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PCT

SOLICITUD

PATENTE DE INVENCION

ENTRADA INTERNACIONAL

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21. EXPEDIENTE No.

54. TITULO

RAYO DE RIGIDEZ VARIABLE PARA UN ENSAMBLE NO NEUMÁTICO

51. CLASIFICACION INTERNACIONAL

71. SOLICITANTE

SOCIETE DE TECHNOLOGIE MICHELIN y MICHELIN RECHERCHE ET TECHNIQUE S.A.

DOMICILIO

CLERMONT-FERRAND, FRANCIA Y GRANGES-PACCOT, SUIZA

74. APODERADO

JUAN PABLO CADENA SARMIENTO

22. SANTAFE DE BOGOTÀ, D.C.

99/

CARTA

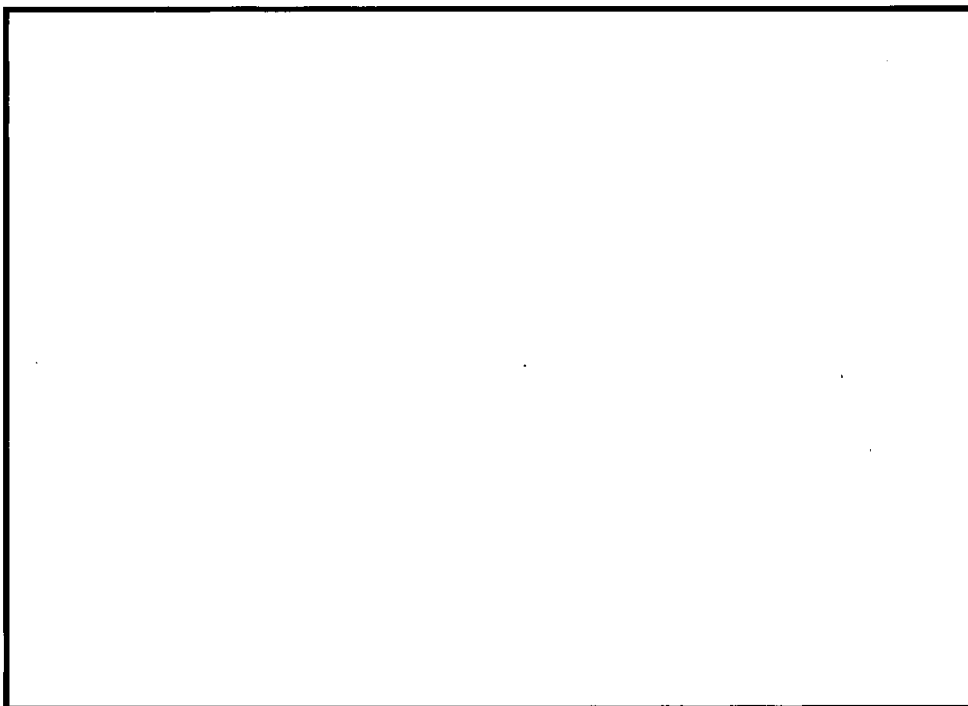
PETITORIO			
AS: 109.017		SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO  No. 08-124807-00000-0000 Fecha: 2008-11-24 16:25:01 Dep. 2020 NULCREACION Tra 11 PATENTELIYII Eje: 378 FASENACIONAL Act 411 PRESENTACION Folios: 58	
		ión	
FORMULARIO ÚNICO DE SOLICITUD DE PATENTE PCT ENTRADA EN FASE NACIONAL			
1 SOLICITUD DE:			
☒ Patente de Invención.		☐ Patente de Modelo de Utilidad.	
☒ Capítulo I.		☐ Capítulo II.	
2 SOLICITANTE (71)	Nombre: SOCIETE DE TECHNOLOGIE MICHELIN y MICHELIN RECHERCHE ET TECHNIQUE S.A. Dirección: 23, rue Breschet, F-63000 Clermont-Ferrand, Francia; Route Louis Braille 10 et 12, CH-1763 Granges-Paccot, Suiza (Respectivamente). Nacionalidad o Domicilio: Francia y Suiza (Respectivamente) Lugar de Constitución: Francia y Suiza (Respectivamente) Teléfono: Fax: E-mail		IDENTIFICACIÓN C.C. ☐ NIT ☐ C.E. ☐ Otro ☐ Cual _____ Número _____
3 REPRESENTANTE O APODERADO	Nombre: JUAN PABLO CADENA SARMIENTO Dirección: Cra. 7 No. 71-21 Torre B – Piso 4, Bogotá, Colombia. Teléfono: 744-2200 Fax: 742-2200 E-mail:		IDENTIFICACIÓN C.C. ☒ NIT ☐ C.E. ☐ Otro ☐ Cual _____ Número 80.410.337 TP 57492
4 INVENTOR (ES) (72)	Nombre: Steven M. CRON. Dirección: 525 Mckinney Road, Simpsonville, SC 29681, US. Nacionalidad o Domicilio: Estados Unidos de América.		
5 PCT (86) Solicitud Internacional No. <u>PCT/US2007/078975</u> Fecha <u>20-09-2007</u> Publicación Internacional No. <u>WO 2007/036789 A3</u> Fecha <u>27-03-2008</u>			
6 Título (54): <u>RAYO DE RIGIDEZ VARIABLE PARA UN ENSAMBLE NO NEUMÁTICO</u>			
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9 Comprobante de pago No. <u>08-80,164</u> Fecha <u>24-11-2008</u>			
Instrucciones para el diligenciamiento del presente formulario, ver reverso de esta página.			

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ANEXOS

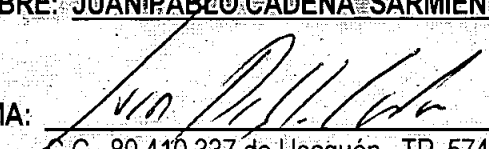
- ☒ Comprobante de pago de la tasa de presentación de la solicitud. \$501.000
 - ☒ Documento que acredita la existencia y representación legal cuando el solicitante sea persona jurídica.
 - ☒ Poderes, si fuere el caso.
 - ☐ Documento de cesión del inventor al solicitante o a su causante.
 - ☐ Declaraciones
 - ☒ Copia de la solicitud internacional. (Resumen, descripción, reivindicaciones, dibujos)
 - ☒ Traducción de la solicitud internacional al castellano. (Resumen, descripción, reivindicaciones, dibujos)
 - ☐ Copia del examen preliminar efectuado por la IPEA.
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 - ☐ De ser el caso, copia del contrato de acceso.
 - ☐ De ser el caso, documento que acredite la licencia o autorización de uso de conocimientos tradicionales de las comunidades indígenas.
 - ☐ De ser el caso, certificado de depósito del material biológico.
 - ☐ Arte final 12x12.
 - ☐ De ser el caso, información sobre otras solicitudes de patente o títulos obtenidos en el extranjero por el mismo titular o su causante, relacionadas parcial o totalmente con la invención de esta solicitud.
 - ☒ Otros Tarjeta de Propietarios
- Documentos PCT

11 FIGURA CARACTERÍSTICA:



12 Solicito la concesión de la patente

NOMBRE: JUAN PABLO CADENA SARMIENTO

FIRMA: 

C.C. 80.410.337 de Usaquén TP 57492 del C.S.J.

Instrucciones para la presentación de los anexos, ver reverso de esta página.

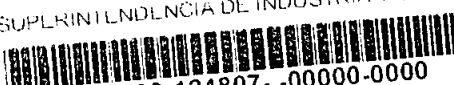
109017 3

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

NIT : 800176089-2

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***** CONSIGNACION *****

POSITANTE	TIPO PAGO	BANCO	CUENTA	No. PAGO	FECHA PGO	Vr. PAGO
IGARD & CASTRO LTDA	CONSIGNACION	BANCO DE BOGOT				900.00
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CONCEPTO						TOTAL CONCEPTO

1 50005-01-01 SOLICITUDES	1 TRAMITES DE SOL. DE PATENTE DE IN	501,000.00
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PATENTE ☒ PCT/US2007/078975 ☐ MODELO DE UTILIDAD ☐ DISEÑO INDUSTRIAL ☐

SOLICITANTE/S. RAZON SOCIAL O APELLIDOS Y NOMBRES SOCIETE DE TECHNOLOGIE MICHELIN y
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DOMICILIO CLERMONT-FERRAND, FRANCIA y GRANGES-PACCOT, SUIZA

APODERADO JUAN PABLO CADENA SARMIENTO

TITULO RAYO DE RIGIDEZ VARIABLE PARA UN ENSAMBLE NO NEUMATICO

CLASIFICACION _____

EXPEDIENTE No. _____ FECHA DE SOLICITUD _____ ROLLO MICROFILM _____

CERTIFICADO No. _____ FECHA DE CONCESION _____ VIGENCIA DESDE _____ HASTA _____

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OTROS _____

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[US/US]; 525 McKinney Road, Simpsonville, SC 29681 (US).

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(74) Agent: **REMICK, E., Martin**; Michelin North America, Inc., Intellectual Property Department, 515 Michelin Road, Greenville, SC 29605 (US).

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(71) Applicant: **SOCIETE DE TECHNOLOGIE MICHELIN** [FR/FR]; 23, Rue Breschet, F-FR-63000 Clermont-ferrand (FR).

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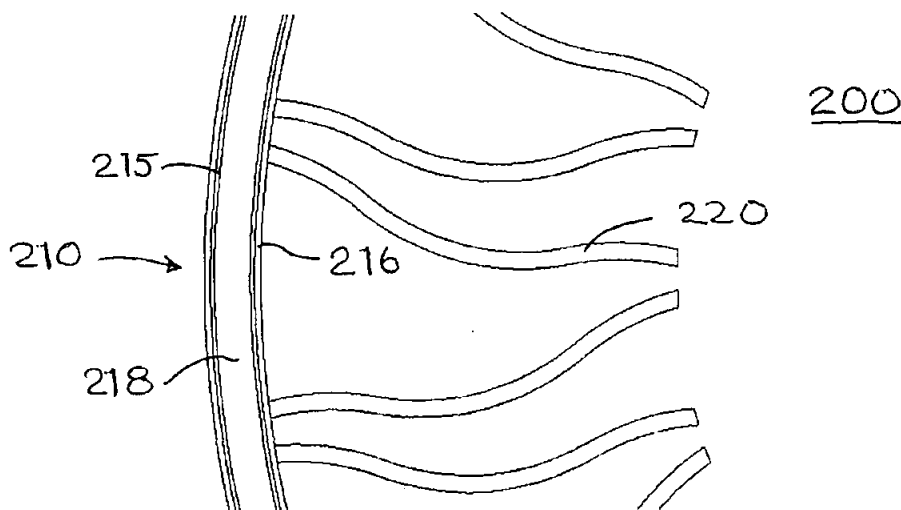
(71) Applicant (for all designated States except US): **MICHELIN RECHERCHE ET TECHNIQUE S.A.** [CH/CH]; Route Louis-braille 10, CH-1763 Granges-paccot (CH).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **CRON, Steven, M.**

[Continued on next page]

(54) Title: VARIABLE STIFFNESS SPOKE FOR A NON-PNEUMATIC ASSEMBLY



(57) Abstract: The invention described herein provides a non-pneumatic deformable structure having a variable stiffness spoke assembly that provides a method of adjusting the vertical stiffness. The structure comprises an outer annular band having a pre-determined stiffness, a set of spoke elements having an outer end and an inner end, where the outer end is connected to the outer band, with the spoke element extending inward and having its inner end connected to a hub, the hub being configured to attach the structure to a vehicle axle or other apparatus capable of rotation about an axis. Each of the spoke elements has a curvilinear length greater than the length of a straight line segment extending from a point of connection of the outer end of the spoke element with the outer annular band to a point of connection of the inner end of the spoke element to the hub. The outer end of said spoke element is tangent to the straight line segment, and the inner end of said spoke element is tangent to the straight line segment.

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A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B60B 9/26 (2008.01)

USPC - 152/5

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

USPC: 152/5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC: 152/11, 246, 270, 271 (text search - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST(USPT,PGPB,EPAB,JPAB); Google Scholar; Google Patents

Search Terms: non-pneumatic, deformable, hub, spoke, inner, band, curved, element, concave, convex, structure, segment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0159385 A1 (Rhyne et al.) 19 August 2004 (19.08.2004), Fig 1, para [0039]	1-7
Y	US 4,917,162 A (De Longcamp) 17 April 1990 (17.04.1990), Fig 1 and 2, col 9, ln 5-11 and ln 47-54, col 10, ln 1-8	1-7

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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Date of mailing of the international search report

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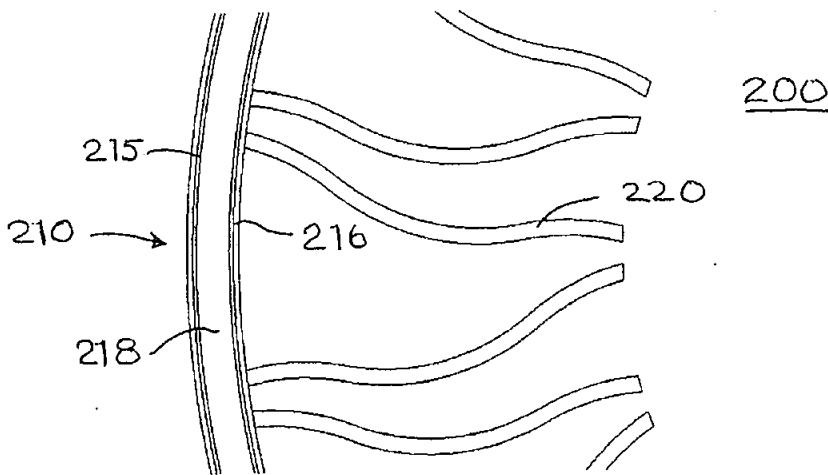
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- (71) Applicant (for all designated States except US): MICHELIN RECHERCHE ET TECHNIQUE S.A. [CH/CH]; Route Louis-braille 10, CH-1763 Granges-paccot (CH).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): CRON, Steven, M. [US/US]; 525 Mckinney Road, Simpsonville, SC 29681 (US).

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Published:
— without international search report and to be republished upon receipt of that report

(54) Title: VARIABLE STIFFNESS SPOKE FOR A NON-PNEUMATIC ASSEMBLY



(57) Abstract: The invention described herein provides a non-pneumatic deformable structure having a variable stiffness spoke assembly that provides a method of adjusting the vertical stiffness. The structure comprises an outer annular band having a pre-determined stiffness, a set of spoke elements having an outer end and an inner end, where the outer end is connected to the outer band, with the spoke element extending inward and having its inner end connected to a hub, the hub being configured to attach the structure to a vehicle axle or other apparatus capable of rotation about an axis. Each of the spoke elements has a curvilinear length greater than the length of a straight line segment extending from a point of connection of the outer end of the spoke element with the outer annular band to a point of connection of the inner end of the spoke element to the hub. The outer end of said spoke element is tangent to the straight line segment, and the inner end of said spoke element is tangent to the straight line segment.

WO 2008/036789 A2

Variable Stiffness Spoke for a Non-pneumatic Assembly**BACKGROUND**

[0001] Non-pneumatic deformable structures for use in the support of loads under rolling conditions, such as to support loads for automotive vehicles have been described, for example in United States Patent No. 7,201,194, which is commonly owned by the assignee of the current invention. The structurally supported, non-pneumatic tire disclosed therein includes a reinforced annular band that supports the load and a plurality of web spokes that transmit in tension the load forces between the annular band and a wheel or hub. The tire supports its load solely through the structural properties and, contrary to the mechanism in pneumatic tires, without support from internal air pressure.

[0002] In the exemplary structure shown in Fig. 1 herein, the spokes are shown as radially-oriented elements, which then extend more or less transversely across the width of the non-pneumatic deformable structure. The structure acts as a "top loading" structure meaning that the vertical load applied from the ground against a fixed hub is resisted by tensile forces in the spokes that are generally outside of the region where the band is in contact with the load surface. The spokes in the latter region carry little or no load, as illustrated in Fig. 1, where these spokes have undergone a buckling deformation.

[0003] A design characteristic of the non-pneumatic deformable structure is its vertical stiffness. In the current context, vertical stiffness is the increment of vertical force generated for each increment of vertical deflection or displacement upward of the ground with the hub held fixed. Depending on the end-use load carrying application, it may be desirable to have a structure that has a higher initial vertical stiffness. An example of this situation would be an application where there is a high static load, such as a piece of heavy construction equipment. In this instance, the high stiffness limits the static vertical deflection. On the other hand, other applications may benefit from a low initial stiffness. An example of such a use is a hand truck where the device needs to roll easily over obstacles when lightly loaded. One method to control the vertical stiffness of the non-pneumatic deformable structure is to adjust the mechanical properties and dimensions of the outer band.

