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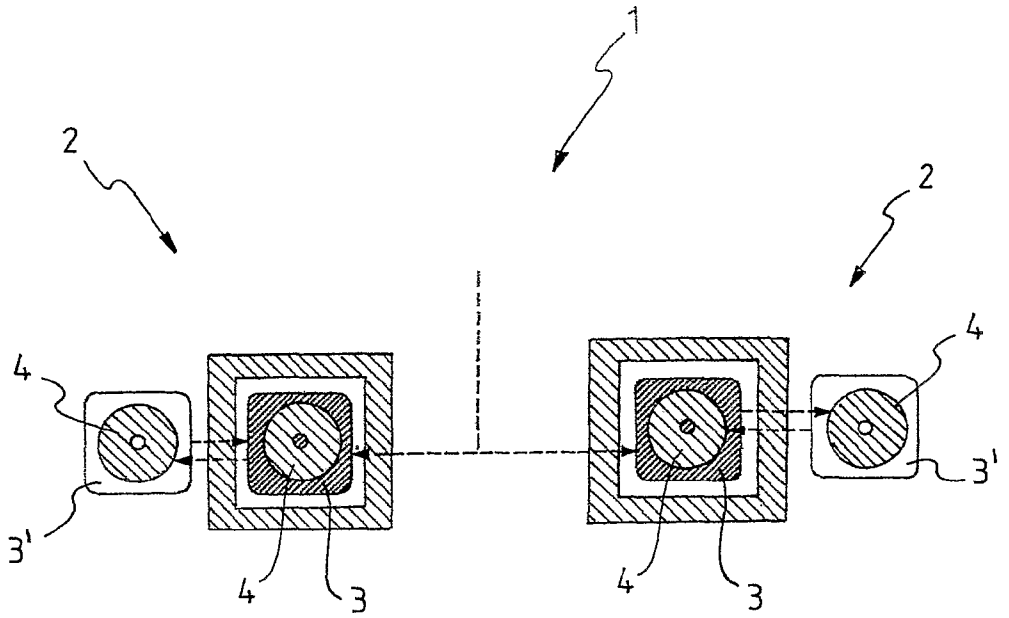
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(54) **Title:** METHOD AND APPARATUS FOR THE VULCANISATION OF TYRES FOR VEHICLE WHEELS



(57) **Abstract:** There are disclosed a vulcanisation apparatus and method for tyres for vehicle wheels, said method comprising the steps of: placing a green tyre, arranged on a toroidal support, inside a vulcanisation mold. Connecting a supplying device of at least one pressurised primary working fluid and a supplying device of at least one pressurised secondary working fluid to the vulcanisation mold in a prevulcanisation and molding station; at least partially vulcanising a radially internal portion of the green tyre on the toroidal support; transferring the mold to a vulcanisation station; completing the vulcanisation of the prevulcanised tyre during by supplying said at least one pressurised primary working fluid inside the toroidal support.

WO 2007/013113 A1

Title: Method and apparatus for the vulcanisation of tyres for vehicle wheels.

DESCRIPTION

Background of the invention

The present invention relates to a method and an apparatus for the vulcanisation of tyres for vehicle wheels.

In particular, the present invention relates to method and apparatus for the vulcanisation of tyres built on a toroidal support.

Technical state of the art

The tyre production cycle provides that, following a building process wherein the different components of the tyre are made and/or assembled, a molding and vulcanisation process is carried out which aims at defining the tyre structure, according to a desired geometry and tread pattern.

For this purpose, the tyre is closed inside a molding cavity, having a suitable configuration, defined internally of a vulcanisation mold and shaped according to the requirements of the tyre to be obtained.

