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(71) Applicant: BRIDGESTONE EUROPE NV/SA [BE/BE];

Kleine Kloosterstraat 10, 1932 Zaventem (BE).

(72) Inventors: REGNO, Riccardo; Bridgestone Europe NV/  
SA - Italian Branch, Via del fosso del Salceto 13/15, 00128

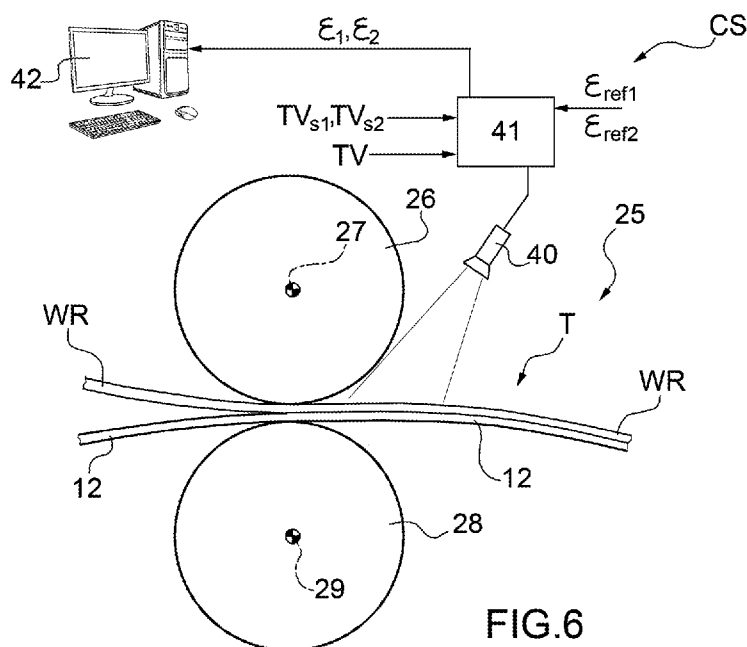
Roma (IT). STELLA, Luca; Bridgestone Europe NV/SA -  
Italian Branch, Via del Fosso del Salceto 13/15, 00128 Ro-  
ma (IT).

(74) Agent: MARCHETTI, Alessio; Bridgestone Europe NV/  
SA - Italian Branch, Via del Fosso del Salceto 13/15, 00128  
Roma (IT).

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AND METHOD FOR THE CONSTRUCTION OF SAID PNEUMATIC TYRE



(57) Abstract: A method for the production of a fabric (T) for the manufacture of a ply (10; 9; 3) of a pneumatic tyre comprising a step of supplying a warp of cords (WR) and an individual green rubber belt (12) which is exclusively supplied above or below the plurality of warp cords (WR); a production step of the rubber belt (12) such that a first surface (17, 18) of the green rubber belt (12) is partially free from the green rubber belt (12); and an optical control step of the rubber belt (12) that is subsequent to the production step, wherein an indicator (S<sub>1</sub>, S<sub>2</sub>) of the adhesiveness of the rubber belt (12) is calculated; and an adjustment step of the production step as a function of said indicator (S<sub>1</sub>, S<sub>2</sub>).



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METHOD FOR THE PRODUCTION OF A FABRIC FOR THE MANUFACTURE OF A PLY OF A PNEUMATIC TYRE AND METHOD FOR THE CONSTRUCTION OF SAID PNEUMATIC TYRE

### DESCRIPTION

#### TECHNICAL SECTOR

The present invention relates to a method for the production of a fabric for the manufacture of a ply of a pneumatic tyre and a method for the construction of said pneumatic tyre.

#### PRIOR ART

As known, a pneumatic tyre comprises a toroidal carcass, which has two annular beads and which supports an annular tread. A tread belt is interposed between the carcass and the tread which comprises a number of tread plies. Each tread ply is manufactured from a fabric defined by a warp of cords, preferably made of steel, that are arranged alongside one another with a determined pitch. According to an initial variant, the cords are embedded within a rubber belt. According to a further variant, a rubber strip (referred to as "gum strip") is interposed between the two tread plies.

Above the tread belt (and therefore between the tread belt and the tread) there is a reinforcing layer, which is commonly referred to as a "cap ply" and it is formed by a continuous green rubber ribbon, internally reinforced with cords, which is circumferentially and spirally wrapped over the carcass of the pneumatic tyre and above the tread belt following a helical trend (in such a way that the ribbon slightly overlaps the previously applied ribbon) and which has the function of protecting and containing the tread

plies. Alternatively, the reinforcing layer is defined by two reinforcing strips, which are commonly referred to as a "cap strip" and which are exclusively arranged in the outer overlapping areas of the tread on the tread belt. Or again, the reinforcing layer can be defined by the continuous green rubber ribbon, internally reinforced with cords, which is longitudinally wrapped above the tread belt and by two cap strips arranged exclusively in the outer overlapping areas of the tread on the tread belt above the continuous green rubber ribbon.

Further alternative embodiments are possible; for example, it is possible to provide two overlapping reinforcing layers (i.e. two continuous green rubber ribbons longitudinally wrapped above the tread belt and overlapping) or a continuous green rubber ribbon wrapped longitudinally above the tread belt and interposed between two cap strips arranged at the axial ends of the tread plies.

The carcass supports a pair of sidewalls arranged between the tread and the beads. An innerliner is arranged within the body ply which is airtight, constitutes an inner lining and has the function of retaining the air within the pneumatic tyre in order to maintain the inflation pressure of the pneumatic tyre itself over time.

The ribbon of the reinforcing layer is made from a fabric that is composed by a warp of cords arranged alongside one another with a determined pitch and normally manufactured from nylon or polyester. The warp cords are completely embedded within a green rubber belt. That is to say that the entire cylindrical outer surface of each warp cord is surrounded by green rubber.

The process for the production of the reinforcing layer provides for the supplying of two rubber belts, wrapped in coils, an upper rubber belt and a lower rubber belt, and the

warp cords to a calendering machine. The calendering machine encapsulates the warp cords between the two rubber belts, forcefully pushing the two rubber belts against the warp cords, in such a way as to incorporate (embed) the warp cords within the rubber belts and therefore to obtain the fabric that constitutes the reinforcing layer by means of the plastic deformation of the rubber belts that are penetrated by the warp cords.

Typically, the calendering machine comprises a frame, at least one fixed upper roller (preferably two upper rollers) mounted swiveling on the frame and at least one movable lower roller (preferably two lower rollers) mounted swiveling on the frame. The rubber belts and the warp cords are supplied between the upper and lower rollers, which are driven by their respective drive motors. The rubber belts are applied to the respective opposite sides of the warp cords. Advantageously, the rollers are heated in order to improve the plastic deformation of the respective rubber belt. Once the calendering process has been completed, the fabric is cut into the desired dimensions by means of two different cutting stations in order to obtain the ribbon of the required thickness.

In recent years, the pneumatic tyre development has aimed to reduce pneumatic tyre production costs and the weight of pneumatic tyres with the same performance.

Therefore, reinforcing layers without the rubber belt and made from a fabric, composed by a warp of cords arranged alongside one another with a determined pitch, and a weft of cords arranged alongside one another with a determined pitch, and which are transverse to the warp cords were proposed. However, a reinforcing layer of the kind just described, whilst allowing a reduction in weight, makes the adhesion of the cords to the surrounding rubber layers and

the overlapping of the cords (warp or weft) very critical in the construction of all variants of the reinforcing layer described in the preceding discussion, and therefore it leads to a worsening in the performance.

In order to reduce production costs and the weight of pneumatic tyres with the same performance, several fabrics were proposed and they comprise a green rubber belt with a first surface and a second surface opposite to one another; and a plurality of warp cords arranged alongside one another with a determined pitch and that are at least partially embedded within the green rubber belt; wherein a cylindrical outer surface of each warp cord is arranged at a certain non-zero distance from the first surface of the green rubber belt and is partially free from the green rubber belt at the second surface of the green rubber belt.

However, it has been experimentally verified that, at the second surface of the rubber belt, it is often not possible to obtain sufficient levels of adhesion in order to ensure the adhesion of the rubber belt to the other components of the pneumatic tyre.