However, this also affects the average contact pressure between the outer band and the loading surface, which is an important overall design criterion for a specific application.

SUMMARY OF THE INVENTION

[0004] The invention described herein provides a non-pneumatic deformable structure having a variable stiffness spoke assembly that provides a method of adjusting the vertical stiffness. Another advantage of the invention is to reduce the stress concentration, which may develop at the ends of the spoke.

[0005] A non-pneumatic deformable structure comprises an outer annular band having a predetermined stiffness, a set of spoke elements having an outer end and an inner end, where the outer end is connected to the outer band, with the spoke element extending inward and having its inner end connected to a hub, the hub being configured to attach the structure to a vehicle axle or other apparatus capable of rotation about an axis. Each of the spoke elements has a curvilinear length greater than the length of a straight line segment extending from a point of connection of the outer end of the spoke element with the outer annular band to a point of connection of the inner end of the spoke element to the hub. The outer end of said spoke element is tangent to the straight line segment, and the inner end of said spoke element is tangent to the straight line segment.

[0006] In a variation of the invention, the spoke element, when viewed in a transverse section, comprises at least two concave segments and at least one convex segment.

[0007] In still another variation, the concave segments and the convex segment are mutually tangent at their points of intersection.

[0008] In an exemplary embodiment described in detail herein, the concave segments and the convex segment are each formed of circular arc segments.

[0009] These and other features, aspects, and advantages of the invention will become better understood with reference to the following description and the appended claims. The accompanying drawings, which are incorporated in and

constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

DESCRIPTION OF THE FIGURES

[0010] Fig. 1 is a transverse section or side view of a non-pneumatic deformable structure 100 illustrating the action of the spoke elements under and upward deflection from an applied vertical force.

[0011] Fig. 2 is a detail view of a non-pneumatic deformable structure 100 illustrating the excess length of a spoke element.

[0012] Fig. 3a is a graphic showing the vertical load (daN) as a function of the imposed vertical displacement (in mm) for the exemplary spoke elements having three levels of excess length.

[0013] Fig. 3b is a graphic showing the vertical stiffness (daN/mm) as a function of the imposed vertical displacement (mm) for the exemplary spoke elements having three levels of excess length.

[0014] Fig. 4a is schematic view of a non-pneumatic deformable structure 100, when loaded by an upward deflection.

[0015] Fig. 4b is detail view corresponding to the rectangular outline of Fig. 4a, illustrating the stress concentration.

[0016] Fig. 5 is a transverse section or side view of a portion non-pneumatic deformable structure 200 illustrating the application of recurved spoke elements.

[0017] Fig. 6a is schematic view of a non-pneumatic deformable structure 200, when loaded by an upward deflection.

[0018] Fig. 6b is detail view corresponding to the rectangle outline of Fig. 6a, illustrating the reduced stress concentration.

[0019] Fig. 7 is a geometric definition of a recurved spoke element showing two concave segments and a convex segment.

[0020] Fig. 8 is a graphic showing the vertical load (daN) as a function of the imposed vertical displacement (mm) comparing a non-pneumatic deformable

12

structure 100 to the non-pneumatic deformable structure 200 having recurved spoke elements, and including a reference having zero excess length.

DETAILED DESCRIPTION

[0021] Figure 1 is an example of a non-pneumatic deformable structure 100. The structure comprises an outer band 110 having a predetermined stiffness. A set of spoke-like elements 120 connect the band 110 to a hub 130. The hub 130 may then be attached to a vehicle axle or other apparatus capable of rotation about an axis. The stiffness of the band may be obtained through various types of reinforcements in single or multiple layers. United States Patents No. 7,013,939 and 6,769,465 provide examples of suitable band constructions and design information to obtain a desired load carrying capability. Figure 1 illustrates the application of a vertical load F_z to the non-pneumatic structure 100 under conditions where the hub 130 is held vertically immovable. The portion of the outer band 110 in contact with the ground undergoes an upward vertical displacement Δ . Figure 3a is a graphical representation of the force F_z (in daN) versus vertical displacement Δ for three levels of excess length EL (described below). Figure 3b is a graphical representation of the vertical stiffness (in daN/mm) versus vertical displacement Δ . Vertical stiffness is the slope of the force versus displacement curve for a given displacement.

[0022] A method proposed for controlling the vertical stiffness of a non-pneumatic deformable structure is to vary the spoke excess length EL is defined as follows and is illustrated in Fig. 2,

$$Excess\ Length = \left[\left(\frac{L_1}{L_0} \right) - 1 \right] * 100\%$$

- i. where L_0 and L_1 are defined below and illustrated in Fig. 2,
- ii. L_0 , is the distance between the spoke ends.
- iii. L_1 , is the curvilinear spoke length.

[0023] An analysis was performed on three different non-pneumatic deformable structures with equal design specifications for materials and reinforcements in all respects except for spoke excess length EL. For the analysis, the spoke elements

17

120 are oriented such that their end attachment points fall on radial lines whereas the spoke elements 120 shown in Fig. 2 are oriented such that their end attachment points fall on lines that are at some angle relative to the radial direction. Either configuration is allowed by the above definition for spoke excess length EL.

[0024] A finite element simulation model using commercially available software was developed to evaluate the effect of varying spoke excess length EL on the vertical stiffness of the non-pneumatic deformable structure 100. The model is a two-dimensional simulation, which would correspond to a non-pneumatic deformable structure 100 having a uniform behavior throughout its transverse width. The two-dimensional simulation is a good approximation to the behavior of an actual three-dimensional non-pneumatic deformable structure 100. An example of the three-dimensional structure is shown in United States Patent No. 7,013,939. The output of the model is the vertical force per unit width of the non-pneumatic deformable structure 100.

[0025] For this model, a non-pneumatic deformable structure 100 comprises an annular outer band 110 having an outside diameter of 300 mm, connected by the spoke elements 120 to a hub 130 having a diameter of 150 mm. The band 110 is approximately 9 mm thick and further comprises two concentric reinforcing coils 115 and 116, respectively, embedded in the band 110 and spaced apart radially by 7 mm. Each coil 115 or 116 comprises a circumferentially oriented winding of 4x0.26 mm steel cables as used for tire belt material and having a lateral spacing of 1.8 mm between cables in the coil. The effective circumferential tensile stiffness of the coils is converted to stiffness per unit width, or effectively a tensile modulus, for use in the finite element model. The spacing of the cables in the coils also permits the flow of material during molding of the non-pneumatic deformable structure. This configuration creates an annular intermediate layer 118 between the two coils having a thickness of about 7 mm. The non-pneumatic structure 100 has twenty spoke elements 120 that are 2.5 mm thick in the view shown in Fig. 2. The outer diameter of the hub is 150 mm. The non-pneumatic deformable structure 100 is molded as a unit from polyurethane supplied by Chemtura under the designation B836 VIBRATHANE.

[0026] Three non-pneumatic deformable structures 100 with single curvature spoke elements having excess spoke length EL of (a) 0.98%, (b) 8.59%, and (c) 22.9%, respectively were modeled. The predicted vertical force (per unit structure width) versus deflection for these three structures is shown in Fig. 3a. The predicted vertical stiffness (per unit structure width) versus deflection curves for these three structures are shown in Fig. 3b. For reference, a non-pneumatic deformable structure with zero excess length is shown as "reference" in Fig. 8. The vertical force versus deflection has been significantly modified by changing the spoke excess length. When the design having an excess spoke length of 0.98% is compared to the reference structure, it can be seen that vertical load is reduced by about 10% at displacements over 15 mm. However, the vertical stiffness for deflections over 15 mm remains comparable for the two designs.

[0027] An unexpected result is found when the variation of vertical stiffness is compared for the three levels of excess spoke length. Fig. 3b provides the comparison of vertical stiffness for the three single curvature designs. Design (a) has a high initial stiffness for deflections less than about 5 mm, and thereafter approaches a relatively constant value, on the order of 0.08 daN/mm at deflections beyond 15 mm. Design (b) has a relatively constant stiffness throughout the range of deflection, and Design (c) has a low initial stiffness that gradually approaches the same value of stiffness as Design (a). This result is advantageous depending on the type of use. For a heavy equipment application having a high static load, the high initial stiffness is desirable to limit the static deflection of the non-pneumatic deformable structure while maintaining a less stiff response during operation of the equipment. On the other hand, for other applications a low initial stiffness is desirable when the device is carrying a small load. In this case, the low stiffness facilitates rolling over obstacles, but a higher stiffness results when a higher load is applied to limit overall deflection of the non-pneumatic deformable structure.

[0028] Managing Stress Distribution with Increasing Spoke Excess Length: The deformed shape of the single curvature spoke element of Design (c) having 22.9% excess spoke length EL is shown in Fig. 4a. Figure 4b provides a detail of the area inside the highlight rectangle showing the intersection between the spoke end and the outer band 110. For a radial spoke element with zero excess length, the intersection is perpendicular. As the spoke excess length EL increases the

intersection angle between the spoke and the outer band decreases. The same effect occurs at the intersection of the spoke element 120 and the hub 130. This leads to a stress concentration in the region where the spokes connect to the band 110 and to the hub 130.

[0029] An alternative, improved design was developed to reduce the stress concentration. The improved design for a deformable non-pneumatic structure 200 has a spoke profile where the attachment angle between the spoke element 220 and the band 210 (or hub 230, not shown but equivalent to hub 130 of Fig. 1) is brought closer in alignment with the overall tensile stress resultant in the spoke itself. This is accomplished by employing a recurved profile for spoke element 220 having three primary curvatures, two convex and one concave, whose design shown in Fig. 5 and in detail in Fig. 7. The terms "concave" and "convex" are used for convenience to indicate the sense, positive or negative, of the curvature of the spoke element 220. Geometrically, the recurved spoke element 220, as shown in Fig. 7, is made up of three arcs of essentially equal radius of curvature, R_1 , R_2 and R_3 that are mutually tangent and also tangent to a line connecting the desired spoke element end attachment points to the band 210 and to the hub 230. It is not necessary for the three radii of curvature R_1 , R_2 and R_3 to be equal. The line connecting the end attachment points (shown by the small circles in Fig. 7) may follow a radial direction or have an angle relative to the radial direction.

[0030] Three non-pneumatic deformable structures 200 as depicted in Fig. 6a with the recurved spoke elements 220 were simulated with the model. To better illustrate the advantages of the recurved design, the amount of excess length EL for each of the three designs was adjusted in the model to yield the same vertical stiffness as for the single curvature structures 100 previously shown in Fig. 3a and Fig 3b. For example, the recurved spoke element 220 required only 14% excess spoke length as compared to 22.9% excess spoke length for the single curvature design to obtain approximately the same vertical stiffness. The vertical load versus deflection for the six designs (three single curvature structures 100 and three recurved structures 200) is shown in Fig. 8, where the legend "Original design" corresponds to the structures 100 and the legend "New design" corresponds to the structures 200 having recurved spoke elements 220, and the legend "Reference" corresponds to a spoke element having zero excess length EL. Figure 6b shows the

detail of the stress concentration area at the intersection of the spoke element 220 with the band 210 for the recurved spoke design. In the single curvature spoke element 120 (see Fig. 2), the peak stress was 0.733 daN/mm² whereas the recurved spoke element 220 has a peak stress at the same location of 0.472 daN/mm², a reduction of 36%. Table 1 below shows a comparison of the single curvature and recurved spoke designs. In each case, the recurved spoke element 220 (within a row in the table) shows a lower principal stress than the single curvature spoke element 120.

Table 1: Spoke Element Excess Length and Maximum Principal Stress

Design	Single Curvature Spoke Elements		Recurved Spoke Elements	
	Excess Length (EL)	Principal Stress (daN/mm ²)	Excess Length (EL)	Principal Stress (daN/mm ²)
(a)	0.98 %	0.832	0.55 %	0.542
(b)	8.59 %	1.019	6.01 %	0.537
(c)	22.9 %	0.733	14.11 %	0.472

[0031] The recurved design can be said to be a more efficient design as it obtains the same adjustment to initial and final vertical stiffness with a reduced amount of excess spoke length and a reduced principal stress at the spoke attachment points. The design principles disclosed have been reduced to practice for non-pneumatic deformable structure 200 for a skid-steer application corresponding to a 12R16.5 pneumatic tire and wheel and for a hand truck application corresponding to a 10x3 pneumatic tire and wheel.

[0032] Applicants understand that many other variations are apparent to one of ordinary skill in the art from a reading of the above specification. These variations and other variations are within the spirit and scope of the instant invention as defined by the following appended claims

Claims

1. A non-pneumatic deformable structure comprising an outer annular band having a predetermined stiffness, a set of spoke elements having an outer end and an inner end, said outer end is connected to the outer band, said spoke element extending inward and said inner end connected is to an inner hub, the hub being configured to attach the structure to a vehicle axle or other apparatus capable of rotation about an axis; each of said spoke elements has a curvilinear length greater than the length of a straight line segment extending from a point of connection of said outer end of said spoke element with the outer annular band to a point of connection of said inner end of said spoke element to the inner hub, and wherein said outer end of said spoke element is tangent to said straight line segment and said inner end of said spoke element is tangent to said straight line segment.
2. The deformable structure according to claim 1, wherein a transverse section of said spoke element comprises at least two concave segments and at least one convex segment.
3. The deformable structure according to claim 2, wherein said concave segments and said convex segment are mutually tangent at their points of intersection.
4. The deformable structure according to claim 3, wherein said concave segments and said convex segment are each formed of a circular arc segment having a radius of curvature.
5. The deformable structure according to claim 4, wherein said radius of curvature of each of said convex and concave segments are equal to each other.
6. The deformable structure according to claim 1, wherein a difference in the curvilinear length of said spoke element and the length of said straight line segment defines a spoke excess length, and wherein said excess length may be varied to obtain a predetermined level of the vertical load versus deflection stiffness of said deformable structure.
7. The deformable structure according to claim 6, wherein said excess length is greater or equal to than about 0.5% and less than or equal to about 15%.