A tyre generally comprises a toroidally ring-shaped carcass including one or more carcass plies, strengthened with reinforcing cords, lying in substantially radial planes, (a radial plane contains the rotation axis of the tyre). Each carcass ply has its ends integrally associated with at least one metal annular reinforcing structure, usually known as bead core, constituting the reinforcing at the beads, i.e. at the radially internal ends of the tyre, the function of which is to enable assembling of the tyre with a corresponding mounting rim. Placed crown wise to said carcass is a band of elastomer material, called tread band, in which, at the end of the vulcanisation and molding steps, a raised pattern is formed for ground contact. A reinforcing structure usually known as belt structure is placed between the carcass and the tread band. In the case of car tyres, this structure usually comprises at least two radially superposed strips of rubberised fabric provided with reinforcing cords, generally of metal material, positioned parallel to each other in each strip and in a crossed relationship with the cords of the adjacent strip preferably symmetrically arranged with respect to the equatorial plane of the tyre. Preferably said belt structure further comprises at a radially external position thereof, at

least on the ends of the underlying strips, also a third layer of textile or metallic cords, circumferentially disposed (at 0 degrees).

Finally, in tyres of the tubeless type, i.e. devoid of an air tube, a radially internal layer, called liner, is present which has imperviousness features to ensure the air-tightness of the tyre.

To the aims of the present description as well as in the following claims, by the term "elastomer material" it is intended a composition comprising at least one elastomer polymer and at least one reinforcing filler. Preferably this composition further comprises additives such as cross-linking and/or plasticizing agents. By virtue of the cross-linking agents, this material can be cross-linked through heating so as to form the final manufactured article.

EP 1 066 952 A1 describes a method and an apparatus for the vulcanisation of tyres. More precisely, a plurality of lines of vulcanisation stations which contain a plurality of series of mobile tyre mold units for tyre vulcanisation is disclosed; a mold opening/closing station through which the vulcanised tyre is removed, and a green tyre is inserted; a first mold transferring device and a second mold transferring device positioned between the mold opening/closing station and the tyre vulcanisation station for the transfer of the tyre mold units.

There are molding and curing methods in which a green tyre put on a rigid toroidal support is arranged within the mold. Said methods are preferably employed for tyres which, according to recent building processes, are produced starting from a limited number of elementary semifinished products fed onto a toroidal support whose outer profile coincides with that of the radially internal surface of the tyre that is wished to be produced. Said toroidal support is moved, preferably by means of a robotized system, among a plurality of workstations in each of which, through automated sequences, a particular building step of the tyre is carried out.

For example, the European Patent Application published under N° 0 976 533, in the name of the same Applicant, discloses a method and an apparatus for molding and curing tyres for vehicle wheels of the aforesaid type, wherein a green tyre built on a toroidal support is closed inside a vulcanisation mold; subsequently steam or other pressurised fluid is fed into at least one gap for fluid diffusion created between the external surface of the toroidal support and the internal surface of the tyre.

In these cases, at the end of the molding and vulcanisation steps, the tyre thus obtained may sometimes exhibit some faults. Because of the absence of the vulcanisation

bladder, the various components of the elastomer material which are still in an uncured state, i.e. in a plastic state, may be displaced in an anomalous manner with respect to the design specifications, as a result of the thrust exercised by the pressurised working fluid introduced between the external surface of the toroidal support and the internal surface of the green tyre. In particular, the carcass ply or plies can move away and slip out from their position in the bead region because of the expansion to which the tyre is subjected by said working fluid. In this way, the tensioning of the carcass ply or plies determined by the molding step is lower than it is provided to be for the finished tyre.

In order to overcome these drawbacks the International Patent Application published under No. WO 2004/045837, in the name of the same Applicant, discloses a method and an apparatus which, by pressing the green tyre from the outside towards the inside, and simultaneously supplying heat to the internal surface of the said tyre, at least a partial vulcanisation of the radially innermost layer of the tyre and of the bead region is obtained, so that a molding and vulcanisation step, which does not result in irregularities or lack of homogeneity in the finished tyre, can be subsequently performed .

In order to carry out said partial vulcanisation, at least a pressurised primary working fluid, suitably heated to supply the heat necessary for the aforesaid partial vulcanisation, and at least a pressurised secondary working fluid are preferably used. The Applicant has perceived that for this reason the apparatuses necessary for accomplishing said partial vulcanisation are provided with multiple connectors for said working fluids and that therefore they results as being complex and expensive.

