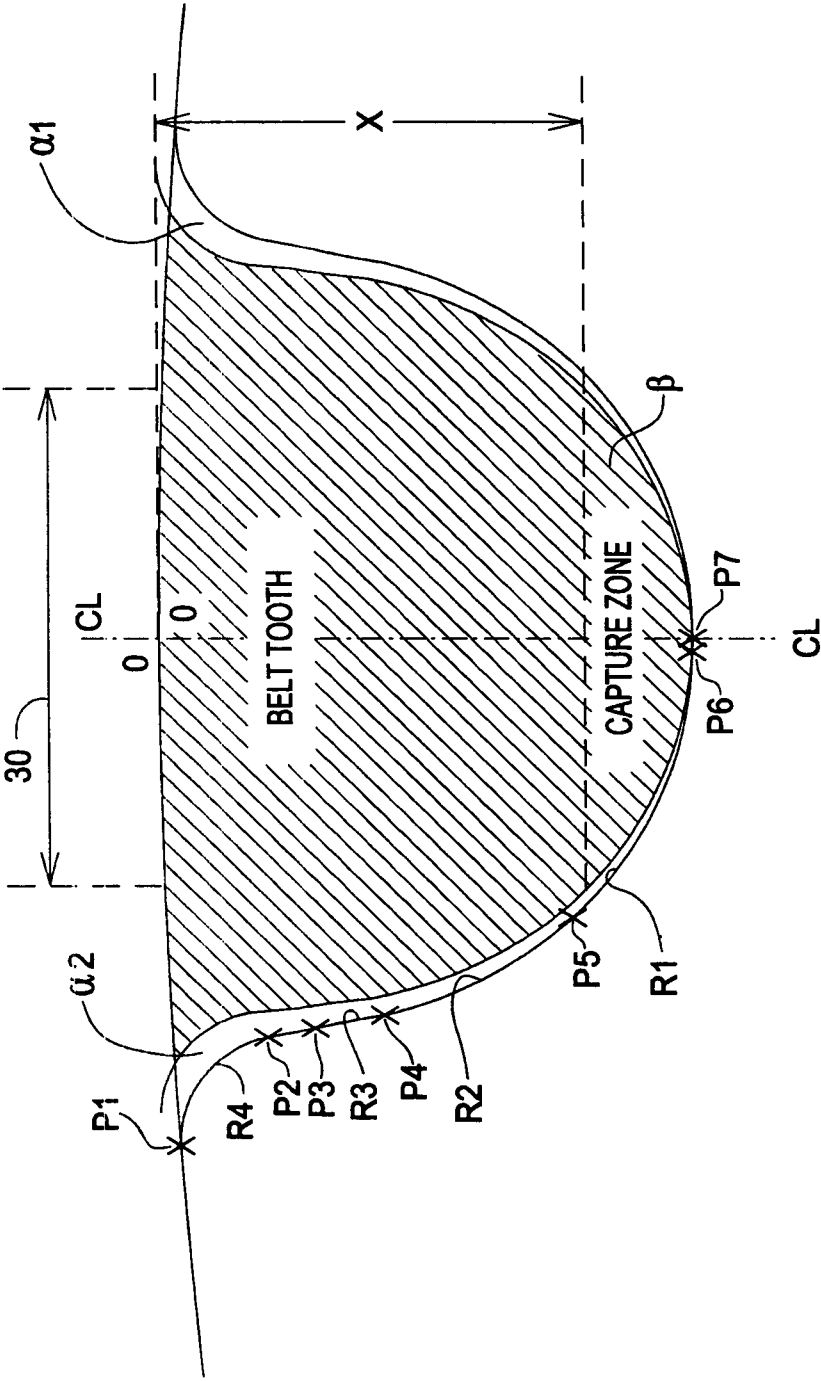


FIG.4

L

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