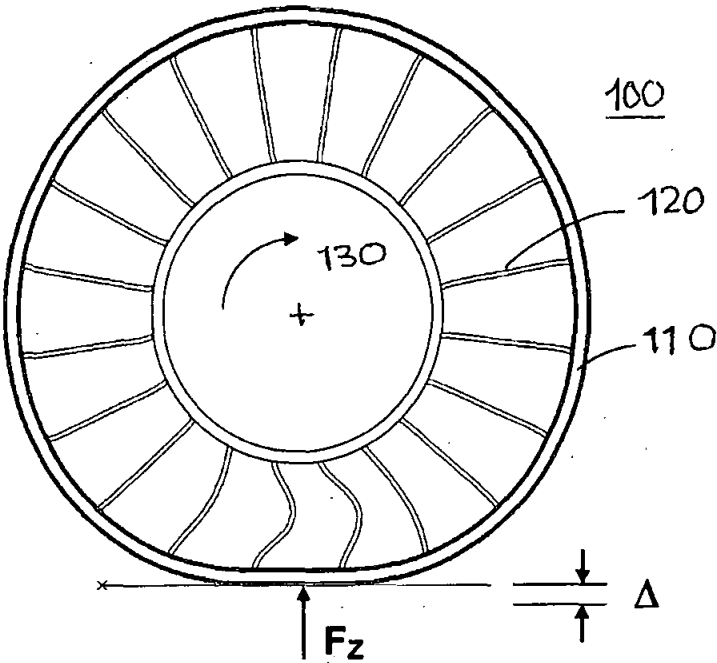


Fig. 1

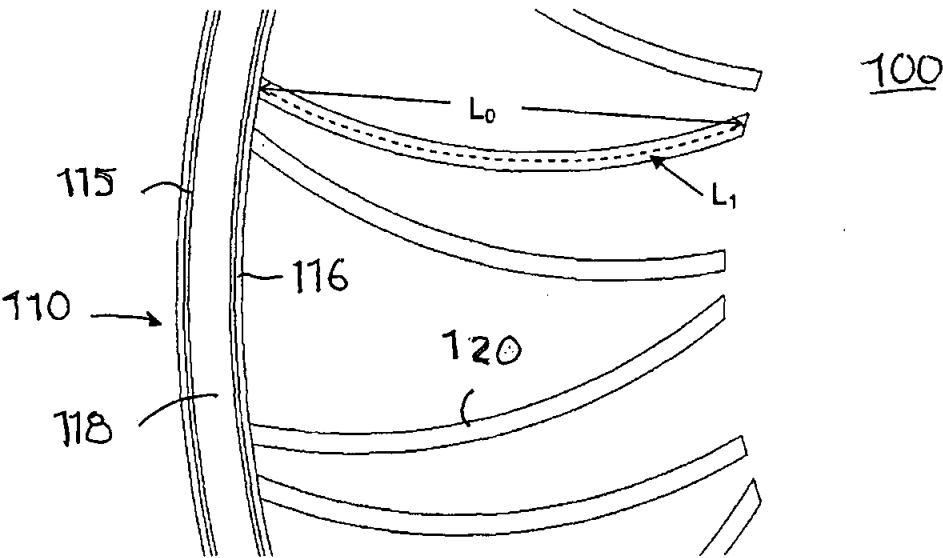


Fig. 2

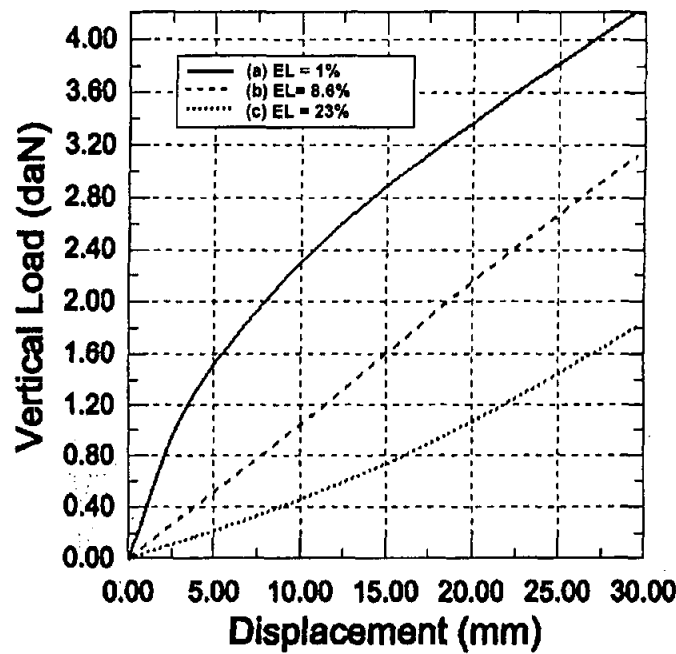


Fig. 3a

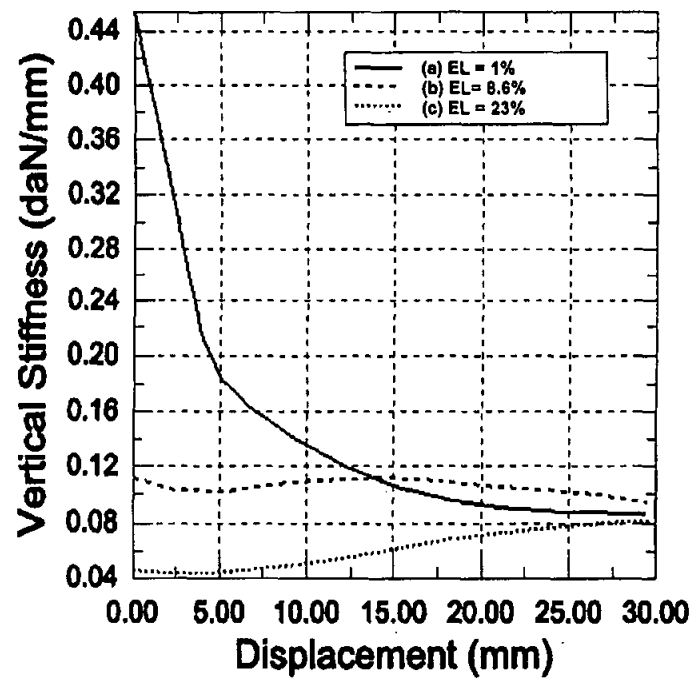


Fig. 3b

WO 2008/036789

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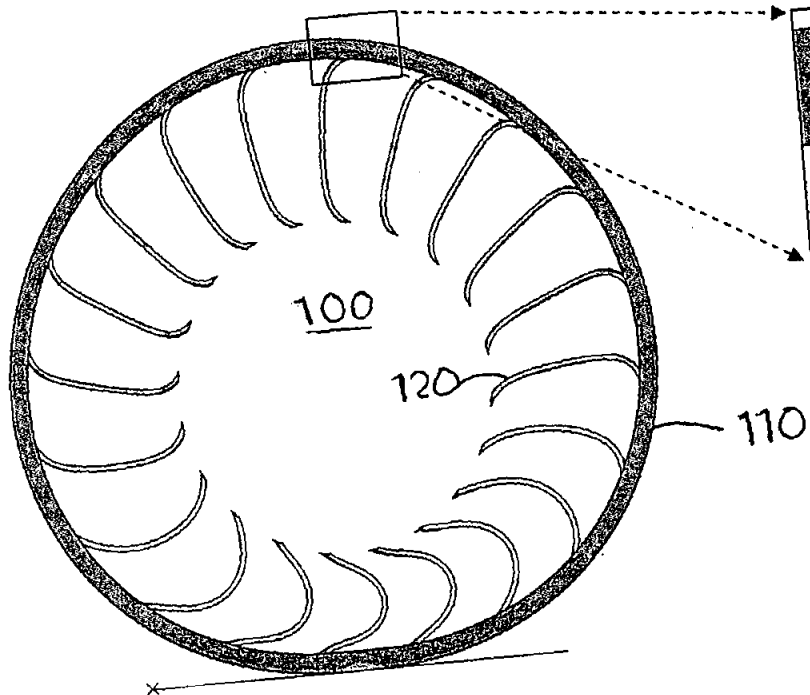


Fig. 4a

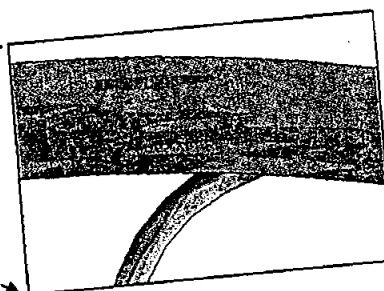


Fig. 4b

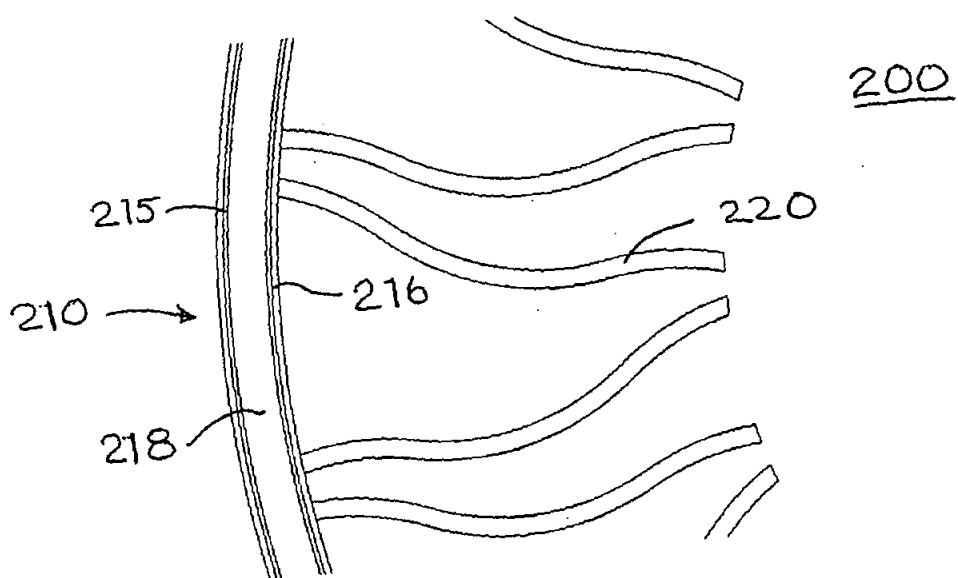


Fig. 5

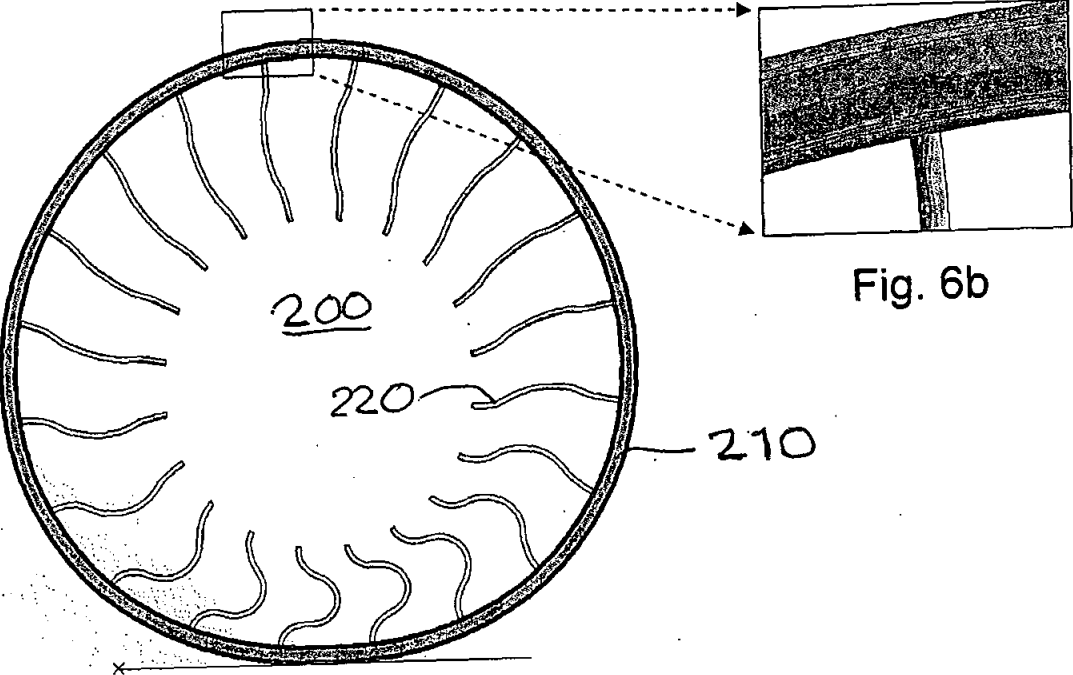


Fig. 6a

Fig. 6b

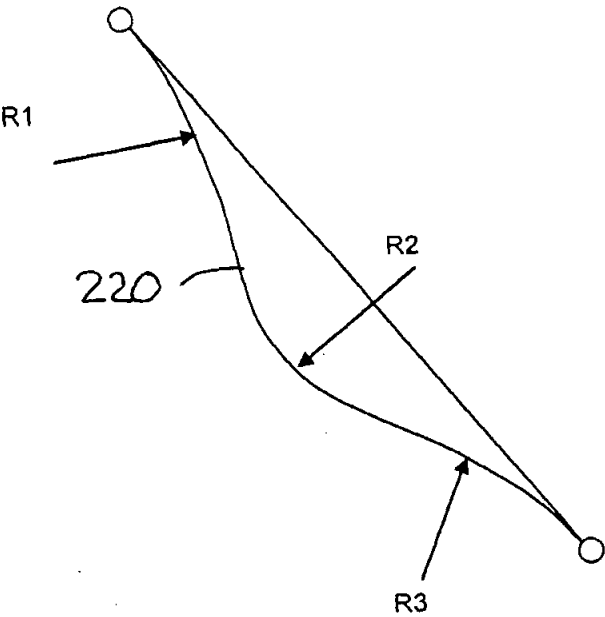


Fig. 7

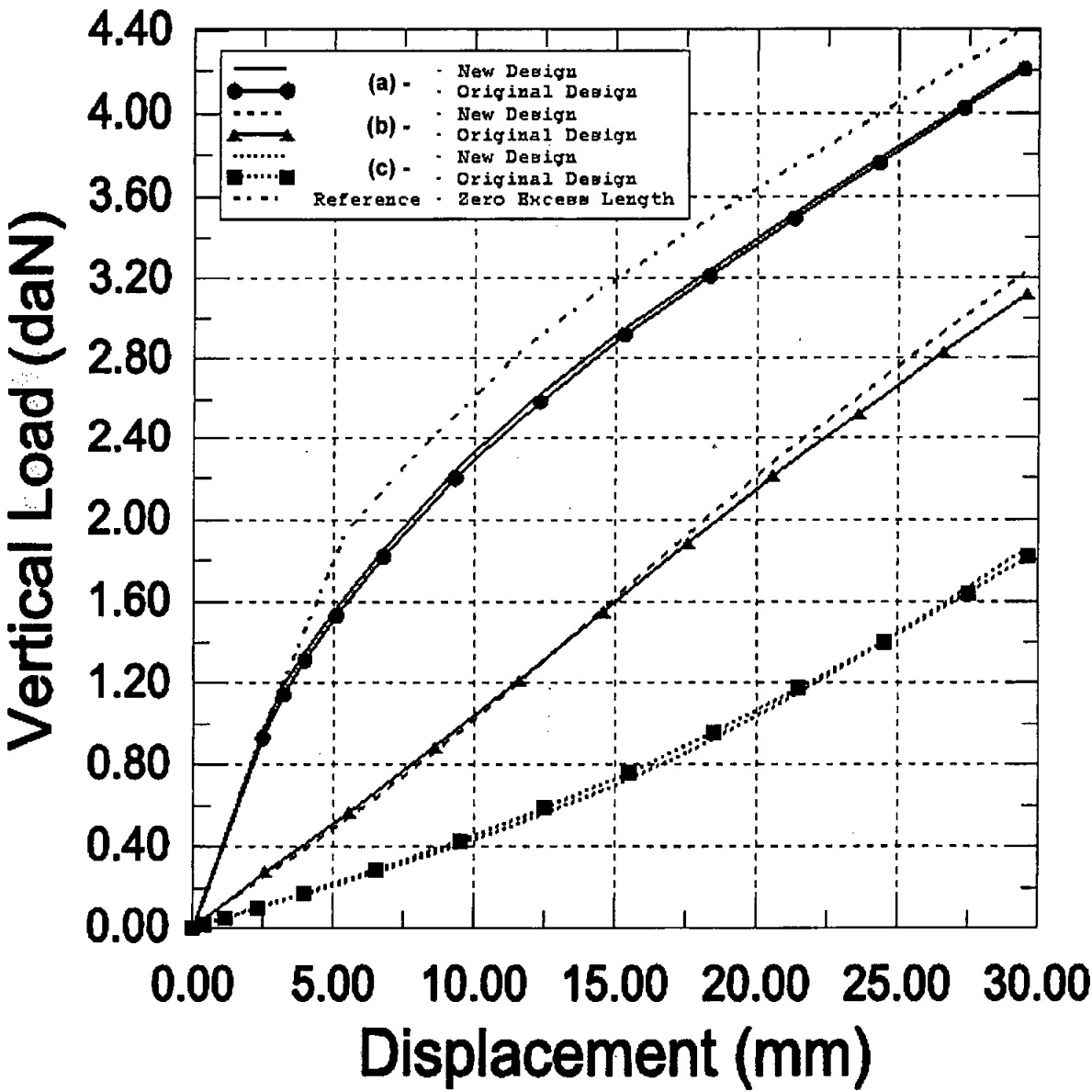


Fig. 8

23

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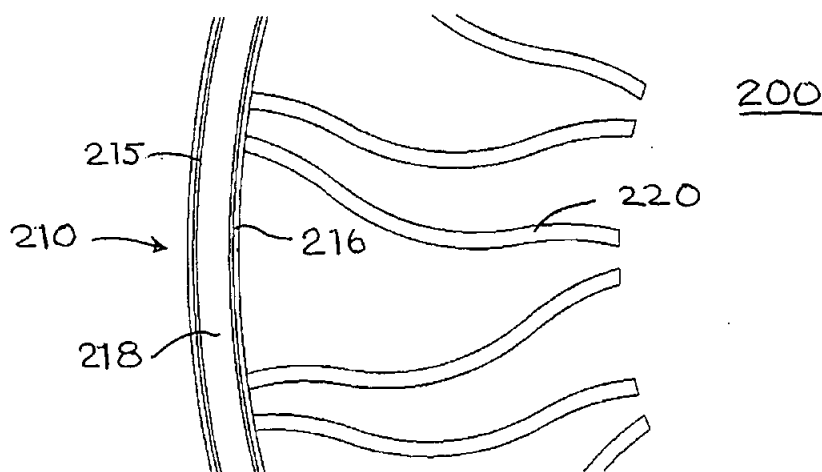
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(81) Países designados (a menos que se indique lo contrario para cada clase de protección disponible):
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[Continúa en la página siguiente]

(54) Título: RAYO DE RIGIDEZ VARIABLE PARA UN ENSAMBLE NO NEUMÁTICO



(57) Extracto: La invención aquí descrita provee una estructura deformable no neumática con un ensamble de rayo de rigidez variable, que ofrece un método de ajustar la rigidez vertical. La estructura comprende una banda anular exterior con una rigidez predeterminada, un conjunto de elementos de rayo con un extremo exterior y un extremo interior, donde el extremo exterior se conecta a la banda exterior, extendiéndose el elemento de rayo hacia adentro y teniendo su extremo interior conectado a un cubo, configurándose el cubo para acoplar la estructura a un eje de un vehículo u otro aparato capaz de girar sobre un eje. Cada uno de los elementos de rayo tiene una longitud curvilínea mayor que la longitud de un segmento de línea recta que se extiende, desde un punto de conexión del extremo exterior del elemento de rayo con la banda anular exterior, hasta un punto de conexión del extremo interno del elemento de rayo al cubo. El extremo exterior del citado elemento de rayo es tangente al segmento de línea recta, y el extremo interior del citado elemento de rayo es tangente al segmento de línea recta.