The Applicant has also ascertained that said connectors are present on each work station, that is, at each mold of the vulcanisation apparatus, even though they are used only during the prevulcanisation step and therefore they are not used for most of the vulcanisation method.

In a similar manner, the Applicant has found the presence of further components present in the vulcanisation apparatus which are used only during some of the tyre vulcanisation steps, which therefore result unused for a quite long period of time. An example of this kind of apparatus is the heating device of the vulcanisation mold used only during the tyre vulcanisation step.

The Applicant has noted that by providing a vulcanisation apparatus which realises a vulcanisation method of the type shown in patent N° WO 2004/045837, it is possible to simplify and reduce the cost of the aforesaid apparatus, by reducing the number of the more expensive components (for example, those related to the supply of the secondary working fluid and/or those concerning the heating of the mold), while maintaining

constant the productive capacity of the same vulcanisation apparatus, by means of a rational use of said apparatuses, increasing the operating time thereof in the vulcanisation cycle.

Therefore the object of the present invention is to provide a vulcanisation method for vehicle wheel tyres which allows to achieve the maximum utilisation degree of the devices associated with each work station while the same method is carried out.

Another object of the present invention is to provide a vulcanisation apparatus for vehicle wheel tyres built on a toroidal support provided with a plurality of work stations, each one being provided with the minimum number of devices required for the specific operation to be performed, in order to reduce the costs for carrying out the apparatus.

Summary of the invention

The Applicant has found that by carrying out a vulcanisation method which uses at least one prevulcanisation and molding work station wherein, both a prevulcanisation of the radially internal portion of the tyre and a molding and a partial vulcanisation of the whole tyre are carried out in subsequent steps, and at least one vulcanisation work station wherein the remaining part of the vulcanisation of the whole tyre is carried out, it is possible to retain at the single prevulcanisation and molding station, the apparatuses necessary for supplying the abovesaid primary and secondary working fluids, while maintaining only the apparatuses for supplying the primary working fluid at the vulcanisation stations, thus obtaining the maximum utilisation degree of the devices available during the same method..

According to a first aspect, the invention relates to a vulcanisation method for vehicle wheel tyres comprising the following steps:

a) placing a green tyre, arranged on a toroidal support, inside a vulcanisation mold which may be operably associated with a plurality of work stations defined in at least one vulcanisation module;

b) closing said vulcanisation mold;

c) connecting a supplying device of at least one pressurised primary working fluid and a supplying device of at least one pressurised secondary working fluid to the vulcanisation mold in a prevulcanisation and molding station;

d) at least partially vulcanising a radially internal portion of the green tyre on the toroidal support by the pressing by means of said pressurised secondary working fluid a radially internal surface of said green tyre towards an external surface of the toroidal support, and supplying heat to said portion of the tyre;

e) molding and continuing the vulcanisation of the aforesaid tyre by supplying at least one pressurised primary working fluid inside the toroidal support pressing a radially external surface of the green tyre towards the internal walls of the vulcanisation mold;

f) disconnecting from the vulcanisation mold the supplying device of said at least one pressurised primary working fluid and the supplying device of said at least one pressurised secondary working fluid;

g) transferring the mold to a vulcanisation station;

h) connecting a respective supplying device of at least one pressurised primary working fluid to the vulcanisation mold in said vulcanisation station;

i) completing the vulcanisation of the tyre molded and prevulcanised during steps d) and e), supplying said at least one pressurised primary working fluid inside the toroidal support, pressing a radially external surface of the green tyre towards the internal walls of the vulcanisation mold and supplying heat to the aforesaid tyre;

j) disconnecting the supplying device of said at least one pressurised primary working fluid;

k) opening the mold and the unloading of the molded and vulcanised tyre from the vulcanisation mold.

The Applicant has further verified that during vulcanisation processes of the type described in WO 2004/045837 the prevulcanisation step wherein the tyre is pressed from the exterior towards the external surface of the toroidal support, in order to obtain through a suitable quantity of heat, at least a partial vulcanisation of the radially internal portion of the tyre (for example of the liner) and of the bead region, has for each tyre model a pre-established execution time which is possibly not able to be divided in subsequent sub-steps. This is due to the fact that because if the tyre, still substantially in a green state, is subject to manipulation and/or interruptions during the aforesaid step, it could has irregularities at the end of the molding and vulcanisation steps caused by unexpected slipping of some layers of elastomer material.