#### DESCRIPTION OF THE INVENTION

The aim of the present invention is to provide a method for the production of a fabric for the manufacture of a ply of a pneumatic tyre that is free from the disadvantages of the state of the art and, especially, that is easy and inexpensive to implement.

A further aim of the present invention is to provide a method for the construction of a pneumatic tyre that is free from the disadvantages of the state of the art and, especially, that is easy and inexpensive to implement.

According to the present invention, a method for the

production of a fabric for the construction of a ply of a pneumatic tyre and a method for building the pneumatic tyre are provided according to what is set within the attached claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described with reference to the attached drawings, illustrating, but not limited to, an exemplary embodiment, wherein:

- Figure 1 is a schematic cross-section, with parts removed for clarity, of a pneumatic tyre manufactured in accordance with the present invention;
- Figure 2 is an enlarged scale view of a detail of the pneumatic tyre of Figure 1;
- Figure 3 is a prospective view and with parts removed for clarity of the pneumatic tyre of Figure 1;
- Figure 4 is a prospective view of a reinforcing layer of the pneumatic tyre of Figure 1;
- Figure 5 is a front view of a detail of the reinforcing layer of Figure 4;
- Figures 6 and 7 are schematic views, side and front respectively, of a first variant of a step of the production process for the reinforcing layer of Figures 4 and 5;
- Figures from 8a to 8d show images of samples of a rubber belt manufactured by means of the production process in Figure 6; and
- Figure 9 is a schematic view of a second variant of a step of the production process for the reinforcing layer of Figures 4 and 5.

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#### PREFERRED EMBODIMENTS OF THE INVENTION

In Figure 1, number 1 denotes a whole a pneumatic tyre

comprising a toroidal carcass 2, consisting of a single body ply 3. The body ply 3 is manufactured from a rubberized fabric defined by a reinforcing warp of cords that preferably extend in a radial direction with respect to the axis of rotation of the pneumatic tyre 1.

On the opposite sides of the carcass 2, two annular beads 4 are arranged, each of which has a bead core 5 that is reinforced with a number of revolutions of a metallic wire and a bead filler 6. The body ply 3 extends up to the bead cores 5; according to a variant, the body ply 3 is partially folded onto itself (presenting two mutually overlapping layers on the lateral sides) in such a way as to surround the two bead cores 5.

The carcass 2 supports an annular tread 7; between the carcass 2 and the tread 7, a tread belt 8 is interposed, which comprises two tread plies 9. Each tread ply 9 is manufactured from a fabric defined by a warp of cords, preferably made of steel (not shown), and preferably arranged alongside one another with a determined pitch. According to an initial variant, the cords are embedded within a rubber belt. According to a further variant, a rubber strip 9\* (referred to as "gum strip" and shown in Figure 3) is interposed between the two tread plies 9.

According to a first variant, the cords of the tread plies 9 are preferably made from steel and extend with an angle of inclination determined by an equatorial plane of the pneumatic tyre 1, preferably with angles of equal inclination, but of opposite signs in relation to one another.

Above the tread belt 8 (and therefore between the tread belt 8 and the tread 7) there is a reinforcing layer 10, which is commonly referred to as a "cap ply" and which constitutes a continuous green rubber ribbon 11, internally

reinforced with cords, which is longitudinally wrapped over the tread belt 8 and which has the function of protecting and containing the tread plies 9. According to a preferred variant, the reinforcing layer 10 (i.e., the continuous green rubber ribbon 11) extends in such a way as to cover the entire tread belt 8.

According to a further variant (not shown), the reinforcing layer 10 is defined by two reinforcing strips, which are commonly referred to as a "cap strip" and which are exclusively arranged in the outer areas where the tread 7 overlaps the tread belt 8. In other words, the reinforcing layer 10 is at least partially absent at the central zone where the tread 7 overlaps the tread belt 8.

According to a further variant (not shown), the reinforcing layer 10 is defined by the continuous green rubber ribbon 11 which is internally reinforced with cords and which is longitudinally wrapped over the tread belt 8 and which extends in such a way as to completely cover the tread belt 8. In addition to the continuous green rubber ribbon 11 two cap strips are provided for, which are exclusively arranged at the outer areas where the tread 7 overlaps the tread belt 8, above the continuous green rubber ribbon 11.

Further alternative embodiments are possible; for example, it is possible to provide two reinforcing layers 10 (i.e. two continuous green rubber ribbons 11 longitudinally wrapped above the tread belt 8 and overlapping) or a continuous green rubber ribbon 11 wrapped longitudinally above the tread belt 8 and interposed between two cap strips arranged at the axial ends of the tread plies 9.

The reinforcing layer 10 is formed by a ribbon 11 (shown in Figures 3 and 4) which is spirally wound

circumferentially around the carcass 2 of the pneumatic tyre 1 with a helical shape. As shown in Figure 4, the ribbon 11 is made from a fabric T defined by a plurality of warp cords WR arranged alongside one another with a determined pitch P. The warp cords WR are preferably made of nylon or polyester or from another synthetic textile fiber (for example Kevlar).

It is important to highlight that the fabric T lacks a weft of cords arranged alongside one another with a determined pitch and transverse to the warp cords WR; the fabric T consists solely and uniquely of warp cords WR (the fabric T is comprised solely and uniquely of the warp cords WR).

The warp cords WR are at least partially embedded within a green rubber belt 12, i.e. a variable width portion of the outer cylindrical surface S of each warp cord WR is surrounded by the rubber belt 12.

In particular, as best illustrated in Figure 5, the rubber belt 12 surrounds at least half of the outer cylindrical surface S of each warp cord WR. In particular, for each warp cord WR, the rubber belt 12 surrounds a surface S\* which is equal to a fraction, between 50% to 99%, of the outer cylindrical surface S. In other words, the penetration of the warp cords WR into the rubber belt is variable. In this way, each warp cord WR is divided into a portion CP which is covered with rubber and a raised portion NP (non-zero) without the rubber coating.

In Figure 5, the letter D denotes a diameter identified by the cross-section of each warp cord WR; the diameter D divides each warp cord WR into an upper semicord  $HWR_U$  and a lower semicord  $HWR_L$ . According to a first variant shown in Figure 5, the rubber ribbon 12 completely surrounds the lower semicord  $HWR_L$  and, preferably, exceeds

the diameter  $D$ , also partially surrounding the upper semicord  $HWR_U$ .

In the same way, according to another variant, the rubber ribbon 12 completely surrounds the upper semicord  $HWR_U$  and, preferably, exceeds the diameter  $D$ , also partially surrounding the lower semicord  $HWR_L$ .

It has been experimentally verified that the best results are obtained when the rubber ribbon 12 surrounds a surface  $S^*$  that is equal to at least 70% of the outer cylindrical surface  $S$  of each warp cord  $WR$ . Preferably, the rubber belt 12 surrounds a surface  $S^*$  which is equal to a fraction, between 70% to 90%, of the outer cylindrical surface  $S$  of each warp cord  $WR$ .

The rubber ribbon 12 is divided into a base portion 13 and by a plurality of appendages 14 which are arranged between two adjacent warp cords  $WR$ . The appendages 14 are defined by two equal lateral surfaces 15 having a curved profile (circular) that surrounds a respective warp cord  $WR$  and by a substantially flat upper surface 16 interposed between two warp cords  $WR$  arranged alongside one another with a determined pitch  $P$ .

The ribbon 11 is provided with a substantially flat lower surface 17 defined by the base portion 13 of the rubber belt 12; furthermore, the ribbon 11 is provided with an upper surface 18, having an irregular profile defined by the alternation of the external surfaces 19 of the emerged portions  $NP$  and devoid of the rubber coating of the warp cords  $WR$  where the upper surfaces 16 are interposed.

It should be emphasized that the outer cylindrical surface  $S$  of each warp cord  $WR$  is arranged at a certain non-zero distance  $D'$  from the lower surface of the rubber belt 12. Similarly, the outer cylindrical surface  $S$  of each warp cord  $WR$  is partially free from the rubber belt 12 at

the upper surface 18 of the rubber belt 12. In the case of a minimum width (but not zero) of the external surfaces 19 of the raised portions NP, the rubber belt 12 can be substantially arranged flush with the outer cylindrical surface S of each warp cord WR.