WO 2008/036789 A3

WO 2008/036789 A3



Declaraciones bajo la Regla 4.17:

— *con respecto a la condición de inventor (Regla 4.17(i))*

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25

Rayo de Rigidez Variable para un Ensemble No Neumático

ARTE PREVIO

[0001] Estructuras deformables no neumáticas para uso en el soporte de cargas bajo condiciones de rodamiento, tales como para soportar cargas de vehículos automotrices, se han descrito por ejemplo en la Patente de los Estados Unidos No. 7,201,194, comúnmente de propiedad del cesionario de la presente invención. La llanta no neumática, soportada estructuralmente, divulgada allí, incluye una banda anular reforzada, que soporta la carga, y una pluralidad de rayos de una red que transmiten en tensión las fuerzas de carga entre la banda anular y una rueda o cubo. La llanta soporta su carga únicamente gracias a las propiedades estructurales y, contrario al mecanismo en llantas neumáticas, sin el soporte de la presión de aire interna.

[0002] En la estructura ejemplar ilustrada en Fig. 1 en esta solicitud, los rayos se muestran como elementos orientados radialmente, que luego se extienden más o menos transversalmente a través del ancho de la estructura deformable no neumática. La estructura actúa como una estructura "de carga superior", lo cual significa que la carga vertical aplicada desde el piso contra un cubo fijo es contrarrestada por fuerzas de tensión en los rayos, que se encuentran generalmente fuera de la región donde la banda está en contacto con la superficie de carga. Los rayos en la última región soportan poca o ninguna carga, como se ilustra en Fig. 1, donde estos rayos han experimentado una deformación de pandeo.

[0003] Una característica de diseño de la estructura deformable no neumática es su rigidez vertical. En el contexto actual, la rigidez vertical es el incremento de fuerza vertical generada para cada incremento de deflexión vertical o desplazamiento ascendente del piso con el cubo mantenido fijo. Dependiendo de la aplicación portadora de carga de uso

final, puede ser deseable tener una estructura que posea una rigidez vertical inicial más elevada. Un ejemplo de esta situación sería una aplicación en donde hay una carga estática elevada, tal como una pieza de equipo pesado de construcción. En este caso, la elevada rigidez limita la deflexión vertical estática. Por otra parte, otras aplicaciones pueden beneficiarse de una rigidez inicial baja. Un ejemplo de tal uso es una carretilla de mano donde el dispositivo necesita rodar fácilmente sobre obstáculos cuando está ligeramente cargado. Un método de controlar la rigidez vertical de la estructura deformable no neumática es ajustar las propiedades y dimensiones mecánicas de la banda exterior. No obstante, esto afecta también la presión media de contacto entre la banda exterior y la superficie de carga, lo cual es un importante criterio de diseño general para una aplicación específica.

SUMARIO DE LA INVENCION

[0004] La invención descrita en esta solicitud provee una estructura deformable no neumática con un ensamble de rayos de rigidez variable, que ofrece un método de ajustar la rigidez vertical. Otra ventaja de la invención es reducir la concentración de esfuerzo, que puede desarrollarse en los extremos del rayo.

[0005] Una estructura deformable no neumática comprende una banda anular exterior con una rigidez predeterminada, un conjunto de elementos de rayo con un extremo exterior y un extremo interior, donde el extremo exterior se conecta a la banda exterior, extendiéndose el elemento de rayo hacia adentro y teniendo su extremo interior conectado a un cubo, configurándose el cubo para acoplar la estructura al eje de un vehículo u otro aparato con capacidad de giro sobre un eje. Cada uno de los elementos de rayo tiene una longitud curvilínea mayor que la longitud de un segmento de línea recta, que se extiende, desde un punto de conexión del extremo exterior del elemento de rayo con la banda anular, a un punto de conexión

del extremo interno del elemento de rayo al cubo. El extremo exterior del citado elemento de rayo es tangente al segmento de línea recta, y el extremo interior del citado elemento de rayo es tangente al segmento de línea recta.

[0006] En una variación de la invención, el elemento de rayo, visto en una sección transversal, comprende por lo menos dos segmentos cóncavos y por lo menos un segmento convexo.

[0007] En todavía otra variación, los segmentos cóncavos y el segmento convexo son mutuamente tangentes en sus puntos de intersección.

[0008] En una incorporación ejemplar descrita en detalle en esta solicitud, los segmentos cóncavos y el segmento convexo se forman cada uno de segmentos de arco circular.

[0009] Estas y otras características, aspectos y ventajas de la invención se entenderán mejor con referencia a la siguiente descripción y las reivindicaciones anexas. Los dibujos acompañantes, que se incorporan en esta especificación y constituyen parte de ella, ilustran incorporaciones de la invención y, junto con la descripción, sirven para explicar los principios de la invención.

DESCRIPCIÓN DE LAS FIGURAS

[0010] Fig. 1 es una sección transversal o vista lateral de una estructura deformable no neumática **100**, que ilustra la acción de los elementos de rayo bajo una deflexión ascendente de una fuerza vertical aplicada.

[0011] Fig. 2 es una vista detallada de una estructura deformable no neumática **100**, que ilustra el exceso de longitud de un elemento de rayo.

[0012] Fig. 3a es una gráfica que muestra la carga vertical (daN) como una función del desplazamiento vertical impuesto (en mm) para los elementos de rayo ejemplares con tres niveles de exceso de longitud.

[0013] Fig. 3b es un gráfico que muestra la rigidez vertical (daN/mm) como una función del desplazamiento vertical impuesto (mm) para los elementos de rayo ejemplares con tres niveles de exceso de longitud.

[0014] Fig. 4a es una vista esquemática de una estructura deformable no neumática **100**, cuando está cargada por una deflexión ascendente.

[0015] Fig. 4b es una vista de un detalle correspondiente al contorno rectangular de Fig. 4a, que ilustra la concentración de esfuerzo.

[0016] Fig. 5 es una sección transversal o vista lateral de una porción de una estructura deformable no neumática **200**, que ilustra la aplicación de elementos de rayo recurvados.

[0017] Fig. 6a es una vista esquemática de una estructura deformable no neumática **200**, cuando está cargada por una deflexión ascendente.

[0018] Fig. 6b es una vista en detalle correspondiente al contorno rectangular de Fig. 6a, que ilustra la concentración de esfuerzo reducida.

[0019] Fig. 7 es una definición geométrica de un elemento de rayo recurvado, que muestra dos segmentos cóncavos y un segmento convexo.

[0020] Fig. 8 es un gráfico que muestra la carga vertical (daN) como una función del desplazamiento vertical impuesto (mm), comparando una estructura deformable no neumática **100** con la estructura deformable no neumática **200**, que tiene elementos de rayo recurvados e incluye una referencia con exceso de longitud cero.

29

DESCRIPCIÓN DETALLADA

[0021] Figura 1 es un ejemplo de una estructura deformable no neumática **100**. La estructura comprende una banda exterior **110** con una rigidez predeterminada. Un conjunto de elementos en forma de rayos **120** conectan la banda **110** a un cubo **130**. El cubo **130** puede acoplarse entonces a un eje de un vehículo u otro aparato capaz de girar sobre un eje. La rigidez de la banda puede obtenerse mediante varios tipos de refuerzos en capas simples o múltiples. Las Patentes de los Estados Unidos No. 7,013,939 y 6,769,465 ofrecen ejemplos de construcciones de banda apropiadas e información de diseño para obtener una capacidad deseada portadora de carga. Figura 1 ilustra la aplicación de una carga vertical F_z a la estructura no neumática **100** bajo condiciones donde el cubo **130** se mantiene verticalmente inmóvil. La porción de la banda exterior **110** en contacto con el piso experimenta un desplazamiento vertical ascendente Δ . Figura 3a es una representación gráfica de la fuerza F_z (en daN) versus el delta de desplazamiento vertical para tres niveles de exceso de longitud **EL** (descrito más adelante). Figure 3b es una representación gráfica de la rigidez vertical (en daN/mm) versus el desplazamiento vertical Δ . La rigidez vertical es la pendiente de la fuerza versus la curva de desplazamiento para un desplazamiento dado.

[0022] Un método propuesto para controlar la rigidez vertical de una estructura deformable no neumática es variar el exceso de longitud del rayo **EL**, definido como sigue e ilustrado en Fig. 2,

$$\text{Exceso de Longitud} = \left[\left(\frac{L_1}{L_0} \right) - 1 \right] * 100\%$$

- i. donde L_0 y L_1 se definen seguidamente y se ilustran en Fig. 2,
- ii. L_0 , es la distancia entre los extremos de rayo,

iii. L_1 , es la longitud curvilínea del rayo.

[0023] Se efectuó un análisis en tres diferentes estructuras deformables no neumáticas con iguales especificaciones de diseño para los materiales y refuerzos en todos los aspectos, excepto por el exceso de longitud **EL** del rayo. Para el análisis, los elementos de rayo **120** se orientan de tal modo que sus puntos de unión extremos caen en líneas radiales, mientras que los elementos de rayo **120** mostrados en Fig. 2 se orientan de tal modo que sus puntos de unión extremos caen en líneas que son en algún ángulo relativas a la dirección radial. Se permite cualquier configuración por la anterior definición de exceso de longitud **EL** del rayo.

[0024] Se desarrolló un modelo de simulación de elementos finitos usando software disponible en el comercio para evaluar el efecto de variar el exceso de longitud del rayo **EL** sobre la rigidez vertical de la estructura deformable no neumática **100**. El modelo es una simulación bidimensional, la cual correspondería a una estructura deformable no neumática **100** que tiene un comportamiento uniforme en todo su ancho transversal. La simulación bidimensional es una buena aproximación al comportamiento de la actual estructura deformable no neumática tridimensional **100**. Un ejemplo de una estructura tridimensional se muestra en la Patente de los Estados Unidos No. 7,013,939. El resultado del modelo es la fuerza vertical por unidad de ancho de la estructura deformable no neumática **100**.

[0025] Para este modelo, una estructura deformable no neumática **100** comprende una banda exterior anular **110** con un diámetro exterior de 300 mm, conectada por los elementos de rayo **120** a un cubo **130** con un diámetro de 150 mm. La banda **110** tiene aproximadamente 9 mm de espesor y comprende además dos bobinas de refuerzo concéntricas **115** y **116**, respectivamente, insertadas en la banda **110** y distanciadas una de la otra radialmente en 7 mm. Cada bobina **115** o **116** comprende un devanado orientado circunferencialmente de cables de acero de 4 x 0.26 mm, como se

utilizan para material de cinturones de rodamiento ("*tire belt material*") y con un espaciado lateral de 1.8 mm entre los cables de la bobina. La rigidez de tensión circunferencial efectiva de las bobinas se convierte en rigidez por unidad de ancho, o módulo de tensión efectiva, para uso en el modelo de elementos finitos. El espaciado de los cables en las bobinas permite asimismo el flujo de material durante el moldeo de la estructura deformable no neumática. Esta configuración crea una capa intermedia anular **118** entre las dos bobinas con un espesor de alrededor de 7 mm. La estructura no neumática **100** tiene veinte elementos de rayo **120** que tienen 2.5 mm de espesor en la vista mostrada en Fig. 2. El diámetro exterior del cubo es de 150 mm. La estructura deformable no neumática **100** se moldea como una unidad de poliuretano suministrado por Chemtura bajo la designación B836 VIBRATHANE.

[0026] Se modelaron tres estructuras deformables no neumáticas **100** con elementos de rayo de curvatura única, que tenían un exceso de longitud de rayo **EL** de (a) 0.98%, (b) 8.59%, y (c) 22.9%, respectivamente. La fuerza vertical prevista (por ancho de estructura unitario) versus deflexión para estas tres estructuras se muestra en Fig. 3a. La rigidez vertical prevista (por ancho de estructura unitario) versus curvas de deflexión para estas tres estructuras se muestran en Fig. 3b. Para referencia, una estructura deformable no neumática con exceso de longitud cero se muestra como "referencia" en Fig. 8. La fuerza vertical versus la deflexión se ha modificado significativamente cambiando el exceso de longitud del rayo. Si se compara el diseño, que tiene con un exceso de longitud del rayo de 0.98%, con la estructura de referencia, puede observarse que la carga vertical se reduce aproximadamente en alrededor del 10% en desplazamientos de más de 15 mm. No obstante, la rigidez vertical para deflexiones de más de 15 mm permanece comparable para los dos diseños.

[0027] Se descubre un resultado inesperado cuando la variación de la rigidez vertical se compara para los tres niveles de exceso de longitud del

32

rayo. Fig. 3b presenta la comparación de rigidez vertical para los tres diseños de curvatura única. El diseño (a) tiene una rigidez inicial para deflexiones menor de alrededor de 5 mm, y aproximaciones adicionales un valor relativamente constante, en el orden de 0.08 daN/mm con deflexiones más allá de 15 mm. El diseño (b) tiene una rigidez relativamente constante a todo lo largo del rango de deflexión, y el diseño (c) tiene una baja rigidez inicial, que se acerca gradualmente al mismo valor de rigidez del diseño (a). Este resultado es ventajoso, dependiendo del tipo de uso. Para una aplicación de equipo pesado con una carga estática elevada, la rigidez inicial alta es deseable para limitar la deflexión estática de la estructura deformable no neumática, manteniendo al mismo tiempo una respuesta rígida menor durante la operación del equipo. De otro lado, para otras aplicaciones, es deseable una rigidez inicial cuando el dispositivo está soportando una carga pequeña. En este caso, la baja rigidez facilita rodar sobre obstáculos, pero resulta una rigidez más elevada cuando se aplica una carga más alta para limitar la deflexión general de la estructura deformable no neumática.

[0028] Manejo de la Distribución de Esfuerzo Aumentando el Exceso de Longitud del Rayo: La forma deformada del elemento de rayo de curvatura única del Diseño (c) con 22.9% de exceso de longitud del rayo **EL** se muestra en Fig. 4a. Figura 4b presenta un detalle del área dentro del rectángulo resaltado que muestra la intersección entre el extremo del rayo y la banda exterior **110**. Para un elemento de rayo radial con exceso de longitud cero, la intersección es perpendicular. A medida que aumenta el exceso de longitud de rayo **EL**, disminuye el ángulo de intersección entre el rayo y la banda exterior. El mismo efecto ocurre en la intersección del elemento de rayo **120** y el cubo **130**. Esto lleva a una concentración de esfuerzo en la región en donde los rayos se conectan a la banda **110** y al cubo **130**.

[0029] Como alternativa, se desarrolló un diseño mejorado para

33

reducir la concentración de esfuerzo. El diseño mejorado para una estructura neumática deformable **200** tiene un perfil de rayo donde el ángulo de unión entre el elemento de rayo **220** y la banda **210** (o cubo **230**, no mostrado pero equivalente al cubo **130** de Fig. 1) se alinea más estrechamente con el esfuerzo de tensión general, resultante en el rayo mismo. Esto se logra empleando un perfil recurvado para el elemento de rayo **220** con tres curvaturas principales, dos convexas y una cóncava, cuyo diseño se muestra en Fig. 5 y en detalle en Fig. 7. Los términos "cóncavo" y "convexo" se usan por conveniencia para indicar el sentido positivo o negativo de la curvatura del elemento de rayo **220**. Geométricamente, el elemento de rayo recurvado **220**, como se muestra en Fig. 7, se compone de tres arcos de radio de curvatura esencialmente igual, **R1**, **R2** y **R3**, que son mutuamente tangentes e igualmente tangentes a una línea que conecta los puntos deseados de unión extremos del elemento de rayo a la banda **210** y al cubo **230**. No es necesario que los tres radios de curvatura **R1**, **R2** y **R3** sean iguales. La línea que conecta los puntos de unión extremos (mostrados por los círculos pequeños en Fig. 7) puede seguir una dirección radial o tener un ángulo relativo a la dirección radial.