The Applicant has therefore noted that the technological limit of maximum efficiency of the vulcanisation method and apparatus necessary for carrying out said method, lies substantially in the duration of the prevulcanisation step, therefore, carrying out a vulcanisation method in such a way that the actual vulcanisation step has a duration that substantially coincides with a multiple time of the duration time of the prevulcanisation step, it is possible to maximise the efficiency of the aforesaid method.

According to a preferred embodiment the vulcanisation method according to the present invention provides therefore that, being the total time required to carry out steps h) + i) + j) equal to t1, and being the total time required to carry out steps k) + a) + b) + c) + d) + e) + f) equal to t2, it is substantially $t1 = m * t2$, where m is a whole number greater than or equal to 1.

It should be noted that in the present description and in the following claims, the duration of two times is considered "substantially" equal when the difference between them is inferior to a prime minute.

According to a second aspect the invention relates to a vulcanisation apparatus for vehicle wheel tyres comprising at least one vulcanisation module wherein is defined a plurality of work stations whereto a plurality of vulcanisation molds, each one containing a green tyre being processed arranged on a respective toroidal support, may be operably associated, said vulcanisation module comprising the following work stations:

at least one prevulcanisation and molding station provided with a supplying device of at least one pressurised primary work fluid and with a supplying device of at least one pressurised secondary work fluid inside one vulcanisation mold located in said station, said pressurised secondary work fluid being adapted to press a radially internal surface of said green tyre towards an external surface of the toroidal support, said pressurised primary work fluid being adapted to press a radially external surface of a green tyre towards the internal walls of the vulcanisation mold;

at least one vulcanisation station provided with a respective supplying device of said at least one pressurised primary work fluid inside one vulcanisation mold located in said station, said pressurised primary work fluid being adapted to press said radially external surface of a green tyre towards the internal walls of the vulcanisation mold in order to complete the vulcanisation of the molded and partially vulcanised tyre;

at least one transfer device adapted to sequentially transfer, each vulcanisation mold of said plurality of molds from one work station to the subsequent one;

at least one moving device adapted to pick up a vulcanised tyre arranged on the toroidal support from said at least one vulcanisation module and to place a green tyre positioned on a respective toroidal support in said at least one vulcanisation module;

at least one mold opening and closing device for the unloading of a vulcanised tyre and the subsequential loading of a green tyre inside a vulcanisation mold.

Brief description of the figures

Further characteristics and advantages of the invention will be more apparent from the following description of some preferred embodiments of apparatuses and methods of vulcanisation methods according to the invention, provided as a non-limiting example, with reference to the appended drawings, wherein:

- Figure 1 shows a plan schematic view of a vulcanisation apparatus for tyres for vehicle wheels according to a preferred embodiment of the invention during a step of the method in question;

- Figure 2 shows a plan schematic view of a vulcanisation apparatus for tyres for vehicle wheels according to a second embodiment of the invention during a step of the method in question;

- Figure 3 shows a plan schematic view of a vulcanisation apparatus for tyres for vehicle wheels according to a third embodiment of the invention during a step of the method in question;

- Figure 4 shows a plan schematic view of a vulcanisation apparatus for tyres for vehicle wheels according to an alternative embodiment of the invention during a step of the method in question;

Detailed description of the preferred embodiments

With reference to figures 1-4, by reference numeral 1 has been generally identified a vulcanisation apparatus for vehicle wheel tyres according to the present invention. The apparatus 1 comprises at least one vulcanisation module 2, preferably a couple of vulcanisation modules 2, wherein a plurality of work stations such as prevulcanisation and molding stations 3, vulcanisation stations 3', and loading and unloading stations 3'' is defined. Said work stations are immovable stations and are adapted to house movable vulcanisation molds 4 during the different steps of the vulcanisation method according to the present invention.