According to what is shown in Figures 1 and 2, between the body ply 3 and the outer ends of the tread belt 8, two tread ply inserts 20 (TPI) are interposed, having the function of a cushion. According to the embodiment shown in the attached Figures, two opposing lateral ends of the body ply 3 are closely arranged below the tread belt 8 and more internally than the interior sidewalls (i.e. pointing towards the center of the pneumatic tyre 1) of the tread ply inserts 20.

Within the body ply 3, over the entire available surface it is arranged an innerliner 21 which is airtight, constitutes an inner lining and has the function of maintaining the air within the pneumatic tyre 1 in order to retain the inflation pressure of the pneumatic tyre 1 itself over time.

The body ply 3 supports a pair of sidewalls 22 (SW) arranged externally to the body ply 3, between the tread 7 and the beads 4. According to the embodiment shown in Figures 1 and 2, the side walls 22 are partially and externally covered by mini side walls 23 (MSW). In particular, the sidewalls 22 are arranged below the tread 7, whilst the mini sidewalls 23 are arranged at the same level as the tread 7, and therefore, in a contact zone, they are arranged side by side with the tread 7 itself.

Finally, the body ply 3 supports a pair of abrasion gum strips 24 (AGS) arranged externally below the sidewalls 22 and at the beads 4.

According to a first variant, the fabric T, composed

by a warp of warp cords WR arranged alongside one another with a determined pitch P and at least partially embedded within a green rubber belt 12 described in the preceding discussion, is used (also or only) for the manufacture of the body ply 3. According to alternative embodiments, the body ply 3 is applied with the warp cords WR facing radially inwards or towards the outside of the pneumatic tyre 1.

According to a first variant, the warp cords WR used for the manufacturing of the body ply 3 are made of a metallic material.

According to a second variant, the warp cords WR used for the manufacturing of the body ply 3 are made of nylon, rayon or polyester or of another synthetic textile fiber.

Alternatively, the fabric T, defined by a plurality of warp cords WR, arranged alongside one another with a determined pitch P and at least partially embedded within a green rubber belt 12 described in the preceding discussion, is used (also or only) for the manufacturing of the tread plies 9. According to alternative embodiments, the tread plies 9 are applied with the warp cords WR facing radially inwards or towards the outside of the pneumatic tyre 1. Preferably, the warp cords WR used for the manufacturing of the tread plies 9 are made of steel. Alternatively, the warp cords WR used for the manufacturing of the tread plies 9 are made of nylon or polyester or of another synthetic textile fiber.

Alternatively, the fabric T, defined by a plurality of warp cords WR, arranged alongside one another with a determined pitch P and at least partially embedded within a green rubber belt 12 described in the preceding discussion, is used (also or only) for the manufacturing of a protective anti-wear ply (not shown), also known as a

*canvas chafer*. The protective anti-wear plies are wrapped around at the beads 4. Preferably, the protective anti-wear plies are applied with the warp cords WR facing towards the beads 4 (i.e. facing radially towards the outside of the pneumatic tyre 1). Preferably, the warp cords WR used for the manufacturing of the protective anti-wear plies are made of nylon or polyester or of another synthetic textile fiber.

The following section describes the method for the production of the reinforcing layer 10.

A set of warp cords WR alongside one another with a determined pitch P is produced during a processing step independent from the process for the formation of the semi-finished pneumatic tyre 1.

Similarly, the rubber belt 12 is produced during an independent processing step. Advantageously, the rubber belt 12 can be obtained by means of a calendering process for the production of a continuous film of the required thickness. During production, the rubber belt 12 is conveyed between pairs of rotating rollers 26, 28, with parallel and heated axes 27, 29, that crush it until the required thickness is obtained.

As shown in Figures 6 and 7, the rubber belt 12 and the warp of warp cords WR are supplied to a calendering machine 25 and wrapped into coils. In particular, the warp cords WR are supplied parallel to the direction of the rubber belt 12 travel. The calendering machine presses the rubber belt 12 against the warp cords WR in order to obtain the fabric T that constitutes the reinforcing layer 10 by means of the deformation of the rubber belt 12 that penetrates the warp cords WR.

Typically, the calendering machine 25 comprises a frame (not shown), at least one upper movable roller 26

(preferably two upper rollers) mounted on the frame and swiveling around an axis of rotation 27, and at least one lower movable roller 28 (preferably two lower rollers) mounted on the frame, provided with an axis 29 which is parallel to the axis of rotation 27 and is preferably fixed. According to what is shown in Figure 6, the rubber belt 12 and the warp cords WR are supplied between the rollers 26 and 28, which are driven by respective drive motors (not shown).

The distance between the two rollers 26 and 28 is variable. The calendering machine 25 actually comprises a handling and control system with relative drives that make it possible both to change the position of the roller 26, and to control the pressure applied to the roller 28 during the calendering operation.

The rubber belt 12 is applied only to one side of the warp cords WR. The method for the production of the reinforcing layer 10 provides, firstly, to determine on which side of the warp cords WR the rubber belt 12 will be applied. The entrainment of the rubber belt 12 and the plastic deformation of the rubber belt 12 itself are implemented by the rotation of both rollers 26 and 28. Advantageously, the rollers 26 and/or 28 are driven into rotation at the same speed. According to a variant, the rollers 26 and/or 28 are driven into rotation at different speeds, especially in order to improve more the penetration of the rubber layer within the tissue being calendered.

The (upper or lower) side whereupon the warp cords WR are applied is established as a function of the cutting stations arranged downstream of the calendering machine 25, in particular as a function of the position of the blades as better described in the discussion that follows.

According to the embodiment shown in Figure 6, in the

case wherein the rubber belt 12 is applied to the underside of the warp cords WR, the rubber belt 12 coating action and the application under pressure of the rubber belt 12 against the warp cords WR are controlled by means of a suitable combination of relative speeds between the roller 28 and the roller 26 (a combination that initially provides for the same speed of rotation, but that can also provide for a variation in the speed of the roller 28) with respect to the roller 26, as well as by means of an appropriate setting of the thrust pressure exerted by the roller 26 against the roller 28, where the roller 26 also serves as a support for the warp cords WR.

Similarly, in the case wherein the rubber belt 12 is applied to the upper side of the warp cords WR, the rubber belt 12 coating action and the application under pressure of the rubber belt 12 against the warp cords WR are controlled by means of a suitable combination of relative speeds between the roller 26 and the roller 28 (a combination that initially provides for the same speed of rotation, but that can also provide for a variation in the speed of the roller 28) relative to the roller 26, as well as by means of an appropriate setting of the thrust pressure exerted by the roller 26 against the roller 28, where the lower roller 28 also serves as a support for the warp cords WR.

Advantageously, the roller 26 or 28 (upper or lower) carrying the rubber belt 12, prior to the application of the coating between the warp cords WR, is heated differently (and, consequently, the rubber belt 12 is heated differently) in order to improve the plastic deformation of the rubber belt 12. In particular, the rollers 26 or 28 (upper or lower) carrying the rubber belt 12 are heated by setting a different average temperature for each of said rollers 26, 28. Each of the two rollers

26, 28 is provided with a conditioning circuit containing flowing water, wherein the temperature is regulated independently from the other roller 26, 28.

The pressure applied to the rubber belt 12 is determined, during a preliminary step, as a function of the penetration of the warp cords WR into rubber belt 12. In particular, the pressure applied by the main roller 26 or 28 to the rubber belt 12 is minimum when, for each warp cord WR, the rubber belt 12 surrounds a surface  $S^*$  that is equal to 50% of the outer cylindrical surface  $S$  and it is maximum when, for each warp cord WR, the rubber belt 12 surrounds a rubber surface  $S^*$  that is equal to 99% of the outer cylindrical surface  $S$ .

It is extremely important in the production process to be able to control the level of adhesion of the rubber belt 12 during the manufacturing process of the rubber belt 12 itself. In particular, it is crucial to obtain a sufficient adhesion level to ensure the adhesion of the rubber belt 12 to the other components of the pneumatic tyre 1.

It is obvious that particular attention should be paid to the level of adhesion of the surface 17, 18 provided with the warp cords WR. In particular, it has been experimentally verified that the level of adhesion of the surface 17, 18 provided with warp cords WR, is directly proportional to the level of surfacing of the rubber between the warp cords WR.