[0030] Tres estructuras deformables no neumáticas **200**, como se describe en Fig. 6a con los elementos de rayo recurvados **220**, se simularon con el modelo. Para mejor ilustrar las ventajas del diseño recurvado, la magnitud del exceso de longitud **EL** para cada uno de los tres diseños se ajustó en el modelo para obtener la misma rigidez vertical que para las estructuras de curvatura única **100** previamente mostradas en Fig. 3a y Fig. 3b. Por ejemplo, el elemento de rayo recurvado **220** requirió únicamente 14% de exceso de longitud del rayo, comparado con el 22.9% de exceso de longitud del rayo para el diseño de curvatura única para obtener aproximadamente la misma rigidez vertical. La carga vertical versus la deflexión para los seis diseños (tres estructuras de curvatura única **100** y tres estructuras recurvadas **200**) se muestra en Fig. 8, donde la leyenda "Diseño Original" corresponde a las estructuras **100** y la leyenda "Diseño

Nuevo" corresponde a las estructuras **200** que tienen elementos de rayo recurvado **220**, y la leyenda "Referencia" corresponde a un elemento de rayo que tiene un exceso de longitud **EL** cero. Figura 6b muestra el detalle del área de concentración de esfuerzo en la intersección del elemento de rayo **220** con la banda **210** para el diseño de rayo recurvado. En el elemento de rayo de curvatura única **120** (véase Fig. 2), el esfuerzo pico fue 0.733 daN/mm², mientras que el elemento de rayo recurvado **220** tiene un esfuerzo pico, en la misma ubicación, de 0.472 daN/mm², una reducción del 36%. La siguiente Tabla 1 muestra una comparación de los diseños de rayo de curvatura única y rayo recurvado. En cada caso, el elemento de rayo recurvado **220** (en una fila en la tabla) muestra un esfuerzo principal más bajo que el elemento de rayo de curvatura única **120**.

Tabla 1: Exceso de Longitud del Elemento de Rayo y Esfuerzo Principal Máximo

Diseño	Elementos de Rayo de Curvatura Única		Elementos de Rayo Recurvado	
	Exceso de Longitud (EL)	Esfuerzo Principal (daN/mm ²)	Exceso de Longitud (EL)	Esfuerzo Principal (daN/mm ²)
(a)	0.98 %	0.832	0.55 %	0.542
(b)	8.59 %	1.019	6.01 %	0.537
(c)	22.9 %	0.733	14.11 %	0.472

[0031] Puede decirse que el diseño recurvado es un diseño más eficiente ya que obtiene el mismo ajuste a la rigidez inicial y final con una magnitud reducida de exceso de longitud del rayo y un esfuerzo principal reducido en los puntos de unión del rayo. Los principios del diseño divulgados se han reducido para poner en práctica la estructura deformable no neumática **200** para una aplicación en un mini-cargador ("*skid-steer*") correspondiente a un neumático 12R16.5 y una rueda y para la aplicación en una carretilla correspondiente a un neumático 10x3 y una rueda.

35

[0032] Los solicitantes entienden que, a partir de la lectura de la especificación anterior, muchas otras variaciones son evidentes a una persona de habilidad ordinaria en el arte. Estas variaciones y otras variaciones están dentro del espíritu y el ámbito de la presente invención, como se define por las siguientes reivindicaciones anexas.

Reivindicaciones

1. Una estructura deformable no neumática, que comprende una banda anular exterior con una rigidez predeterminada, un conjunto de elementos de rayo con un extremo exterior y un extremo interior, el citado extremo exterior se conecta a la banda exterior, el citado elemento de rayo se extiende hacia adentro y el citado extremo interior se conecta a un cubo interior, configurándose el cubo para unir la estructura al eje de un vehículo u otro aparato con capacidad de giro sobre un eje; cada uno de los citados elementos de rayo tiene una longitud curvilínea mayor que la longitud de un segmento de línea recta, que se extiende, desde un punto de conexión del citado extremo exterior del citado elemento de rayo con la banda anular exterior, hasta un punto de conexión del citado extremo interior del citado elemento de rayo al cubo interior, y en donde el citado extremo exterior del citado elemento de rayo es tangente al citado segmento de línea recta y el citado extremo interior del citado elemento de rayo es tangente al citado segmento de línea recta.
2. La estructura deformable según la reivindicación 1, en donde una sección transversal del citado elemento de rayo comprende por lo mismo dos segmentos cóncavos y por lo menos un segmento convexo.
3. La estructura deformable según la reivindicación 2, en donde los citados segmentos cóncavos y el citado segmento convexo son mutuamente tangentes en sus puntos de intersección.
4. La estructura deformable según la reivindicación 3, en donde los citados segmentos cóncavos y el citado segmento convexo se forman cada uno de un segmento de arco circular con un radio de curvatura.
5. La estructura deformable según la reivindicación 4, en donde los

citados radios de curvatura de cada uno de los citados segmentos cóncavos y convexos son iguales entre sí.

6. La estructura deformable según la reivindicación 1, en donde una diferencia en la longitud curvilínea del citado elemento de rayo y la longitud del citado segmento de línea recta define un exceso de longitud del rayo, y en donde el citado exceso de longitud puede variarse para obtener un nivel predeterminado de la carga vertical versus la rigidez de deflexión de la citada estructura deformable.
7. La estructura deformable según la reivindicación 6, en donde el citado exceso de longitud es mayor o igual que alrededor de 0.5% y menor o igual que alrededor de 15%.

39

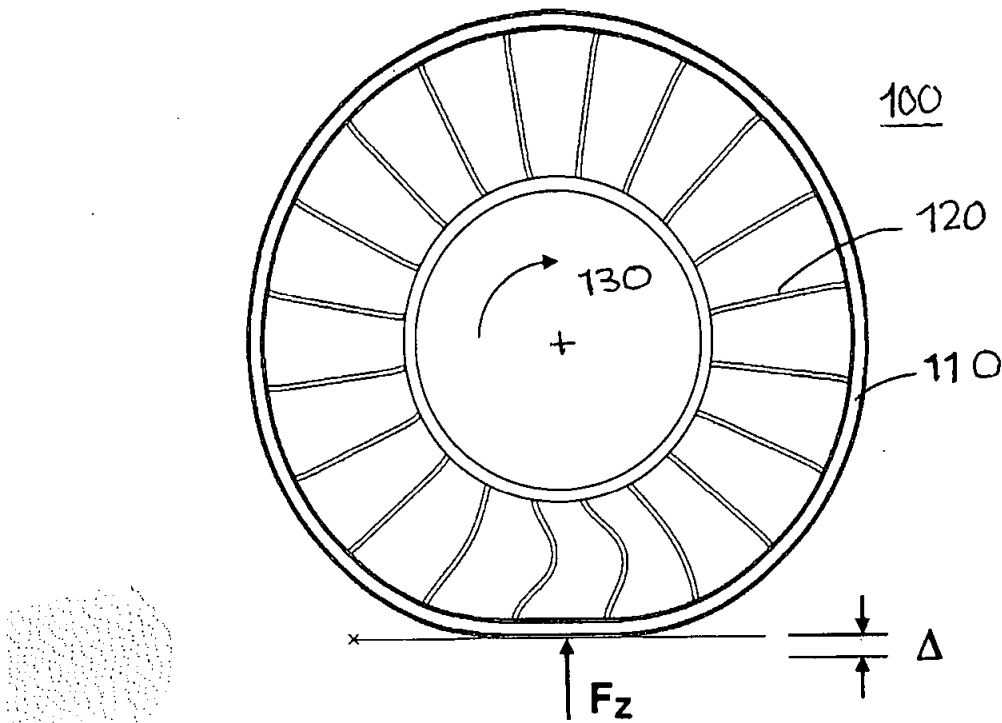


Fig. 1

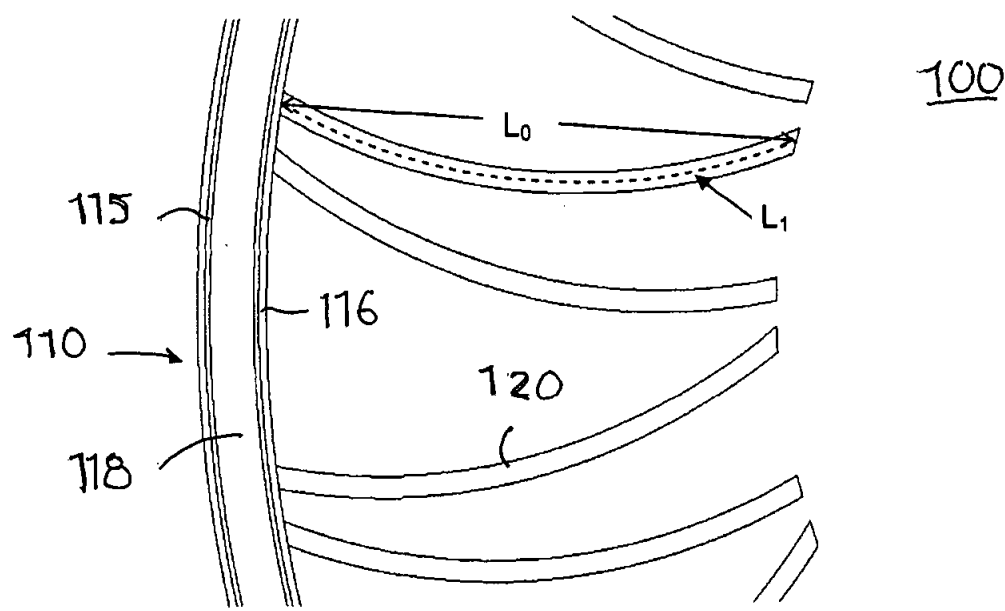


Fig. 2

39

2 / 5

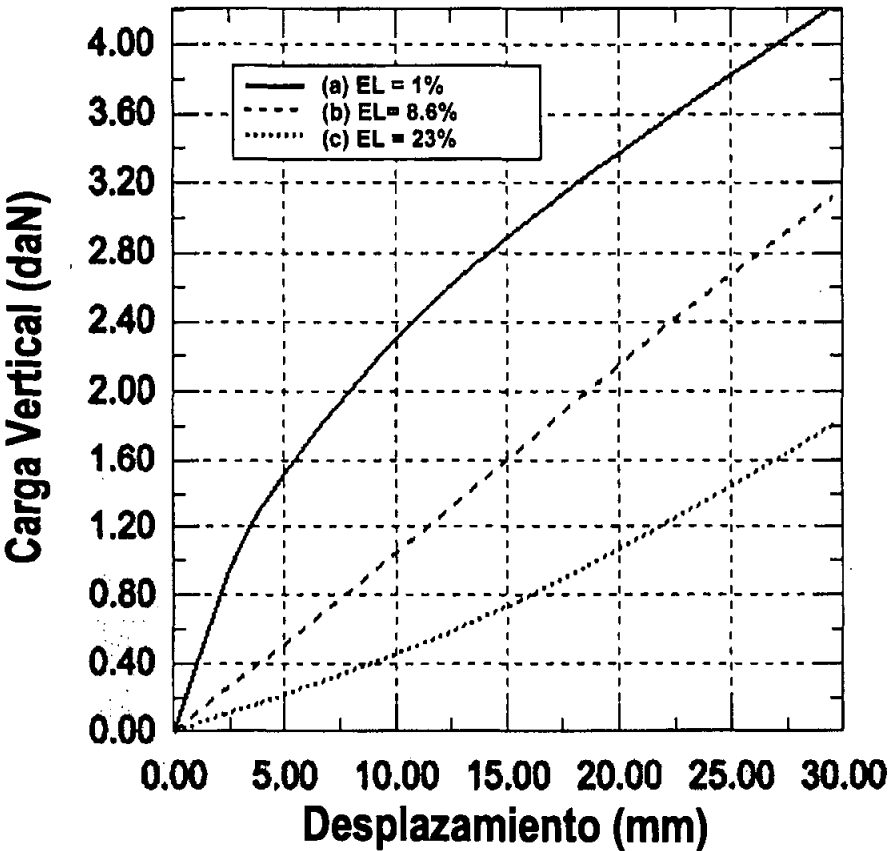
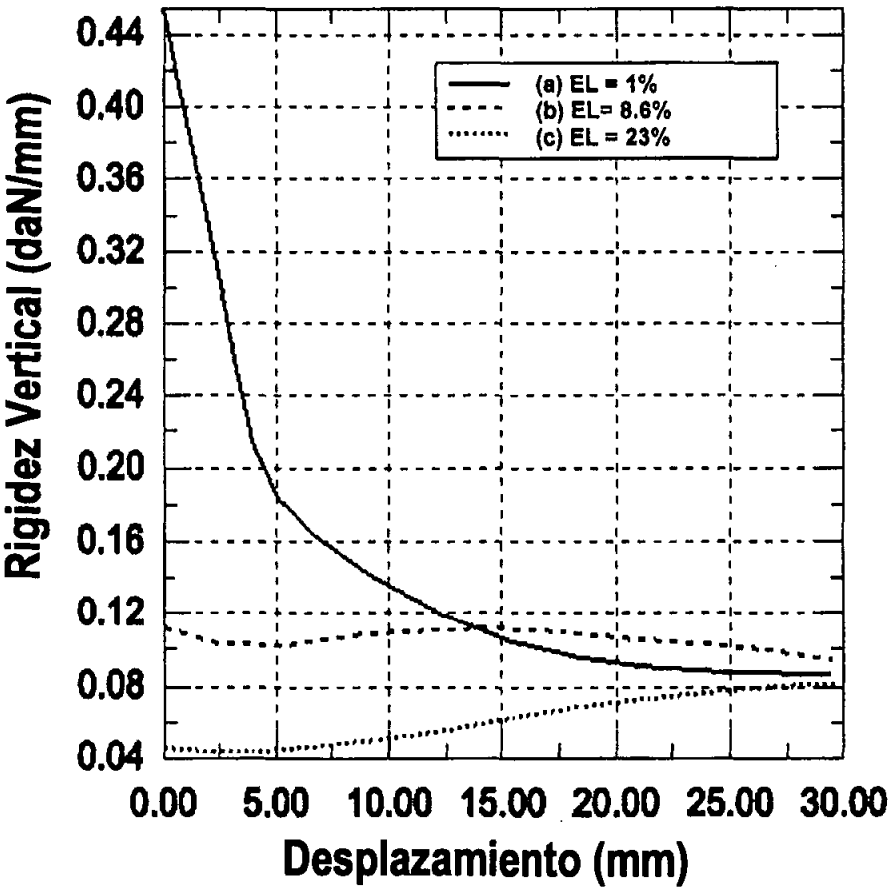