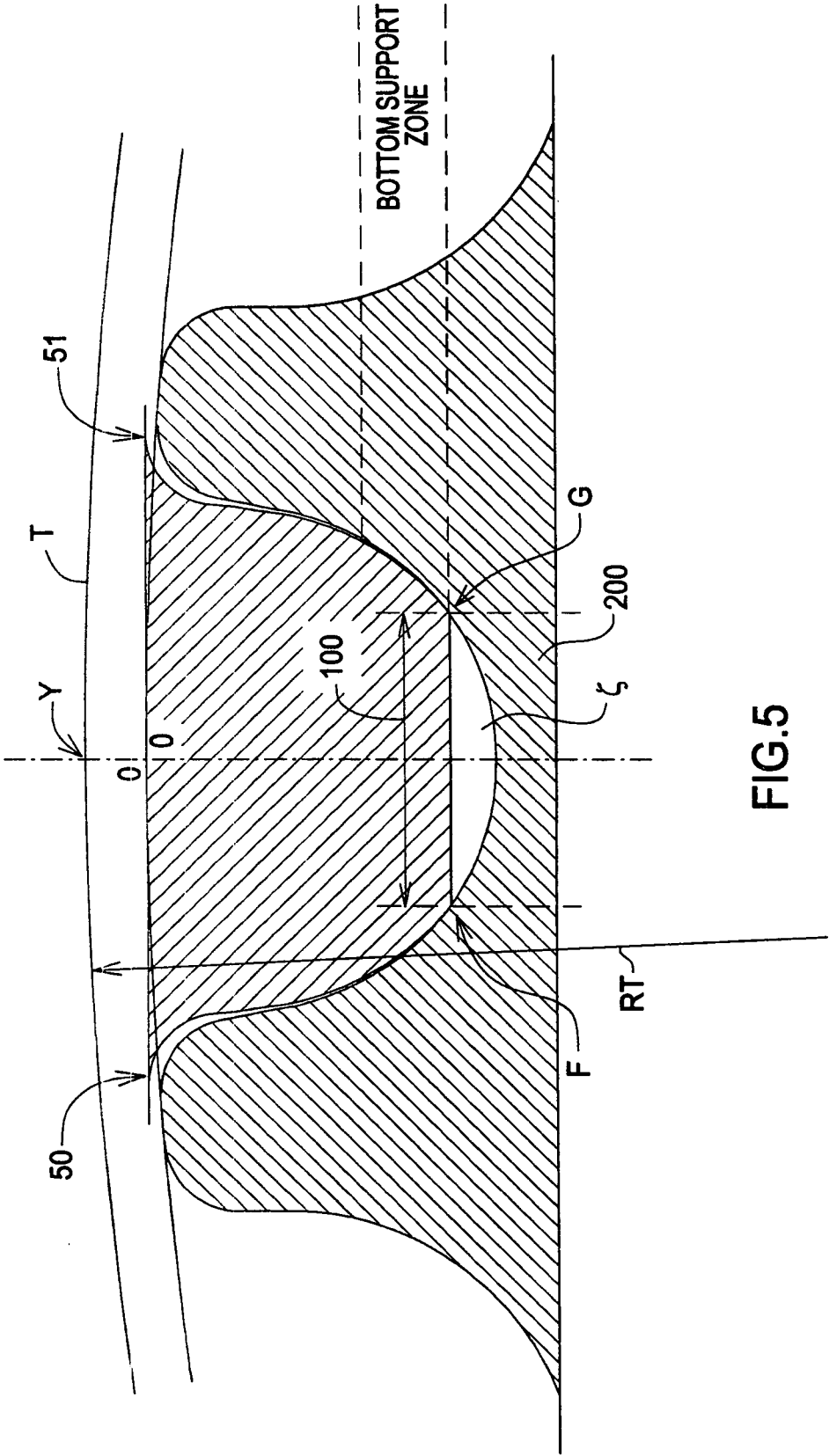


FIG.5

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