In particular, at each work station may be associated a vulcanisation mold 4 containing a green tyre being processed during a step of the vulcanisation method.

The vulcanisation molds 4 are preferably airtight and are adapted to house a tyre being processed previously arranged or built on a toroidal support, whose external surface substantially reproduces the internal conformation of the tyre to be obtained. Said vulcanisation molds 4 are provided with devices for passage of working fluids as illustrated for example in the International Patent application published under No. WO 2004/045837, in the name of the same Applicant, which is hereby integrally incorporated by reference.

Each vulcanisation module 2 comprises at least one prevulcanisation and molding station 3 and at least one vulcanisation stations 3'.

Said prevulcanisation and molding station 3 is provided with a supplying device of at least one pressurised primary working fluid, preferably heated, and with a supplying device of at least one pressurised secondary working fluid inside the vulcanisation mold 4 temporarily located in the same prevulcanisation and molding station 3.

The pressurised secondary working fluid preferably comprises air, nitrogen or other substantially inert gases, and is adapted to press a radially internal surface of said green tyre towards an external surface of the toroidal support; the pressurised primary working fluid preferably comprises steam and nitrogen or other substantially inert gases, and is adapted to press a radially external surface of the green tyre towards the internal walls of the vulcanisation mold. Said primary and secondary working fluids cooperate in order to carry out a prevulcanisation of the tyre as illustrated in the aforesaid application WO 2004/045837.

In the present description and in the following claims, the term prevulcanisation refers to at least a partial vulcanisation of the radially innermost layer of the tyre and of the bead region.

Whiled the vulcanisation station 3', is provided only with the supplying devices of at least one pressurised primary work fluid, preferably heated, inside the vulcanisation mold temporarily located in the same vulcanisation station 3'.

The pressurised primary working fluid preferably comprises steam or and nitrogen or other substantially inert gases and is adapted to press said radially external surface of the green tyre towards the internal walls of the vulcanisation mold 4 in order to

complete the vulcanisation of the tyre molded and partially vulcanised in the prevulcanisation and molding station 3.

Preferably, the supplying device of said at least one pressurised primary working fluid and the supplying device of said at least one pressurised secondary working fluid of the prevulcanisation and molding station 3 and the supplying device of said at least one pressurised primary working fluid of the vulcanisation station 3' comprise advantageously at least one quick snap-on clutch adapted to rapidly connect the fluid supplying device to the vulcanisation mold 4.

Each mold 4 includes advantageously at least one airtight connector adapted to keep the pressure of said at least one primary working fluid constant inside the mold when the quick snap-on clutch of the supplying device of said pressurised primary working fluid is disconnected.

Each vulcanisation module 2 is further provided with at least one transfer device 5 adapted to transfer each vulcanisation mold 4 from one work station to the subsequent one. Preferably, said at least one transfer device 5 of the vulcanisation molds 4 comprises at least one conveyor belt, not shown in figure 1, which is adapted to transfer each vulcanisation mold 4 at the work station wherein the specific operative step to which the tyre has to be subjected is carried out. Said at least one conveyor belt acts also as a support for said vulcanisation molds 4 which are removably connected thereto.

Alternatively, the aforesaid at least one transfer device 5 may comprise a turntable which may be driven in rotation in order to move each vulcanisation mold 4 at each of the aforesaid work stations.

In a further preferred embodiment and with reference to figure 4 it can be seen that said at least one transfer device 5 may comprise a rotating arm adapted to pick up each vulcanisation mold 4 from one work station to transfer it to the subsequent one.

According to the present invention, each vulcanisation module 2 is operably associated with at least one moving device 6, adapted to pick up from the same vulcanisation module 2 a vulcanised tyre arranged on a respective toroidal support, and to place in the same vulcanisation module 2 a green tyre previously built on a respective toroidal support. Preferably a single moving device 6 is associated with several vulcanisation modules 2, as shown in figure 4. In a preferred embodiment, the moving device 6 may comprise at least one robotised arm, for example, such as the type described in the European Patent EP 1 150 829 in the name of the same Applicant, in case with the addition of auxiliary moving devices.