Fig. 3a



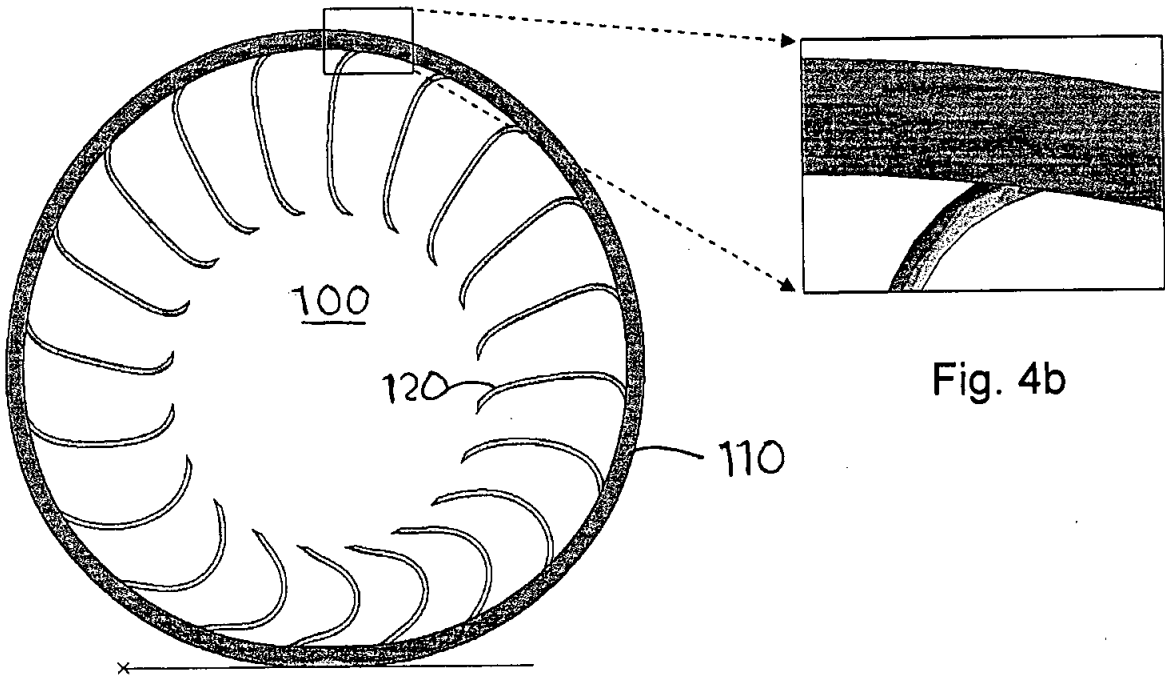


Fig. 4a

Fig. 4b

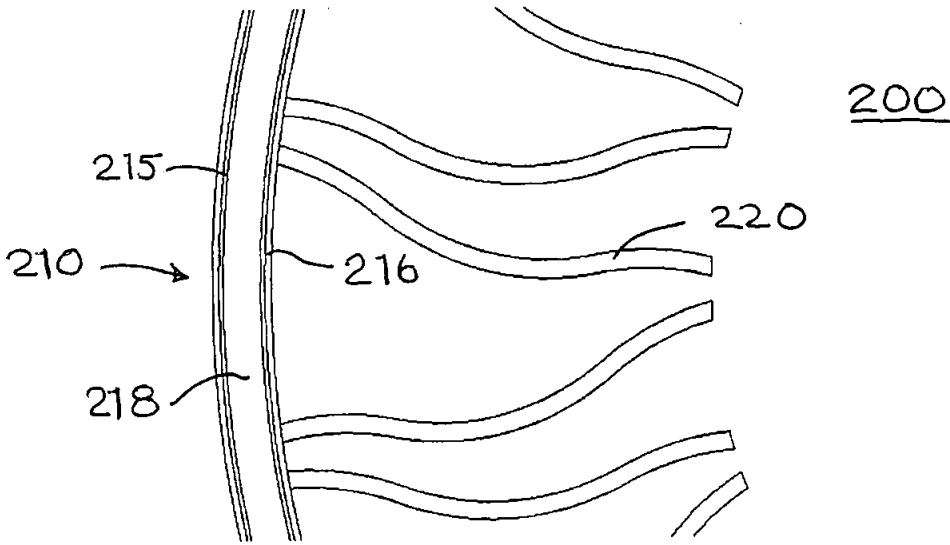


Fig. 5

41

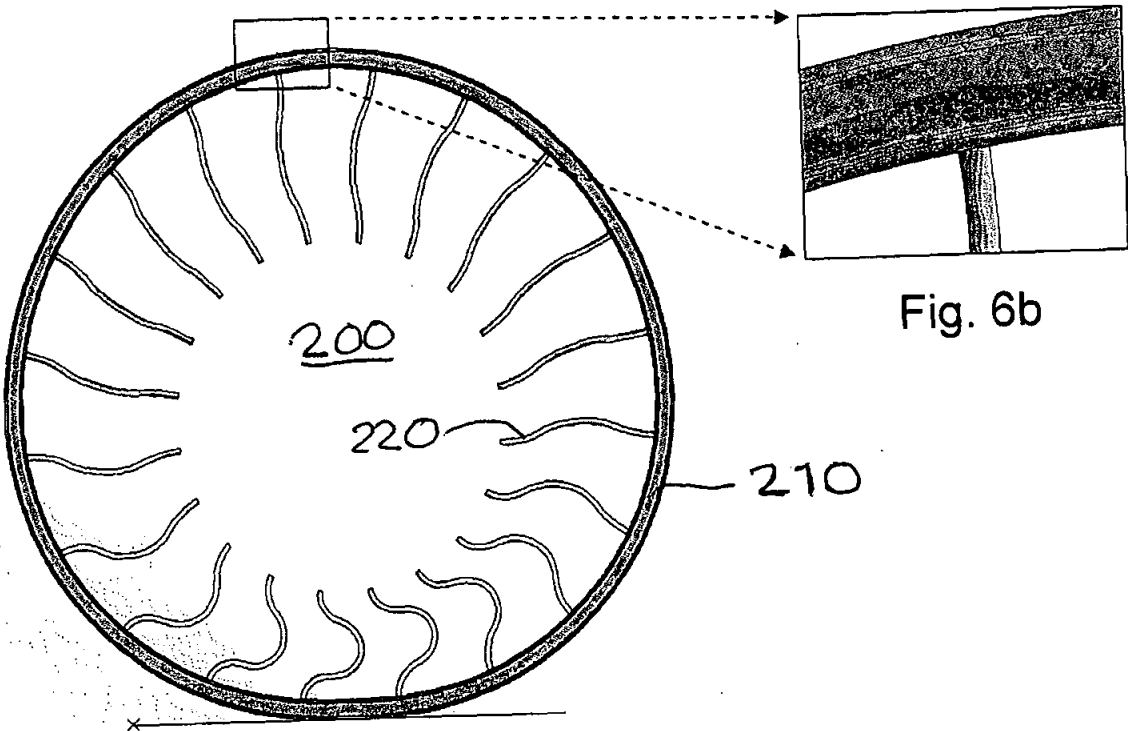


Fig. 6b

Fig. 6a

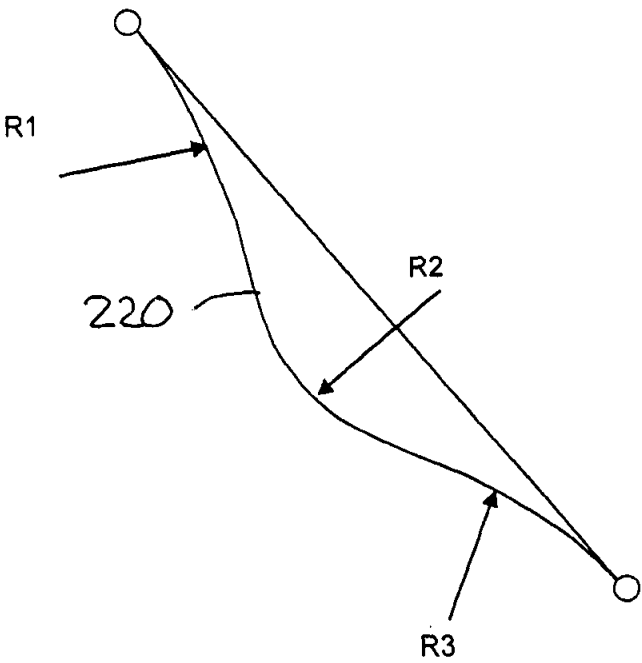
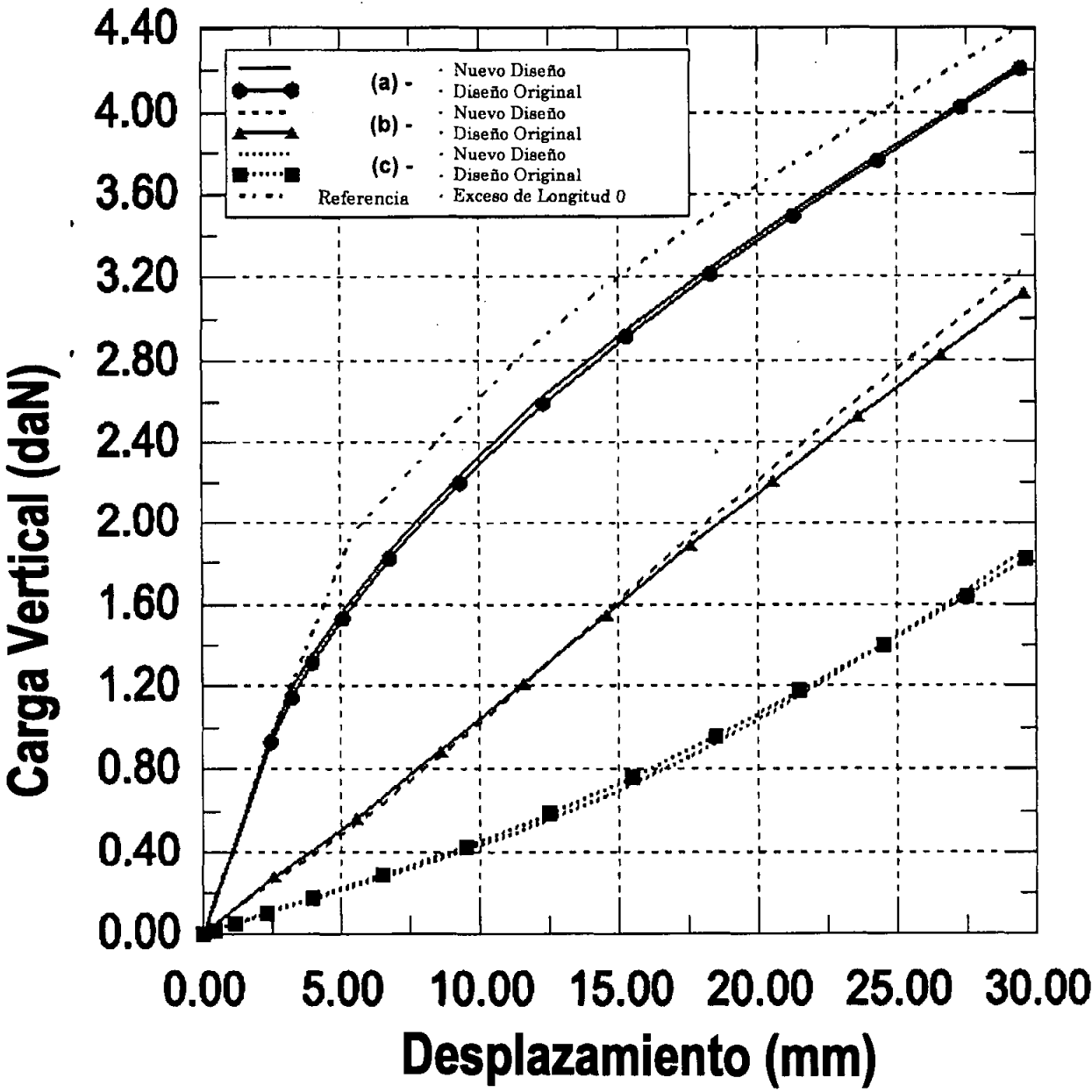


Fig. 7

42



PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P50-0206-WO-PCT	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US 07/78975	International filing date (day/month/year) 20 September 2007 (20.09.2007)	(Earliest) Priority Date (day/month/year) 20 September 2006 (20.09.2006)
Applicant SOCIETE DE TECHNOLOGIE MICHELIN		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the language, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).

c. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.

2. ☐ Certain claims were found unsearchable (see Box No. II).

3. ☐ Unity of invention is lacking (see Box No. III).

4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,

a. the figure of the drawings to be published with the abstract is Figure No. 5

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 07/78975

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - B60B 9/26 (2008.01) USPC - 152/5 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) USPC: 152/5		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC: 152/11, 246, 270, 271 (text search - see terms below)		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PubWEST(USPT,PGPB,EPAB,JPAB); Google Scholar; Google Patents Search Terms: non-pneumatic, deformable, hub, spoke, inner, band, curved, element, concave, convex, structure, segment		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0159385 A1 (Rhyne et al.) 19 August 2004 (19.08.2004), Fig 1, para [0039]	1-7
Y	US 4,917,162 A (De Longcamp) 17 April 1990 (17.04.1990), Fig 1 and 2, col 9, ln 5-11 and ln 47-54, col 10, ln 1-8	1-7
☐ Further documents are listed in the continuation of Box C. ☐		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 10 February 2008 (10.02.2008)	Date of mailing of the international search report 11 APR 2008	
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774	

PATENT COOPERATION TREATY

RECEIVED

45

From the
INTERNATIONAL SEARCHING AUTHORITY

APR 15 2008

To:
E. MARTIN REMICK
MICHELIN NORTH AMERICA, INC.
INTELLECTUAL PROPERTY DEPARTMENT
515 MICHELIN ROAD
GREENVILLE, SC 29605

PCT

Intellectual Property
Department

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing
(day/month/year)

11 APR 2008

Applicant's or agent's file reference
P50-0206-WO-PCT

FOR FURTHER ACTION

See paragraph 2 below

International application No.
PCT/US 07/78975

International filing date (day/month/year)
20 September 2007 (20.09.2007)

Priority date (day/month/year)
20 September 2006 (20.09.2006)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - B60B 9/26 (2008.01)
USPC - 152/5

Applicant SOCIETE DE TECHNOLOGIE MICHELIN

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

ENTERED INTO

3. For further details, see notes to Form PCT/ISA/220.

APR 16 2008

SEP

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Date of completion of this opinion 10 February 2008 (10.02.2008)	Authorized officer MEMOTECH Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774
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WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/US 07/78975

Box No. 1 Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:
 - ☒ the international application in the language in which it was filed.
 - ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).
2. ☐ This opinion has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established on the basis of:
 - a. type of material
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing
 - ☐ contained in the international application as filed
 - ☐ filed together with the international application in electronic form
 - ☐ furnished subsequently to this Authority for the purposes of search
4. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/US 07/78975

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-7	YES
	Claims	None	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-7	NO
Industrial applicability (IA)	Claims	1-7	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-7 lack an inventive step under PCT Article 33(3) as being obvious over US 2004/0159385 A1 to Rhyne et al. (hereinafter 'Rhyne') in view of US 4,917,162 A to De Longcamp et al. (hereinafter 'De Longcamp').

As per claim 1, Rhyne discloses a non-pneumatic deformable structure comprising an outer annular band (110) having a predetermined stiffness, a set of spoke elements (150) having an outer end and an inner end, said outer end is connected to the outer band, said spoke element extending inward and said inner end connected is to an inner hub (160), the hub being configured to attach the structure to a vehicle axle or other apparatus capable of rotation about an axis (Fig 1; see para [0039]); and wherein said outer end of said spoke element is tangent to said straight line segment and said inner end of said spoke element is tangent to said straight line segment. Rhyne does not specifically disclose each of said spoke elements has a curvilinear length greater than the length of a straight line segment extending from a point of connection of said outer end of said spoke element with the outer annular band to a point of connection of said inner end of said spoke element to the inner hub. De Longcamp discloses a deformable structure wherein each of said spoke elements (col 10, ln 1-8) has a curvilinear length greater than the length of a straight line segment extending from a point of connection of said outer end of said spoke element with the outer annular band to a point of connection of said inner end of said spoke element to the inner hub (Fig 1; col 9, ln 47-54). It would have been obvious to one of ordinary skill in the art to modify the structure as disclosed by Rhyne to include the curved elements as disclosed by De Longcamp since the use of curved elements decreases the rigidity of the structure thereby enhancing performance.

As per claim 2, De Longcamp further discloses wherein a transverse section of said spoke element comprises at least two concave segments and at least one convex segment (Fig 2).

As per claim 3, De Longcamp further discloses wherein said concave segments and said convex segment are mutually tangent at their points of intersection (Fig 2).

As per claim 4, De Longcamp further discloses wherein said concave segments and said convex segment are each formed of a circular arc segment having a radius of curvature (rc; Fig 2).

As per claim 5, De Longcamp further discloses wherein said concave segments and said convex segment are each formed of a circular arc segment having a radius of curvature (rc; Fig 2). De Longcamp does not specifically disclose wherein said radius of curvature of each of said convex and concave segments are equal to each other. However, it would have been obvious to one of ordinary skill in the art to have the radius of curvature of each of said convex and concave segments equal to each other since having the radii equal would avoid excessive deflection under pressure in a side direction.

As per claim 6, De Longcamp further discloses wherein a difference in the curvilinear length of said spoke element and the length of said straight line segment defines a spoke excess length (e). De Longcamp does not specifically disclose wherein said excess length may be varied to obtain a predetermined level of the vertical load versus deflection stiffness of said deformable structure. However, it would have been obvious to one of ordinary skill in the excess length could be varied to obtain a predetermined level of the vertical load versus deflection stiffness of said deformable structure since an increase in length would increase either the number of concave and convex portions or the value of the radii, either of which would decrease stiffness in the structure.

As per claim 7, De Longcamp further discloses wherein said excess length is greater or equal to than about 0.5% and less than or equal to about 15% (col 9, ln 5-11).

Claims 1-7 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.

48

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

PCT/US07/78975

International Application No.