Therefore, the calendering machine 25 comprises an optical device 39 arranged at a control station CS positioned in the downstream of the rollers 26, 28. The optical device 39 is intended to continuously implement the optical control of the rubber belt 12, in particular of the surface 17, 18 provided with the warp cords WR. The optical device 39 comprises a detection device 40, preferably a

video camera, and a control unit 41 connected to the detection device 40 and communicating with an external supervision unit 42, generally a computer. The detection device 40 faces the rubber belt 12 which is brought out by the rollers 26, 28. More specifically, the detection device 40 is arranged facing the surface 17, 18 which is provided with the warp cords WR. The device detection 40 is intended to capture images of the samples of the rubber belt 12.

A parameter  $S_1$  is introduced which is defined by the ratio between the black colored area within the sample detected by the detection device 40 and the area of the sample detected by the detection device 40. It was experimentally verified that the surfacing level of the rubber within the spaces defined between two warp cords WR placed in succession is directly proportional to the parameter  $S_1$ ; in other words, increasing values of the parameter  $S_1$  correspond to increasing values of the surfacing level of the rubber.

Moreover, it is introduced an additional parameter  $S_2$  which is defined by the ratio between the number of warp cords WR within the area of the sample, having a distance from the adjacent warp cords WR that is lower than a threshold value TV and the total number of warp cords WR within the area of the sample, as detected by the detection device 40. The threshold value TV is defined during a preliminary development phase of the production method of the reinforcing layer 10; advantageously, the threshold value TV is variable as a function of the formula of the rubber belt 12, that is to say as a function of the materials used and the spacing of the warp cords WR.

Figures from 8a to 8c show some examples of images of the samples of the rubber belt 12 detected by the device 40 and characterized by the increasing values of the surfacing

level between the warp cords WR and, consequently, by the increasing values of the parameter  $S_1$ . Figure 8d shows a further sample of the rubber belt 12 wherein excess pressure caused distortion in the spacing of the warp cords WR.

The detection device 40 continuously detects images of the samples of the rubber belt 12 and transmits them to the control unit 41, which is configured in such a way as to calculate the parameters  $S_1$  and  $S_2$  for each sample. After calculating the parameters  $S_1$  and  $S_2$  for each sample, the control unit 41 proceeds with comparing said parameters  $S_1$  and  $S_2$  with two respective threshold values indicated respectively with  $TV_{S_1}$  and  $TV_{S_2}$ . The threshold values  $TV_{S_1}$  and  $TV_{S_2}$  are also defined during a preliminary development phase of the production method of the reinforcing layer 10; advantageously, the threshold values  $TV_{S_1}$  and  $TV_{S_2}$  are variable as a function of the formula of the rubber belt 12, that is to say as a function of the materials used and the spacing of the warp cords WR.

Later, the deviations  $\varepsilon_1$  and  $\varepsilon_2$  are calculated, they correspond to the absolute value of the difference between the two parameters  $S_1$  and  $S_2$  and the threshold values  $TV_{S_1}$  and  $TV_{S_2}$  thereof.

In the case wherein both of the deviations  $\varepsilon_1$  and  $\varepsilon_2$  are greater than or equal to the respective reference values  $\varepsilon_{REF\_1}$  and  $\varepsilon_{REF\_2}$ , this means that the rubber belt 12 has a suitable adhesiveness that allows for the adhesion of the rubber belt 12 to the other rubber components of the pneumatic tyre 1. The reference values, indicated with  $\varepsilon_{REF\_1}$  and  $\varepsilon_{REF\_2}$ , are also defined during a preliminary development phase of the production method of the reinforcing layer 10 and, advantageously, they are variable as a function of the formula of the rubber belt 12.

In the case wherein at least one of said deviations  $\varepsilon_1$  and  $\varepsilon_2$  is instead less than or equal to the respective reference values  $\varepsilon_{REF\_1}$  and  $\varepsilon_{REF\_2}$ , this means that the rubber belt 12 has an insufficient adhesiveness to ensure the adhesion of the rubber belt 12 to the other rubber components of the pneumatic tyre 1. In this case, the control unit 41 is configured to send a control signal to the external supervision unit 42 that is proportional to the offset  $\varepsilon_1$  and  $\varepsilon_2$ .

The external supervision unit 42 is configured to correct the calendering step as a function of the offset  $\varepsilon_1$  and  $\varepsilon_2$ . In particular, the external supervision unit 42 is configured to drive the handling and control system in order to modify the position of the roller 26, as well as to control the application pressure of the roller 28 during the calendering operation, in a controlled manner as a function of the offset  $\varepsilon_1$  and  $\varepsilon_2$ .

It is evident that the calendering step just described can be advantageously applied both in the case of warp cords WR made of a metallic material, and in the case of warp cords WR made of nylon or polyester or another synthetic textile fiber.

Once the calendering step has been completed, the fabric T is cut into the required dimensions by means of various cutting stations.

Initially, the fabric T obtained from the calendering machine 25 is separated, by means of a longitudinal cut, into two or more portions within a first cutting station; the continuous longitudinal cut of the ribbon of fabric T requires to cut the rubber belt 12 between two consecutive warp cords WR without cutting the two warp cords WR themselves. To this end, the longitudinal cut is implemented by means of at least one thin, preferably

heated, blade that enters centrally into the rubber belt 12 in the space between two flanking warp cords WR by means of a radial movement. According to a variant, two flanking blades that are moved transversely in opposite directions are required to be able to separate the two portions of fabric T obtained. The blade is preferably floating in order to be able to make small transverse adjustment movements and therefore to follow, during the cutting, the profile of the warp cords WR without damaging the warp cords WR themselves.

Two or more portions of the fabric thus obtained are wrapped into coils and supplied to a second cutting station. In the second cutting station, the longitudinal cutting of the portion of fabric T makes it possible to separate the rubber ribbons 11 which are internally reinforced with the warp cords WR of the required width. Typically, each ribbon 11 comprises a reduced number of warp cords WR between four and sixteen warp cords WR. Preferably, the number of warp cords WR is between five and twelve; advantageously the number of warp cords WR is equal to five, six or else twelve. Also in this case, the longitudinal cut of the portion of fabric T provides for cutting the rubber belt 12 to be cut between two consecutive warp cords WR without cutting the two warp cords WR themselves. To this end, the longitudinal cut is implemented by means of at least one thin, preferably heated, blade that enters centrally into the rubber belt 12 in the space between two flanking warp cords WR by means of a radial movement. According to a variant, two flanking blades that are moved transversely in opposite directions are provided for in order to be able to separate the two portions of rubber belt 12 obtained. The blade is preferably floating in order to be able to make small

transverse adjustment movements and therefore to follow, during the cutting, the profile of the warp cords WR without damaging the warp cords WR themselves. Since the ribbon 11 comprises a reduced number of warp cords WR, the second cutting station is provided with a device for adjusting the tensioning of the portion of fabric T.

A second embodiment describes hereinafter the method for the production of the reinforcing layer 10.

The rubber used to make the rubber belt 12 is supplied inside the extrusion unit 30 which is provided with an extrusion head 31. Within the extrusion unit 30 the rubber advances being pushed by a worm gear (not shown) and is heated up until its complete plasticization. Once plasticization occurs, the rubber is then supplied to a chamber located within the extrusion head 31. Within the extrusion head 31 an inlet opening of the rubber(not shown) and an inlet opening 33 of the warp cords WR need to be coated with the rubber belt 12 and they are supplied after being unwound from the collecting warps. In particular, the individual warp cords WR are supplied in a parallel way to a direction 32 of travel of the rubber that will be used to make the rubber belt 12. The individual warp cords WR are supplied alongside one another with a determined pitch P.

The inlet opening 33 of the warp cords WR has such dimensions in order to be able to arrange a plurality of warp cords WR alongside one another with a determined pitch P. Preferably, the number of warp cords WR arranged alongside one another with a determined pitch P is between five and twelve; advantageously the number of warp cords WR is equal to five, six or else twelve.

Within the extrusion head 31 there is, in one end opposite to the inlet opening 33 of the warp cords WR, an outline 34 that reproduces the shape of the finished fabric

T to be obtained.