Each vulcanisation module 2 is also provided with at least one mold opening and closing device adapted to open each vulcanisation mold 4 in order to allow the unloading of the vulcanised tyre and the loading of the green tyre and then the closing of the same mold 4.

Preferably, said mold opening and closing device is integrated in said prevulcanisation and molding station 3. Alternatively it may also be external with respect to the aforesaid station.

The present invention provides that the mold opening and closing device cooperate with the moving device 6 in such a way that when the vulcanisation mold 4 is opened by the opening and closing device, the moving device 6 picks up the toroidal support with the vulcanised tyre from the vulcanisation module 2 and places the toroidal support with the green tyre on the same vulcanisation module 2.

According to a first embodiment, schematically shown in figure 1, the vulcanisation apparatus 1 comprises two vulcanisation modules 2 and, for each vulcanisation module 2, a single prevulcanisation and molding station 3, and a single vulcanisation station 3'.

In a second embodiment, schematically shown in figure 2, the vulcanisation apparatus 1 comprises two vulcanisation modules 2 but, in each vulcanisation module 2, are present a prevulcanisation and molding station 3 and two vulcanisation stations 3'.

Analogously, in a third embodiment, schematically shown in figure 3, the vulcanisation apparatus 1 comprises two vulcanisation modules 2 but, in each vulcanisation module 2, are present one prevulcanisation and molding station 3 and three vulcanisation stations 3'.

According to a fourth embodiment, schematically shown in figure 4, the vulcanisation apparatus 1 comprises two vulcanisation modules 2, each of which is provided with two prevulcanisation and molding stations 2, and four vulcanisation stations 3'. In this embodiment two loading and unloading stations 3'', wherein the unloading of the vulcanised tyres and the loading of the green tyres are performed, are provided. The transfer devices 5 comprise a rotating arm adapted to transfer each vulcanisation mold 4 from one work station to the subsequent one.

In the first three embodiments the tyre loading and unloading operations are carried out in the prevulcanisation and molding stations 3 and therefore no specific loading and unloading stations 3'' have been provided, that is the mold opening and closing device is, in this case, integrated in the prevulcanisation and molding station 3.

Preferably, the number of the vulcanisation stations 3' present in each vulcanisation module 2 is comprised between 2 and 4. In this manner, in fact, it is possible to obtain the maximum efficiency of the apparatus, because, as mentioned previously, the prevulcanisation step which cannot be divided into sub-steps, has a duration period that is far shorter than that of the vulcanisation step. With 2 to 4 vulcanisation stations 3' available for each module 2 and therefore for each prevulcanisation station 3, it is possible to obtain the maximum efficiency of all the elements of the vulcanisation apparatus, as it will be explained in more detail in the following.

Optionally, each vulcanisation station 3' may be provided with heating devices of the vulcanisation molds 4.

Also the prevulcanisation and molding station 3 can be optionally provided with heating devices of the vulcanisation molds 4.

Said heating devices of the vulcanisation molds 4 in the prevulcanisation and molding station 3 and in the vulcanisation station 3' may be associated with said supplying device of said pressurised primary fluid. In particular, the primary working fluid may be used to heat the vulcanisation mold 4. Alternatively, electric resistors may be provided for this purpose.

Each vulcanisation module 2 may be provided with mold change stations 3''', as shown in figure 4. Said mold change stations 3''' are adapted to allow the replacement of the vulcanisation mold 4 according to manufacture needs, for example in case of variation of the size of the tyre to be vulcanised.

In different alternative solutions, such as those shown in figures 1, 2 and 3, for example, the mold change station (in these cases not shown), may coincide with one of the prevulcanisation stations 3 or vulcanisation stations 3' or may be positioned adjacent to one of said stations according to the required layout of the vulcanisation apparatus 1.