20 SEP 2007 (20.09.07)

International Filing Date

PCT International Application RO/US

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) P50-0206-WO-PCT

Box No. I TITLE OF INVENTION	
VARIABLE STIFFNESS SPOKE FOR A NON-PNEUMATIC ASSEMBLY	
Box No. II APPLICANT ☐ This person is also inventor	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	
Societe de Technologie Michelin 23, rue Breschet FR-63000, Clermont-Ferrand France	
Telephone No. 864-422-4134	
Facsimile No. 864-422-3517	
Applicant's registration No. with the Office	
State (that is, country) of nationality: FR	
State (that is, country) of residence: FR	
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☒ the States indicated in the Supplemental Box	
Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.	
Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	
REMICK, E. Martin Michelin North America, Inc. Intellectual Property Department 515 Michelin Road Greenville, South Carolina 29605 United States of America	
Telephone No. 864-422-4134	
Facsimile No. 864-422-3517	
Agent's registration No. with the Office 45,038	
☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.	

49

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S) <i>If none of the following sub-boxes is used, this sheet should not be included in the request.</i>	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i>	
Michelin Recherche et Technique S.A. Route Louis-Braille 10 CH-1763, Granges-Paccot Switzerland	
This person is: ☒ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i>	
Applicant's registration No. with the Office	
State <i>(that is, country)</i> of nationality: CH	State <i>(that is, country)</i> of residence: CH
This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i>	
CRON, Steven M. 525 McKinney Road Simpsonville, South Carolina 29681 United States of America	
This person is: ☐ applicant only ☒ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i>	
Applicant's registration No. with the Office	
State <i>(that is, country)</i> of nationality: US	State <i>(that is, country)</i> of residence: US
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i>	
This person is: ☐ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i>	
Applicant's registration No. with the Office	
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i>	
This person is: ☐ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i>	
Applicant's registration No. with the Office	
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i>	
This person is: ☐ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i>	
Applicant's registration No. with the Office	
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.	

Supplemental Box*If the Supplemental Box is not used, this sheet should not be included in the request.*

1. *If, in any of the Boxes, except Boxes Nos. VIII(i) to (v) for which a special continuation box is provided, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ..." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*
- (i) *if more than one person is to be indicated as applicant and/or inventor and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;*
 - (ii) *if, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*
 - (iii) *if, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*
 - (iv) *if, in addition to the agent(s) indicated in Box No. IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*
 - (v) *if, in Box No. VI, there are more than three earlier applications whose priority is claimed: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.*
2. *If the applicant intends to make an indication of the wish that the international application be treated, in certain designated States, as an application for a patent of addition, certificate of addition, inventor's certificate of addition or utility certificate of addition: in such a case, write the name or two-letter code of each designated State concerned and the indication "patent of addition," "certificate of addition," "inventor's certificate of addition" or "utility certificate of addition," the number of the parent application or parent patent or other parent grant and the date of grant of the parent patent or other parent grant or the date of filing of the parent application (Rules 4.11(a)(iii) and 49bis.1(a) or (b)).*
3. *If the applicant intends to make an indication of the wish that the international application be treated, in the United States of America, as a continuation or continuation-in-part of an earlier application: in such a case, write "United States of America" or "US" and the indication "continuation" or "continuation-in-part" and the number and the filing date of the parent application (Rules 4.11(a)(iv) and 49bis.1(d)).*

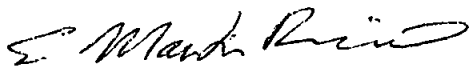
Continuation of Box II:
Societe de Technologie Michelin is applicant for all designated states except Canada, Mexico and the United States of America.

51

Sheet No. ...4...

Box No. V DESIGNATIONS				
The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents. However, ☐ DE Germany is not designated for any kind of national protection ☐ JP Japan is not designated for any kind of national protection ☐ KR Republic of Korea is not designated for any kind of national protection ☐ RU Russian Federation is not designated for any kind of national protection <i>(The check-boxes above may only be used to exclude (irrevocably) the designations concerned if, at the time of filing or subsequently under Rule 26bis.1, the international application contains in Box No. VI a priority claim to an earlier national application filed in the particular State concerned, in order to avoid the ceasing of the effect, under the national law, of this earlier national application.)</i>				
Box No. VI PRIORITY CLAIM				
The priority of the following earlier application(s) is hereby claimed:				
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application: regional Office	international application: receiving Office
item (1) 20/09/2006	60/846,071	US		
item (2)				
item (3)				
☐ Further priority claims are indicated in the Supplemental Box.				
Transmit certified copy: the receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) <i>(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)</i> identified above as: ☐ all items ☒ item (1) ☐ item (2) ☐ item (3) ☐ other, see Supplemental Box				
Restore the right of priority: the receiving Office is requested to restore the right of priority for the earlier application(s) identified above or in the Supplemental Box as item(s) (_____). <i>(See also the Notes to Box No. VI: further information must be provided to support a request to restore the right of priority.)</i>				
Incorporation by reference: where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.				
Box No. VII INTERNATIONAL SEARCHING AUTHORITY				
Choice of International Searching Authority (ISA) <i>(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):</i> ISA / US				
Request to use results of earlier search; reference to that search <i>(if an earlier search has been carried out by or requested from the International Searching Authority):</i> Date (day/month/year) Number Country (or regional Office)				
Box No. VIII DECLARATIONS				
The following declarations are contained in Boxes Nos. VIII (i) to (v) <i>(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):</i>				Number of declarations
☐ Box No. VIII (i)	Declaration as to the identity of the inventor			:
☐ Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent			:
☐ Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application			:
☒ Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)			1
☐ Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty			:

52

Box No. IX CHECK LIST; LANGUAGE OF FILING		
This international application contains:		This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item):
(a) on paper, the following number of sheets:		
request (including declaration and supplemental sheets) :	6	1. ☒ fee calculation sheet : 1
description (excluding sequence listing and/or tables related thereto) :	8	2. ☐ original separate power of attorney :
claims :	1	3. ☐ original general power of attorney :
abstract :	1	4. ☒ copy of general power of attorney; reference number, if any: : 2
drawings :	5	5. ☐ statement explaining lack of signature :
Sub-total number of sheets :	21	6. ☒ priority document(s) identified in Box No. VI as item(s): item 1 : 1
sequence listing :		7. ☐ translation of international application into (language): :
tables related thereto :		8. ☐ separate indications concerning deposited microorganism or other biological material :
(for both, actual number of sheets if filed on paper, whether or not also filed in electronic form; see (c) below)		9. ☐ sequence listing in electronic form (indicate type and number of carriers) :
Total number of sheets :	21	(i) ☐ copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application) :
(b) ☐ only in electronic form (Section 801(a)(i))		(ii) ☐ (only where check-box (b)(i) or (c)(i) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter :
(i) ☐ sequence listing		(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing mentioned in left column :
(ii) ☐ tables related thereto		10. ☐ tables in electronic form related to sequence listing (indicate type and number of carriers) :
(c) ☐ also in electronic form (Section 801(a)(ii))		(i) ☐ copy submitted for the purposes of international search under Section 802(b-quater) only (and not as part of the international application) :
(i) ☐ sequence listing		(ii) ☐ (only where check-box (b)(ii) or (c)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Section 802(b-quater) :
(ii) ☐ tables related thereto		(iii) ☐ together with relevant statement as to the identity of the copy or copies with the tables mentioned in left column :
Type and number of carriers (diskette, CD-ROM, CD-R or other) on which are contained the		11. ☒ other (specify): Transmittal letter : 1
☐ sequence listing:		
☐ tables related thereto:		
(additional copies to be indicated under items 9(ii) and/or 10(ii), in right column)		
Figure of the drawings which should accompany the abstract: Figure 5		Language of filing of the international application: English
Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE		
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).		
		
REMICK, E. Martin Agent		

For receiving Office use only	
1. Date of actual receipt of the purported international application: 20 SEP 2007 (20.09.07)	2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA / US	
6. ☐ Transmittal of search copy delayed until search fee is paid	
For International Bureau use only	
Date of receipt of the record copy by the International Bureau:	

Brigard & Castro

BOGOTA - COLOMBIA

PODER

Yo (nosotros) **SOCIETE DE TECHNOLOGIE MICHELIN**,
domiciliado en 23 rue Breschet -
F-63000 CLERMONT-FERRAND - Francia

Nombro(amos) a: **JUAN PABLO CADENA SARMIENTO y/o CARLOS H. PALACIO EASTMAN y/o MATIN E. TORRES CARDOZO**, de Bogotá, Colombia, apoderados verdaderos y legales con poder especial, amplio y suficiente, para recabar de las oficinas y autoridades colombianas administrativas, judiciales y de policía, en cualquier instancia o recurso, la obtención de patentes de invención, registros de marcas, diseños industriales, modelos de utilidad, depósitos de nombres comerciales, lemas comerciales y enseñas, registros de derechos de autor y contratos sobre los mismos, obtención de certificados de obtentor de variedades vegetales, así como sus prórrogas, renovaciones, anotaciones de traspaso, cambios de nombre y/o domicilio; elaborar, tramitar y registrar contratos de licencia y licencias de cualesquiera clases; intervenir como demandante o como mandado en cualquier instancia y recurso ante cualquier juez, corporación, funcionario público o autoridad en acciones judiciales, administrativas y de policía tales como: oposiciones al registro de marcas; acciones de caducidad, cancelación y nulidad; acciones reivindicatorias, acciones derivadas de la obtención o explotación de licencias; acciones de competencia desleal; demandas penales; acciones de indemnización de perjuicios, reclamos y observaciones a solicitudes de patentes, diseños industriales, modelos de utilidad, en el ejercicio de medidas cautelares y en otras acciones o medidas similares.

A este efecto, lo(s) faculto(amos) para elevar solicitudes, formular descripciones, enmiendas, protestas, declaraciones, oposiciones, cancelaciones, nulidades, apelaciones y reclamos; pagar impuestos, cuotas y gravámenes prescritos por la ley; renunciar o desistir a derechos concedidos o en curso de concesión; recibir toda clase de documentos y valores, dando el descargo respectivo, y, en general, para dar ante dichas autoridades todos los pasos necesarios al efecto indicado y tomar todas las medidas que creyeren conducentes al resguardo de mis (nuestros intereses), con todas las demás facultades legales necesarias.

Este poder comprende la facultad de ratificar o confirmar en mi (nuestro) nombre lo actuado así como la facultad de desistir, transigir, comprometer, y la de sustituirlo en todo o en parte y revocar sustituciones. Asimismo nombro(amos) a: **JUAN PABLO CADENA SARMIENTO y/o CARLOS H. PALACIO EASTMAN y/o MATIN E. TORRES CARDOZO**, domiciliado(s) en la Carrera 7 No. 16-56 Piso 9, mis (nuestros) apoderados en Colombia, con facultades para recibir notificaciones y designar apoderados judiciales o extrajudiciales.

POUVOIR

Je (nous) **SOCIETE DE TECHNOLOGIE MICHELIN**,
domicilié 23 rue Breschet
F-63000 CLERMONT-FERRAND - France

Nomme (nommons): **JUAN PABLO CADENA SARMIENTO et/ou CARLOS H. PALACIO EASTMAN et/ou MATIN E. TORRES CARDOZO**, de Bogotá, Colombie, mandataires vrais et légaux avec pouvoir spécial, ample et suffisant, pour demander aux bureaux et autorités administratives, judiciaires et de police colombiennes, dans toute instance ou recours, l'obtention de brevets d'invention, dépôts de marques, dessins industriels, modèles d'utilité, dépôts de noms commerciaux, slogans commerciaux et enseignes, dépôts de droits d'auteur et contrats versant sur lesdits droits, obtention de certificats d'obtentor de variétés végétales, ainsi que ses prorogations, rénovations, annotations de cession, changements de nom et/ou domicile; élaborer, transmettre et déposer des contrats de licence et licences de toute sorte; intervenir comme requérant ou comme défendeur dans toute instance ou recours devant n'importe quel juge, corporation, fonctionnaire public ou autorité en actions judiciaires, administratives et de police telles que: oppositions au dépôt de marques; actions de déchéance, annulation et nullité, actions de revendication, actions dérivées de l'obtention ou exploitation des licences; actions de concurrence déloyale, requêtes pénales; actions d'indemnisation de préjudices, réclamations et observations à des demandes de brevets, dessins industriels, modèles d'utilité, dans l'exercice des mesures préventives et dans d'autres actions ou mesures similaires.

À cet effet, je (nous) l'(les) autorise (autorisons) à faire des requêtes, formuler des descriptions, amendements, protestes, déclarations, oppositions, annulations, nullités, recours en appel et réclamations; payer impôts, frais et charges prescrits par la loi; renoncer ou se désister de droits accordés ou en cours de l'être; recevoir toute sorte de documents et valeurs, en faisant la décharge respective, et, en général, à réaliser devant lesdites autorités toutes les démarches nécessaires à cet effet, et à prendre toutes les mesures qu'il considéreront appropriées à la sauvegarde de mes (nos) intérêts, avec toute autre faculté légale nécessaire.

Ce pouvoir comprend la faculté de ratifier ou confirmer en mon (notre) nom tout acte ou procédure, ainsi que la faculté de renoncer, transiger, compromettre, et celle de substituer ce pouvoir en tout ou en part, et de révoquer les substitutions. De même je (nous) nomme (nommons) **JUAN PABLO CADENA SARMIENTO et/ou CARLOS H. PALACIO EASTMAN et/ou MATIN E. TORRES CARDOZO**, domicilié (s) à la Carrera 7 No. 16-56, Piso 9, mes (nos) mandataires en Colombie, avec facultés pour recevoir des notifications et désigner des mandataires judiciaires ou extrajudiciaires.

Fait et signé

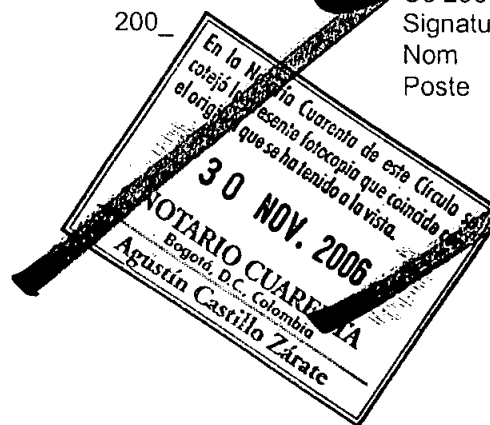
Ce 23e jour de mai 2006

Signature

Nom Jean-Dominique SENÁRD

Poste Fondé de Pouvoir/Apoderato

Otorgado y firmado en
hoy de de 200
Firma
Nombre
Cargo



CERTIFICADO NOTARIAL (SOCIEDAD)

CERTIFICAT DE NOTAIRE (SOCIÉTÉ)

Hoy de
personalmente compareció ante mí

de

Ce 23e jour de mai 2006
a comparu personnellement devant moi
Jean-Dominique SENARD

a quien conozco, y de quien me consta que firmó el anterior
documento, debidamente juramentado declaró y dijo que él
(ella) es

que je connais, et que je sais être la personne qui a
signé le document précédent, et je déclare et dis sous
serment qu' il est Fondé de Pouvoir de la Société dite

de

- SOCIETE DE TECHNOLOGIE MICHELIN

Sociedad legalmente constituida para un período de
duración que aún no ha terminado; que el declarante está
autorizado por dicha compañía para conferir este poder;
que el sello estampado por él al pie de tal poder, en
nombre y representación de la expresada compañía, es el
sello oficial de ella; y que el objeto para el cual se confiere
este instrumento está comprendido dentro del objeto
social de la sociedad.

Qui est une société légalement constituée et dont le
terme n' a pas expiré; que le « déclarant » est
autorisé par ladite Compagnie à signer cette cession ;
que le nom écrit à la machine à écrire par le déposant
est celui de ladite Compagnie ; et que l' objet pour
lequel cette cession est signée est inclus dans les
objets inscrits dans les buts de la compagnie.

El suscrito Notario hace constar que tuvo a la vista las
pruebas de la existencia de la sociedad.

Le Notaire soussigné certifie qu' il a vu les documents
qui prouvent l' existence de cette Compagnie

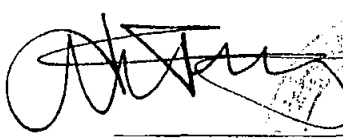
Estado de
con fecha

Clermont-Ferrand, France
En date du 16 janvier 2006.

y que quien confiere el presente poder es su representante.

et que la personne qui a accepté cette cession est son
représentant.


Notario Público (sello)


Notaire Public (sceau)

LEGALIZACION POR APOSTILLA ES REQUERIDA.