The dimensions and shape of the chamber and the dimensions and shape of the profile 34 are chosen in such a way that they generate dynamic pressure conditions within the chamber to favor the coating action of the rubber for the warp cords WR.

The chamber is shaped in such a way that the rubber is not completely, but only partially, wound around the warp cords WR. In other words, the green rubber is only supplied above or below the plurality of individual warp cords WR.

The rubber belt 12 is applied only to one side of the warp cords WR. The method for the production of the reinforcing layer 10 provides, firstly, to determine on which side of the warp cords WR the rubber belt 12 will be applied. In particular, the (upper or lower) side of the warp cords WR whereupon to apply the rubber belt 12 is established as a function of the cutting stations arranged at the downstream of the extrusion unit 30, in particular as a function of the position of the blades.

For example, according to a preferred embodiment, support/abutment elements are present within the chamber for isolating the portion NP, that is raised and without the rubber coating, from the green rubber in the passage within the extrusion head 31.

As a further example, according to what is shown in Figure 9, the extrusion head 31 comprises two overlapping coupling plates 35, 36 within two semi-matrices 37, 38 in order to define passages  $P_1$ ,  $P_2$  that are required for the green rubber and that are arranged respectively above and below the warp cords WR.

As shown in Figure 9, the rubber is conveyed through the passage  $P_2$  in order to make a continuous film, with the required thickness, that defines the rubber belt 12.

In particular, between the coupling plate 36 and the semi-matrix 38 it is defined a passage  $P_2$  that allows for a constant flow of green rubber supplied below the warp cords WR. Instead, the coupling plate 35 is arranged to impede a flow of green rubber to be supplied above the warp cords WR through the passage  $P_1$ . In this way, by passing through the profile 34, the rubber belt 12 is exclusively located below the warp cords WR.

Alternatively, it may be defined the passage  $P_1$ , located between the coupling plate 35 and the semi-matrix 37, that allows for a constant flow of rubber to be supplied above the warp cords WR. Instead, the coupling plate 36 is arranged to impede a flow of rubber to be supplied below the warp cords WR through the passage  $P_2$ . In this way, by passing through the profile 34, the rubber belt 12 is exclusively located above the warp cords WR.

The traction of the rubber belt 12 through motorized rollers (not shown) makes it possible to drag the individual warp cords WR and to produce the fabric T from the profile 34. In particular, the motorized rollers apply the necessary force required to unroll the individual warp cords WR from the warps and to overcome the friction generated by the gum strip 12 within the extrusion head 31.

The penetration of the warp cords WR into the rubber belt 12 (i.e., the portion  $S^*$  of the outer cylindrical surface S of each warp cord WR surrounded by the green rubber belt 12) is adjusted by means of the ratio between the traction speed exerted by the motorized rollers and the pressure generated by the rubber within the chamber, the temperature of the warp cords WR and the temperature of the green rubber.

It is evident that the extrusion step just described can be advantageously applied both in the case of warp

cords WR made of a metallic material, and in the case of warp cords WR made of nylon or polyester or another synthetic textile fiber.

In the case wherein the fabric T exiting the extrusion unit 30 does not have the required dimensions, the fabric T is cut into the required dimensions by means of various cutting stations as described in the preceding discussion.

It is evident that in this second embodiment of the method for the production of the reinforcing layer 10 it is not necessary to produce separately the warp of the warp cords WR and/or the rubber belt 12, as the different materials (warp cords WR and green rubber) involved in the extrusion process can be supplied to the extrusion unit 30, thereby reducing the number of processing steps.

It is also clear that, at the downstream of the extrusion unit 30, a control station CS is provided for having an optical device 39 of the type described in the preceding discussion.

The method for the construction of a pneumatic tyre 1 described in the preceding discussion, firstly, provides for applying the protective anti-wear plies (where present) and the innerliner 21 which has the function of waterproofing the pneumatic tyre 1 on a molding drum (not shown) in such a way that they are subsequently arranged on the inner surface of the body ply 3. Advantageously, the innerliner 21 can be pre-assembled to the protective anti-wear plies (where present).

The method then provides for the coupling of the tread ply inserts 20 (where present) to the body ply 3 and the incorporation of the beads 4, i.e., the reinforced hoops 5 and the fillers 6 of the beads 4. Finally, the body ply 3 is subsequently wound around the forming drum in order to give the body ply 3 an annular shape, overlapping the two

opposite ends of the body ply 3. Finally the formation of the green pneumatic tyre 1 is completed by bonding also the other components to the body ply 3, i.e. the sidewalls 22, the tread belt 8, reinforcing layer 10 which is wound onto the tread belt 8 and the tread 7.

Once the assembly of the green pneumatic tyre 1 has been completed, the latter is subjected to a vulcanization process in special molds in order to obtain a semi-finished pneumatic tyre 1.

According to alternative embodiments, the reinforcing layer 10 is applied with warp cords WR facing inwards or towards the outside of the pneumatic tyre 1.

In other words, advantageously, according to a first variant, the reinforcing layer 10 is applied with the warp cords WR facing the tread 7 warp and with the rubber belt 12 facing the tread plies 9.

Instead, according to a second embodiment, the reinforcing layer 10 is applied with the warp cords WR facing the tread plies 9 and with the rubber belt 12 facing the tread 7.

It should also be highlighted that the fabric T described in the preceding discussion can be advantageously applied in the production of a plurality of plies 3, 9, 10, or in the manufacture of the protective anti-wear ply of the pneumatic tyre 1, with ply meaning a reinforcing textile of any dimension.

The mono filament warp cords WR described in the preceding discussion and shown in detail in Figures 4 and 5, can be replaced by a plurality of twisted filaments to define a warp cord WR with a substantially cylindrical outer surface S.

It is evident that the reinforcing layer 10 and the method for the production of the reinforcing layer 10 as

heretofore described have several advantages. Firstly, the reinforcing layer 10 just described allows for a reduction in the production costs of pneumatic tyres 1 compared to the traditional production process and, at the same time, the elimination of a rubber belt 12 compared to traditional pneumatic tyres 1 also allows for a reduction in the weight and rolling resistance of pneumatic tyres 1.

Furthermore, the fabric T used to make the reinforcing layer 10 can easily be adapted to the production of the tread plies 9, the body ply 3 and the protective anti-wear ply.

CLAIMS

1. - Method for the production of a fabric (T) for the manufacture of a ply (10; 9; 3) of a pneumatic tyre comprising:

a step of supplying a warp of cords (WR) arranged alongside one another with a determined pitch (P);

a step of supplying an individual green rubber belt (12); wherein the green rubber is only supplied above or below the plurality of warp cords (WR);

a production step of the rubber belt (12) such that an outer cylindrical surface (S) of each warp cord (WR) is arranged at a certain non-zero distance from a first surface (17, 18) of the green rubber belt (12) and is partially free from the green rubber belt (12) at a second surface (17, 18) of the green rubber belt (12); wherein, during the production step, some parameters are adjusted as a function of the portion (S\*) of said outer cylindrical surface (S) surrounded by the green rubber belt (12);

an optical control step of the rubber belt (12) that is subsequent to the production step; the control step comprising the sub-steps of:

- acquiring images of the samples of the second surface (17, 18) of the rubber belt (12); and

- calculating, for each sample, at least a first indicator (S<sub>1</sub>, S<sub>2</sub>) of the adhesiveness of the rubber belt (12) by means of the respective image; and

an adjustment step of the production step as a function of said first indicator (S<sub>1</sub>, S<sub>2</sub>).

2.- Method according to claim 1, wherein said indicator (S<sub>1</sub>) is equal to the ratio between the black area of the sample and the total area of the sample.

3.- Method according to claim 1 or 2, wherein said

indicator ( $S_2$ ) is equal to the ratio between the number of warp cords (WR) within the area of the sample having a distance from the adjacent warp cords (WR) that is less than a first threshold value (TV) and the total number of warp cords (WR) within the area of the sample.