With reference to the vulcanisation apparatus 1 shown in figures 1-4, a description of a preferred embodiment of a vulcanisation method according to the invention will be now disclosed. According to a first step, a green tyre, arranged or built on a respective toroidal support, is placed inside a vulcanisation mold 4 which may be operably associated with the plurality of work stations defined in said at least one vulcanisation module 2 of the vulcanisation apparatus 1. Afterwards, the vulcanisation mold 4 is closed, preferably by means of said mold opening and closing devices.

Then the step of connecting a supplying device of the pressurised primary work fluid, preferably heated, and a supplying device of the pressurised secondary work fluid to the vulcanisation mold 4 at the prevulcanisation and molding station 3, is carried out.

At this point, a radially internal portion of the green tyre on the toroidal support is vulcanised at least partially by pressing by means of the pressurised secondary work fluid the radially internal surface of the green tyre towards the external surface of the toroidal support and supplying heat to said portion, preferably by supplying the pressurised primary work fluid inside the toroidal support. It is to be noted that, as shown in WO 2004/045837, in the solution preferred by the Applicant, the secondary working fluid, being adapted to press the radially internal surface of the tyre towards the external surface of the toroidal support, is supplied with a pressure greater than the supply pressure of the primary working fluid, which, during this step is adapted to supply the heat necessary for the aforesaid prevulcanisation.

Afterwards, the tyre molding step is carried out, by disconnecting the supply of the pressurised secondary fluid which is evacuated from the mold, continuing with the single supply of the pressurised primary working fluid inside the toroidal support so as to press the radially external surface of the green tyre towards the internal walls of the vulcanisation mold 4, taking place the step of real vulcanisation.

In a following step, the supplying devices of the pressurised primary working fluid and the supplying device of the pressurised secondary working fluid are disconnected from the vulcanisation mold 4 which is transferred to a vulcanisation station 3'.

In this vulcanisation station 3', a supplying device of the pressurised primary working fluid is connected to the vulcanisation mold 4 and therefore the vulcanisation of the tyre, previously prevulcanised and molded, is completed by supplying heat to the tyre through the pressurised primary working fluid supplied inside the toroidal support. In this step the primary working fluid continues to press the radially external surface of the green tyre towards the internal walls of the vulcanisation mold 4.

At this point, it may be accomplished a step of transferring the vulcanisation mold 4 to a loading and unloading station 3'', which can be integrated in the prevulcanisation and molding station 3, followed by the opening of the vulcanisation mold 4 for the unloading of the molded and vulcanised tyre.

As mentioned previously, the opening of the vulcanisation molds is preferably carried out by mold opening and closing devices which may be optionally integrated in said prevulcanisation and molding station 3, and which cooperate with the aforesaid moving

devices 6 so that when the vulcanisation mold 4 is opened, the moving devices 6 pick up the vulcanised tyre arranged on the respective toroidal support from the vulcanisation module 2 and place a green tyre inside the same module in the vulcanisation mold 4.

Preferably, and in order to maximise the efficiency of the vulcanisation method according to the present invention, the actual vulcanisation step has a duration that substantially coincides with a multiple time of the duration of the prevulcanisation and molding step. In particular, indicating with t1 the total time required for carrying out the following steps:

h) connecting the supplying device of the pressurised primary work fluid to the vulcanisation mold 4 in the vulcanisation station 3';

i) completing the vulcanisation of the molded and prevulcanised tyre by supplying the pressurised primary work fluid inside the toroidal support and pressing a radially external surface of the green tyre towards the internal walls of the vulcanisation mold 4;

j) disconnecting the supplying device of the pressurised primary work fluid;

and indicating with t2 the total time required for carrying out the following steps:

k) opening the vulcanisation mold 4 and unloading the molded and vulcanised tyre from the same vulcanisation mold 4;

a) placing a green tyre, arranged on a respective toroidal support, inside a vulcanisation mold 4 which may be operably associated with the work stations in the vulcanisation module 2;

b) closing the vulcanisation mold 4;

c) connecting the supplying device of the heated pressurised primary work and the supplying device of the pressurised secondary work fluid to the vulcanisation mold 4 in the prevulcanisation and molding station 3;