LEGALISATION PAR APOSTILLE REQUISE



APOSTILLE

(Convention de La Haye du 5 octobre 1961)

1. République française

Le présent acte public

2. a été signé par

3. agissant en qualité de

4. est revêtu du sceau/timbre de

Morane à guzlat 63
M. Morane
M. Morane

5. a RIOM

6. le 1 - JUIN 2006

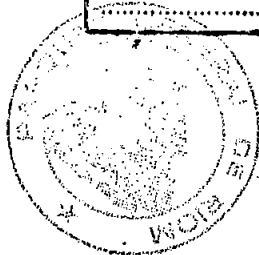
7. par le Procureur général près la Cour d'appel d'

8. sous n°

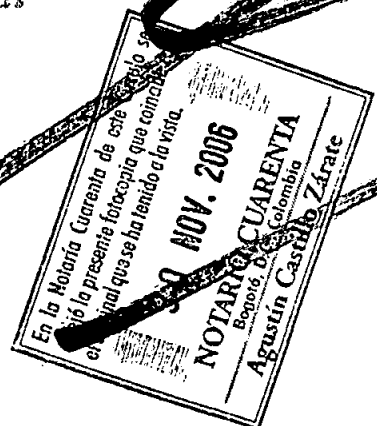
262

9. Sceau :

10. Signature :



Gérard PITELIS
Avocat Général



TRADUCCION AL ESPAÑOL del Documento de Poder otorgado por
SOCIETE DE TECHNOLOGIE MICHELIN, domiciliada en **23 rue Breschet**,
F-63000 CLERMONT-FERRAND, Francia.

APOSTILLA

(Convención de La Haya del 5 de octubre de 1961)

1. Republica Francesa

El presente documento público

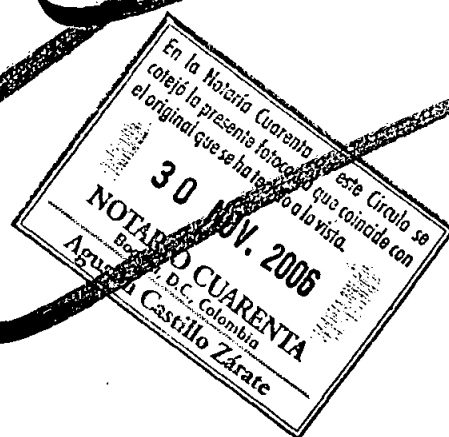
2. ha sido firmado por Lic. Montagnon
3. Actuando en capacidad de notario público
4. lleva el sello/ timbre de Lic. Montagnon, notario de Gerzat 63

Certificado

5. en RIOM
6. el 1 de junio de 2006
7. por el Procurador General de la Corte de Apelaciones
8. bajo el n° 262
9. Sello

10. Firma

(Firma)



Brigard & Castro

BOGOTA - COLOMBIA

PODER

Yo (nosotros) **MICHELIN RECHERCHE ET TECHNIQUE S.A.**, domiciliado(s) en Route Louis Braille 10 et 12 CH-1763 GRANGES-PACCOT - Suiza

Nombro(amos) a: **JUAN PABLO CADENA SARMIENTO y/o CARLOS H. PALACIO EASTMAN y/o MATIN E. TORRES CARDOZO**, de Bogotá, Colombia, apoderados verdaderos y legales con poder especial, amplio y suficiente, para recabar de las oficinas y autoridades colombianas administrativas, judiciales y de policía, en cualquier instancia o recurso, la obtención de patentes de invención, registros de marcas, diseños industriales, modelos de utilidad, depósitos de nombres comerciales, lemas comerciales y enseñanzas, registros de derechos de autor y contratos sobre los mismos, obtención de certificados de obtentor de variedades vegetales, así como sus prórrogas, renovaciones, anotaciones de traspaso, cambios de nombre y/o domicilio; elaborar, tramitar y registrar contratos de licencia y licencias de cualesquiera clases; intervenir como demandante o como demandado en cualquier instancia y recurso ante cualquier juez, corporación, funcionario público o autoridad en acciones judiciales, administrativas y de policía tales como: oposiciones al registro de marcas; acciones de caducidad, cancelación y nulidad; acciones reivindicatorias, acciones privadas de la obtención o explotación de licencias; acciones de competencia desleal; demandas penales; acciones de indemnización de perjuicios, reclamos y observaciones a solicitudes de patentes, diseños industriales, modelos de utilidad, en el ejercicio de medidas cautelares y en otras acciones o medidas similares.

A este efecto, lo(s) faculto(amos) para elevar solicitudes, formular descripciones, enmiendas, protestas, declaraciones, oposiciones, cancelaciones, nulidades, apelaciones y reclamos; pagar impuestos, cuotas y gravámenes prescritos por la ley; renunciar o desistir a derechos concedidos o en curso de concesión; recibir toda clase de documentos y valores, dando el descargo respectivo, y, en general, para dar ante dichas autoridades todos los pasos necesarios al efecto indicado y tomar todas las medidas que creyeran conducentes al resguardo de mis (nuestros intereses), con todas las demás facultades legales necesarias.

Este poder comprende la facultad de ratificar o confirmar en mi (nuestro) nombre lo actuado así como la facultad de desistir, transigir, comprometer, y la de sustituirlo en todo o en parte y revocar sustituciones. Asimismo nombro(amos) a: **JUAN PABLO CADENA SARMIENTO y/o CARLOS H. PALACIO EASTMAN y/o MATIN E. TORRES CARDOZO**, domiciliado(s) en la Carrera 7 No. 16-56 Piso 9, mis (nuestros) apoderados en Colombia, con facultades para recibir notificaciones y designar apoderados judiciales o extrajudiciales.

POUVOIR

Je (nous) **MICHELIN RECHERCHE ET TECHNIQUE S.A.**, domicilié (s) à Route Louis Braille 10 et 12 CH-1763 GRANGES-PACCOT - Switzerland

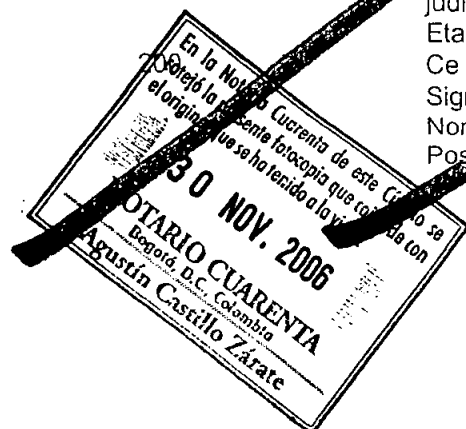
Nomme (nommons): **JUAN PABLO CADENA SARMIENTO et /ou CARLOS H. PALACIO EASTMAN et/ou MATIN E. TORRES CARDOZO**, de Bogotá, Colombie, mandataires vrais et légaux avec pouvoir spécial, ample et suffisant, pour demander aux bureaux et autorités administratives, judiciaires et de police colombiennes, dans toute instance ou recours, l'obtention de brevets d'invention, dépôts de marques, dessins industriels, modèles d'utilité, dépôts de noms commerciaux, slogans commerciaux et enseignes, dépôts de droits d'auteur et contrats versant sur lesdits droits, obtention de certificats d'obtentor de variétés végétales, ainsi que ses prorogations, renouvellements, annotations de cession, changements de nom et/ou domicile; élaborer, transmettre et déposer des contrats de licence et licences de toute sorte; intervenir comme requérant ou comme défendeur dans toute instance ou recours devant n'importe quel juge, corporation, fonctionnaire public ou autorité en actions judiciaires, administratives et de police telles que: oppositions au dépôt de marques; actions de déchéance, annulation et nullité, actions de revendication, actions dérivées de l'obtention ou exploitation des licences; actions de concurrence déloyale, requêtes pénales; actions d'indemnisation de préjudices, réclamations et observations à des demandes de brevets, dessins industriels, modèles d'utilité, dans l'exercice des mesures préventives et dans d'autres actions ou mesures similaires.

À cet effet, je (nous) l'(les) autorise (autorisons) à faire des requêtes, formuler des descriptions, amendements, protestes, déclarations, oppositions, annulations, nullités, recours en appel et réclamations; payer impôts, frais et charges prescrits par la loi; renoncer ou se désister de droits accordés ou en cours de l'être; recevoir toute sorte de documents et valeurs, en faisant la décharge respective, et, en général, à réaliser devant lesdites autorités toutes les démarches nécessaires à cet effet, et à prendre toutes les mesures qu'il considéreront appropriées à la sauvegarde de mes (nos) intérêts, avec toute autre faculté légale nécessaire.

Ce pouvoir comprend la faculté de ratifier ou confirmer en mon (notre) nom tout acte ou procédure, ainsi que la faculté de renoncer, transiger, compromettre, et celle de substituer ce pouvoir en tout ou en part, et de révoquer les substitutions. De même je (nous) nomme (nommons) **JUAN PABLO CADENA SARMIENTO et/ou CARLOS H. PALACIO EASTMAN et/ou MATIN E. TORRES CARDOZO**, domicilié (s) à la Carrera 7 No. 16-56, Piso 9, mis (nos) mandataires en Colombie, avec facultés pour recevoir des notifications et désigner des mandataires judiciaires ou extrajudiciaires.

Etabli et signé
Ce 20^e jour de juin 2006
Signature Philippe BERTHER
Nom Philippe BERTHER
Poste Président du Conseil d'Administration
Presidente del Consejo de Administracion

Otorgado y firmado en
hoy de de
Firma
Nombre
Cargo



30 000 000
30 000 000
30 000 000

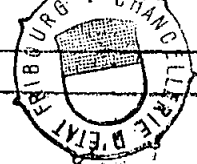
APOSTILLE

(Convention de La Haye du 5 octobre 1961)

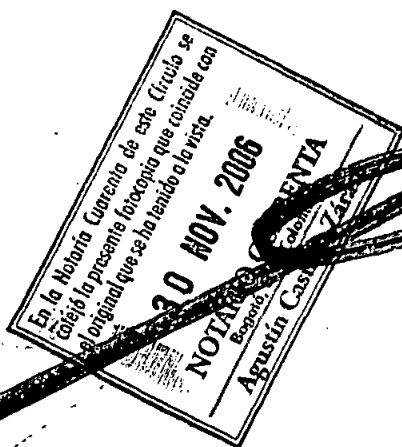
1. Pays : Suisse
- Le présent acte public
2. a été signé par De Olivier Andrey
3. agissant en qualité de notaire
4. est revêtu du sceau/timbre de Olivier Andrey, notaire
5. à Tribourey
6. le 21 JUIN 2006
7. par Alexandra Thuthausen
8. sous No A572 Fr. 35

9. Sceau/timbre :

10. Signature :



Alexandra Thuthausen



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MICHELIN RECHERCHE ET TECHNIQUES S.A., domiciliada en **Route
Louis Braille 10 et 12, CH-1763 GRANGES-PACCOT, Suiza..**

APOSTILLA

(Convención de La Haya del 5 de octubre de 1961)

1. País: Suiza

El presente documento público

2. ha sido firmado por Lic. Olivier Andrey

3. Actuando en capacidad de notario público

4. lleva el sello/ timbre de Lic. Olivier Andrey, notario

Certificado

5. en Friburg

6. el 21 de junio de 2006

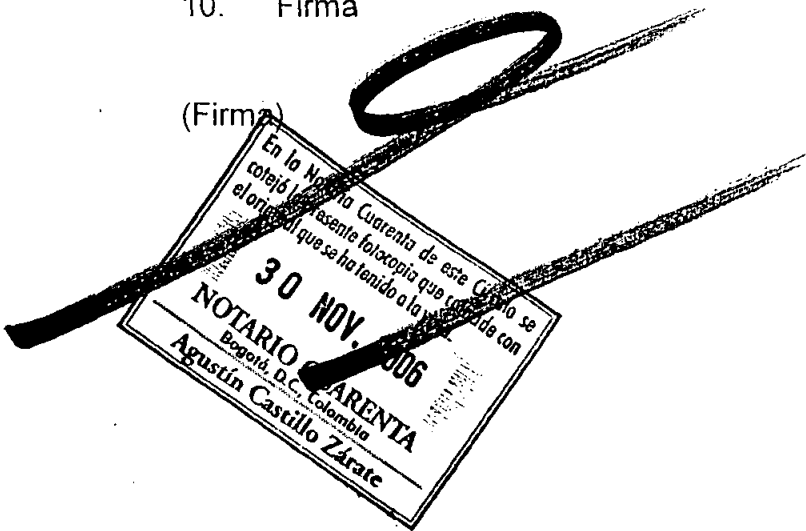
7. por el Alexandra Thathauser

8. bajo el n° 1077

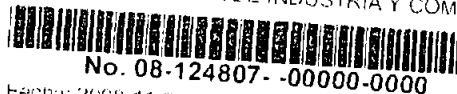
9. Sello

10. Firma

(Firma)



SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO



No. 08-124807- -00000-0000

Fecha: 2008-11-24 16:25:01 Dep. 2020 NULCRLACIONI
Tra 11 PATENTE Y Lvs 378 FASE NACIONAL
Act 411 PRESENTACION Folios 58

210
37A

REQUISITOS MINIMOS PARA ADMISION A TRAVIJE
PCT

PATENTE DE INVENCION



MODELO DE UTILIDAD []

- ◆ Indicación de que se solicita la concesión de una patente []
- ◆ Datos de identificación del solicitante o de la persona que presenta la solicitud []
- ◆ Descripción de la invención []
- ◆ Dibujos de ser estos pertinentes []
- ◆ Comprobante de pago de las tasas establecidas []

COMPLETA []

INCOMPLETA []

DISEÑO INDUSTRIAL []

- ◆ Indicación de que se solicita el registro de Diseño Industrial []
- ◆ Datos de identificación del solicitante o de la persona que presenta la solicitud []
- ◆ Representación gráfica y fotográfica del Diseño Industrial o muestra del material que incorpora el diseño []
- ◆ Comprobante de pago de las tasas establecidas []

COMPLETA []

INCOMPLETA []

ESQUEMA DE TRAZADO []

- ◆ Indicación de que se solicita el registro de un Esquema de Trazado []
- ◆ Datos de identificación del solicitante o de la persona que presenta la solicitud []
- ◆ Representación gráfica del esquema trazado []
- ◆ Comprobante de pago de las tasas establecidas []

COMPLETA []

INCOMPLETA []

Sandra Rodríguez

Firma Responsable

Fecha No. 24-28

Carrera 13 No. 27-00 Piso 5, 7 y 10
Conmutador: 3 82 08 40
Fax: 350 52 20
E-mail: info@slc.gov.co
www.slc.gov.co
Bogotá, D.C., Colombia

60

REPUBLICA DE COLOMBIA
SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

Bogotá,
2020

Doctor(a)
CADENA SARMIENTO JUAN PABLO
Apoderado(a) y/o Representante de
SOCIETE DE TECHNOLOGIE MICHELIN
MICHELIN RECHERCHE ET TECHNIQUE S.A

REFERENCIA	Radicación No.	8 124807
	Solicitud internacional	PCT/US2007/078975
	Fecha inicio fase nacional	20/04/2009
	Trámite	11
	Evento	378
	Actuación	430
	Oficio No.	- 5097

Como resultado del examen de forma, realizado con fundamento en el artículo 38 de la Decisión 486 de la Comisión de la Comunidad Andina, artículo 27 del Tratado de Cooperación en Materia de Patentes (PCT), regla 51 bis del Reglamento y Circular Única de la Superintendencia de Industria y Comercio, se le comunica que:

1. La solicitud no contiene la copia del documento en que consta la cesión del derecho a la patente del inventor al solicitante o a su causante, conforme a lo establecido por el artículo 26 literal k) de la Decisión 486 de la Comisión de la Comunidad Andina. Cuando se trate de documentos otorgados en el extranjero, estos deberán legalizarse de conformidad con lo dispuesto por los artículos 259 y 260 del Código de Procedimiento Civil. Cuando se trate de las declaraciones a que hace referencia la Regla 4.17 ii) del Tratado de Cooperación en Materia de Patentes PCT., el alcance de las tales declaraciones se determinará según indiquen claramente una cesión de derechos del inventor al solicitante o su causante, de conformidad con lo dispuesto en el numeral 5.2.15 del Capítulo Quinto, Título X de la Circular Única de Superintendencia de Industria y Comercio.

En cumplimiento de lo dispuesto por el artículo 39 de la Decisión 486, se le requiere para que dentro del término de dos meses siguientes a la fecha de notificación del presente oficio, complete los requisitos anteriormente enunciados. En caso de no dar cumplimiento al presente requerimiento, la solicitud se considerará abandonada y perderá su prelación.

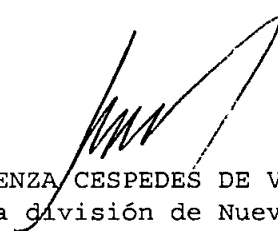
Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Unica No.10 de 2001.

Continúa en la página siguiente...

d

REPUBLICA DE COLOMBIA
SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

Radicación No.: 8 124807


ALIX CARMENZA CESPEDÉS DE VERGEL
Jefe de la división de Nuevas Creaciones

El anterior requerimiento fue notificado por fijación en lista de
fecha 08 MAYO 2009
adpall