4.- Method according to any of the preceding claims, wherein the control step comprises the further sub-steps of:

- calculating a deviation ( $\varepsilon_1, \varepsilon_2$ ) by means of the absolute value of the difference between said first indicator ( $S_1, S_2$ ) and a threshold value ( $TV_{S1}$  and  $TV_{S2}$ );

- comparing the deviation ( $\varepsilon_1, \varepsilon_2$ ) with a reference value ( $\varepsilon_{REF\_1}, \varepsilon_{REF\_2}$ ); and

the adjustment step comprises an adjustment of the production step as a function of the comparison between the deviation ( $\varepsilon_1, \varepsilon_2$ ) and the reference value ( $\varepsilon_{REF\_1}, \varepsilon_{REF\_2}$ ).

5.- Method according to claim 4, wherein the threshold value ( $TV_{S1}$  and  $TV_{S2}$ ) is variable as a function of the formula of the rubber belt (12), that is to say as a function of the materials used and of the spacing of the warp cords (WR).

6.- Method according to claim 4 or 5 wherein the adjustment step comprises an adjustment as a function of the deviation ( $\varepsilon_1, \varepsilon_2$ ), in the case wherein the deviation ( $\varepsilon_1, \varepsilon_2$ ) is less than the reference value ( $\varepsilon_{REF\_1}, \varepsilon_{REF\_2}$ ).

7.- Method according to any of the preceding claims, wherein the production step comprises a calendering step of the warp cords (WR) and of the individual green rubber belt (12).

8.- Method according to claim 7, wherein the production step provides for an adjustment of the pressure to be applied during the calendering step as a function of the portion ( $S^*$ ) of the outer cylindrical surface (S) of

each warp cord (WR) surrounded by the green rubber belt (12).

9.- Method according to claim 7 or 8 and comprising the further step, during the calendering step, of heating the green rubber belt (12) in order to improve the plastic deformation thereof.

10.- Method according to any of claims from 1 to 6, wherein the production step comprises an extrusion step of the warp cords (WR) and of the green rubber, wherein the green rubber produces a continuous film of the required thickness that defines a green rubber belt (12).

11.- Method according to claim 10 and comprising the step of isolating the portions (NP) that are devoid of the rubber coating of the warp cords (WR) during the extrusion step.

12.- Method according to claim 10 or 11, wherein the production step provides for an adjustment of parameters such as the rubber belt (12) traction speed and/or the pressure generated by the rubber and/or the temperature of the warp cords (WR) and/or the temperature of the green rubber.

13.- Method according to any of the preceding claims and comprising a plasticizing step by heating the green rubber before the extrusion step.

14.- Method according to any of the preceding claims, wherein the warp cords (WR) are supplied parallel to the direction of travel of the rubber belt (12).

15.- Method according to any of the preceding claims and comprising at least one cutting step subsequent to the calendering step for separating the fabric (T) in order to obtain a ribbon (11) of the required width.

16.- Method according to claim 15 and comprising a further adjustment step, occurring simultaneously with the

cutting step, of the tensioning of the fabric (T).

17.- Method for the construction of a pneumatic tyre (1) comprising the following steps:

winding a body ply (3) around a molding drum overlapping the ends thereof in order to give the body ply (3) an annular shape and in order to obtain a green pneumatic tyre;

applying a tread belt (8) comprising two tread plies (9) to the body ply (3);

wrapping a reinforcing ply (10) around the tread belt (8);

applying the tread (7) to the reinforcing ply (10);  
and

vulcanizing the green pneumatic tyre (1) within a mold in order to obtain a finished pneumatic tyre (1);

the method is **characterized in that** at least one ply (10; 9; 3) is produced according to any of the claims from 1 to 16.

18.- Method according to claim 17 and comprising the further step of applying to the molding drum a protective anti-wear ply produced according to any of the preceding claims from 20 to 25 and implemented in order to protect a pair of beads (4).

19.- Method according to claim 17 or 18, wherein said ply is the reinforcing ply (10); the method comprises the further step of applying the reinforcing ply (10) with the warp cords (WR) facing the tread (7) and with the first surface (17, 18) of the fabric (T) facing towards the tread plies (9).

20.- Method according to claim 17 or 18, wherein said ply is the reinforcing ply (10); the method comprises the further step of applying the reinforcing ply (10) with the warp cords (WR) facing the tread plies (9) and with the

first surface (17, 18) of the fabric (T) facing towards the tread (7).

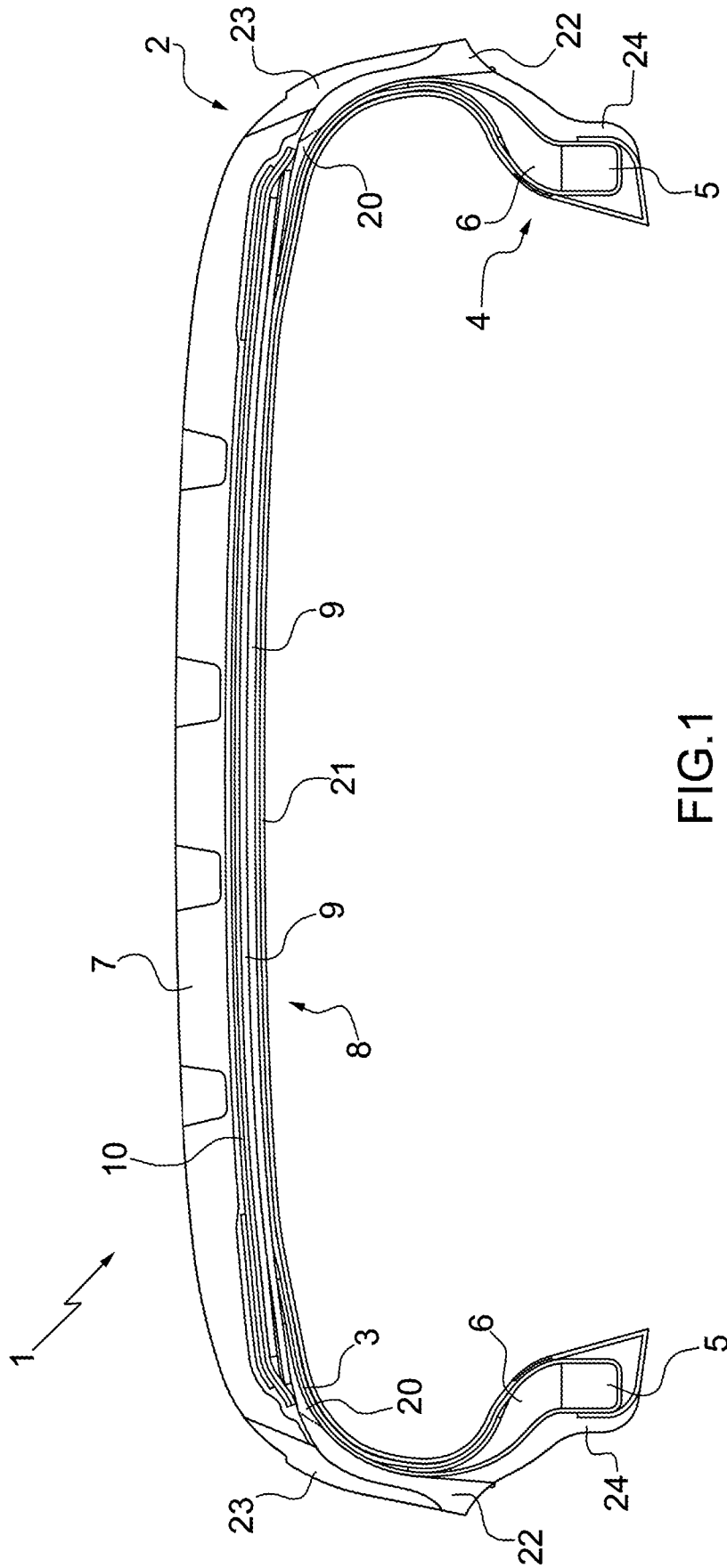


FIG.1

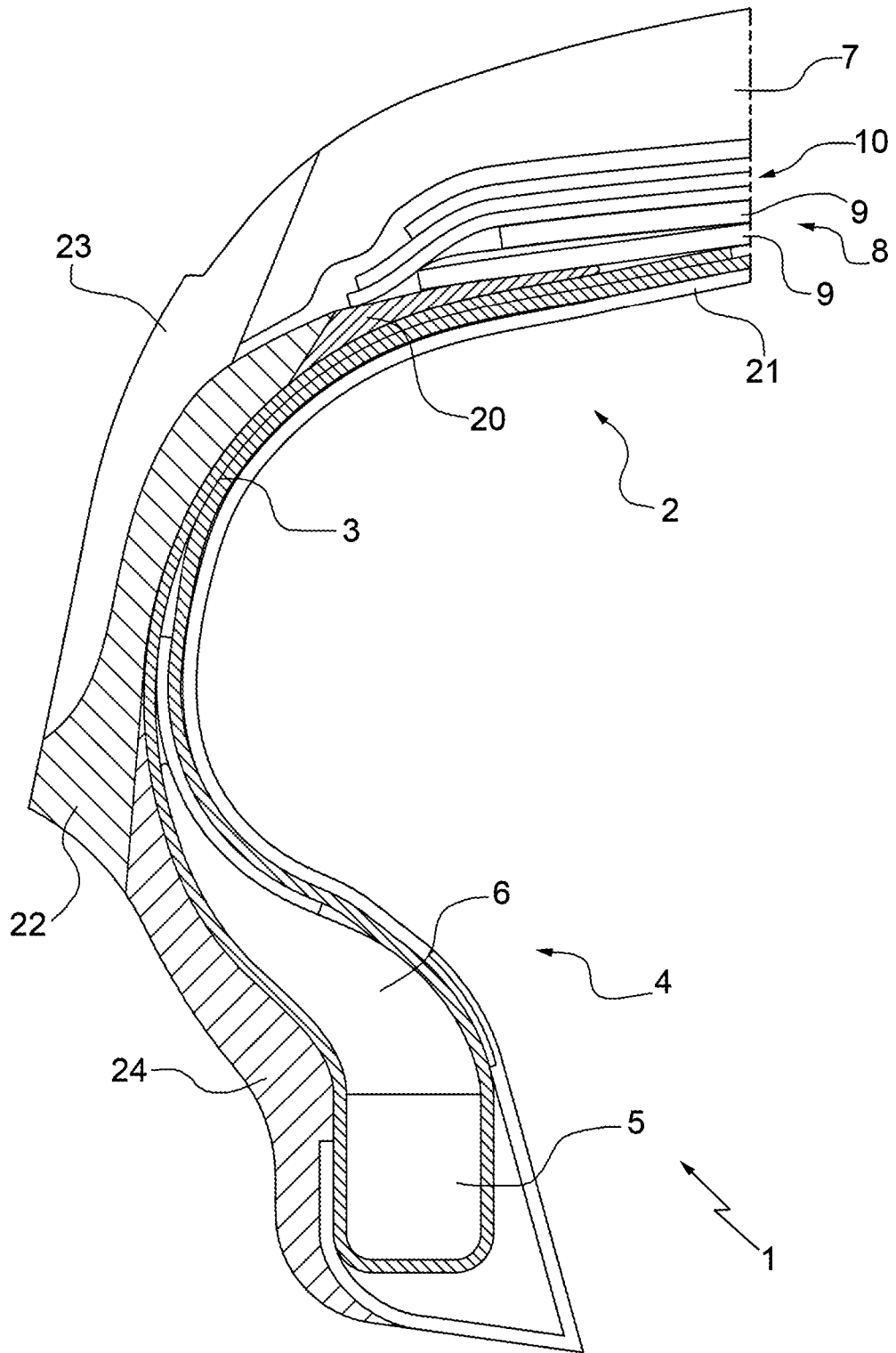
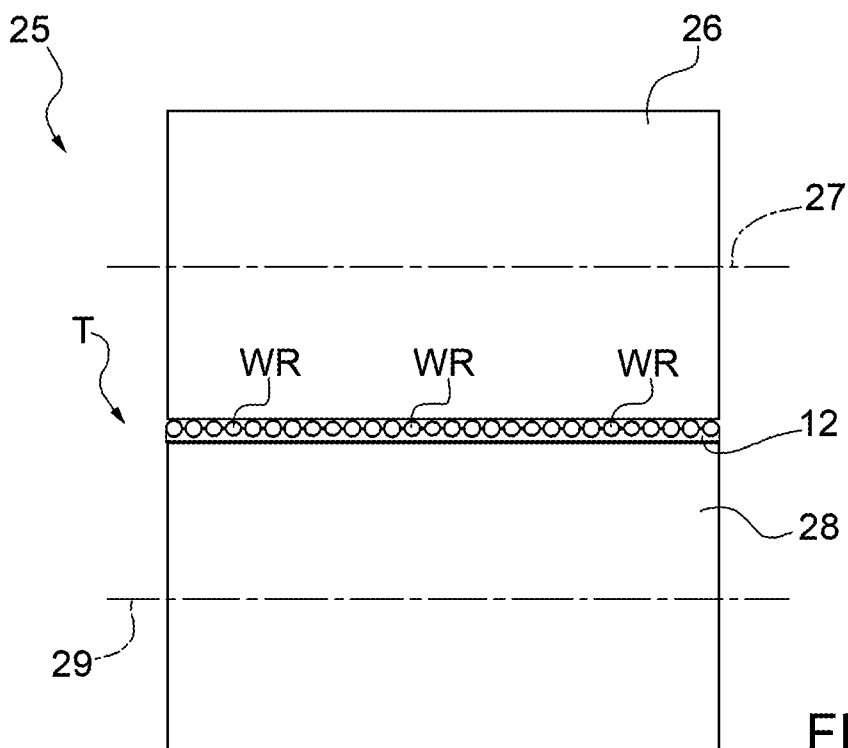
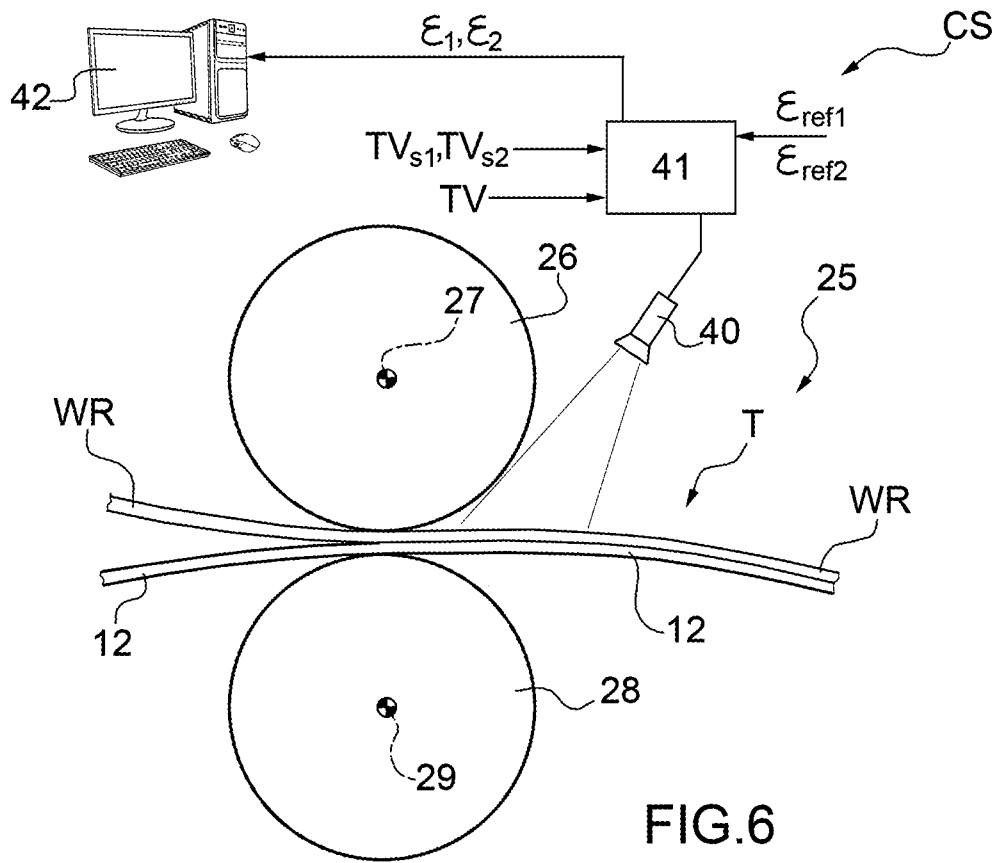


FIG.2







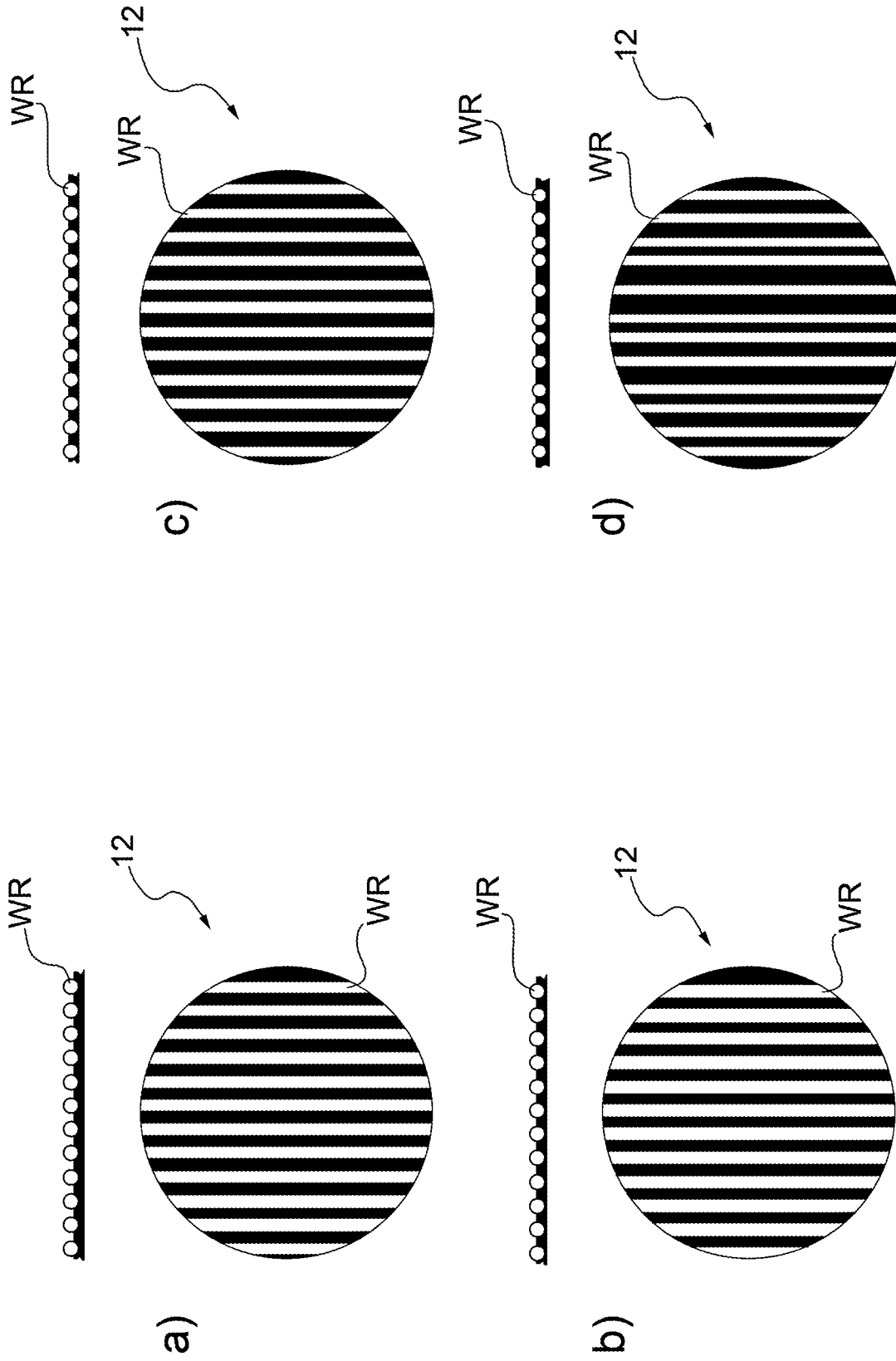
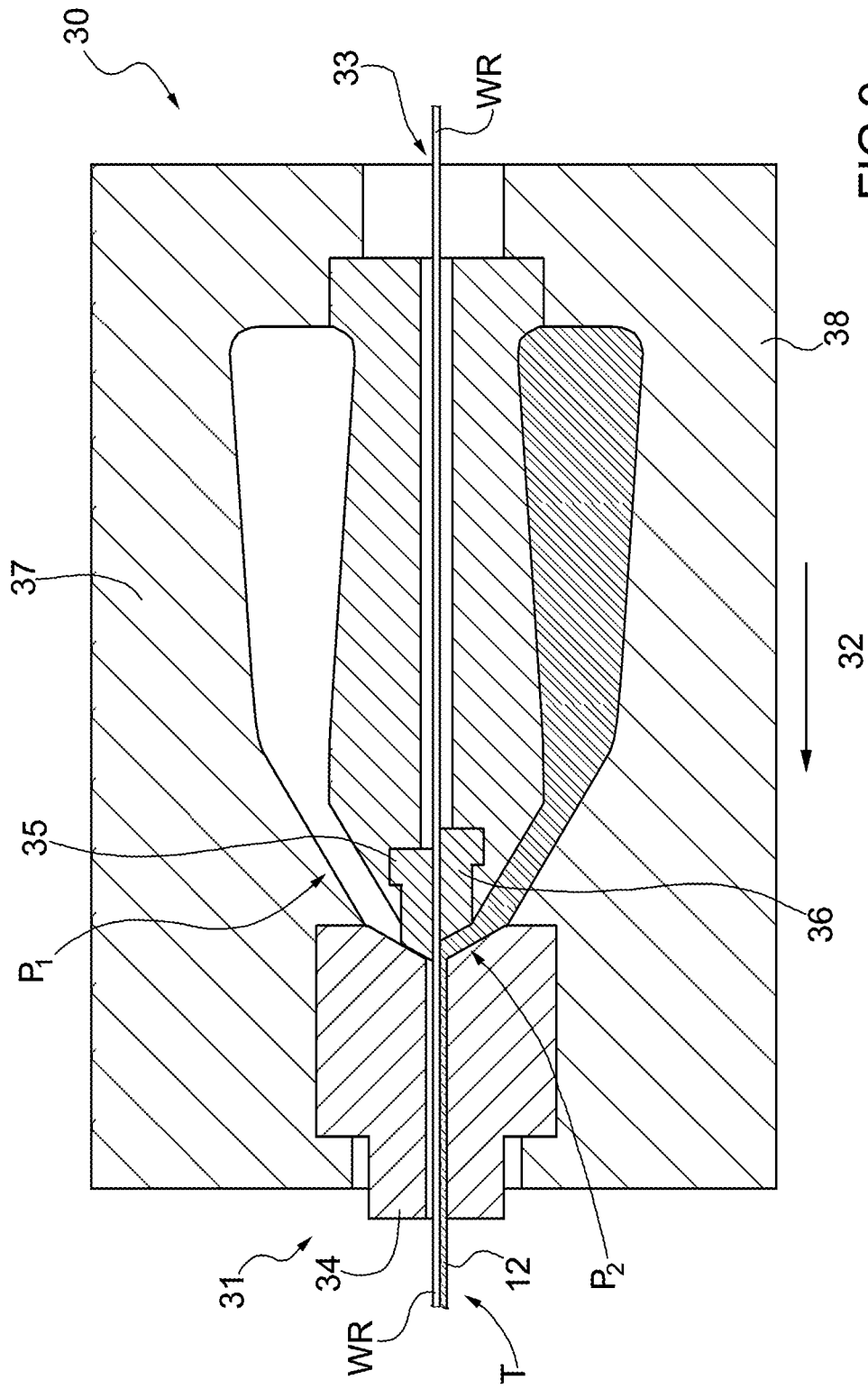


FIG.8



**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/IB2018/060171

**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. B29D30/38 B29C43/24 B29C43/28 B29C43/22 B29C48/02  
 ADD.  
 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)  
 B29D B29C B60C G01B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of Box C.  See patent family annex.

\* 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  7 March 2019	Date of mailing of the international search report  19/03/2019
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Kopp, Christian
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 International application No  
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