d) at least partially vulcanising a radially internal portion of the green tyre on the toroidal support pressing by means of said pressurised secondary work fluid a radially internal surface of said green tyre towards an external surface of the toroidal support, and supplying heat to said portion by supplying the pressurised primary work fluid inside the toroidal support;

e) molding and continuing the vulcanisation of the aforesaid tyre by supplying the pressurised primary work fluid inside the toroidal support pressing a radially external surface of the green tyre towards the internal walls of the vulcanisation mold 4;

f) disconnecting from the vulcanisation mold 4, the supplying device of the pressurised primary work fluid and the supplying device of the pressurised secondary work fluid;

the present invention provides that in a preferred embodiment, t1 is substantially equal to m*t2 where m is a whole number greater than or equal to 1 and preferably comprised between 2 and 4.

According to some preferred embodiments, the number of the vulcanisation stations 3' for each vulcanisation module 2 is equal to m in order to have none work station stopped at any time, and in order to obtain the maximum performance from the vulcanisation method and apparatus.

In other words, considering that the total vulcanisation time of a tyre is generally comprised between 18 and 30 minutes, and estimating therefore an average total time of 24 minutes, it is possible to estimate a time t2 equal to 8 minutes, m equal to 2, and therefore a time t1 equal to 16 minutes. In this case, in order to obtain the maximum utilisation degree of the apparatus and method, according to the present invention, it is necessary to plan for each vulcanisation module 2 of the type shown in the figures 1, 2 and 3, a prevulcanisation and molding station 3 and two vulcanisation stations 3', that is the embodiment shown in figure 2. In fact, in this case, when the steps k), a), b), c), d), e) and f) are carried out within a time t2 equal to 8 minutes in the prevulcanisation and molding station 3, the vulcanisation mold 4 is transferred to the vulcanisation station 3' where the steps h), i) and j) are carried out in a time t1 equal to 16 minutes. Therefore it is possible to repeat in this time the steps k), a) and b) in the prevulcanisation station 3 with a new mold 4 which will then be transferred to the second vulcanisation station 3'. In the mean time the vulcanisation of the tyre housed in the first mold 4 in the first vulcanisation station 3' will be completed. Said first mold 4 will therefore be transferred to station 3 for the unloading thus leaving the station 3' free and ready for a third vulcanisation mold.

In this manner, all the various steps of the method are carried out in the work stations substantially simultaneously, thus obtaining the maximum utilisation degree of the apparatus and the method according to the present invention, considerably reducing the dead times in each of the work stations.

In the case wherein m is equal to 1, the stop time of the vulcanisation mold 4 in the prevulcanisation and molding station 3 is substantially equal to its stop time in the vulcanisation station 3' and it is sufficient to provide a single prevulcanisation station 3 and a single vulcanisation station 3' in each vulcanisation module 2, as shown in figure 1.

In this case, it is appropriate to plan different forward and return paths between the prevulcanisation and molding station 3 and the vulcanisation station 3' to optimise the organisation of each vulcanisation module 2 which can be summarised as follows.

Supposing that the two molds 4 are initially unloaded, the moving device 6, for example in the form of a robotised arm, will cooperate with the mold opening and closing device to load a first green tyre in a first mold positioned in the prevulcanisation and molding station 3. The mold is closed and the steps of prevulcanisation, molding and starting the vulcanisation are carried out as described previously. When the time t2 is completed, the first mold will be moved by the transfer device 5 towards the vulcanisation station 3' where the vulcanisation will be completed, while the second mold present in this station is moved by the same transfer device 5 towards the prevulcanisation and molding station 3. Here, a second tyre is loaded into the second mold to start its own prevulcanisation, molding and starting vulcanisation step. When it is completed, in the hypothesised case (m=1), the first tyre has completed its vulcanisation, and therefore the second mold is moved to the vulcanisation station 3', the first mold is brought back to the prevulcanisation and molding station 3, where the first tyre is extracted, while a third tyre is placed inside the first mold. The vulcanisation module 2 therefore continues its own steps of controlling operative mode steps, within the scope of the vulcanisation method, as described above.

It should be noted that the operational organisation described for each vulcanisation module 2 is provided simply as an example for manufacturing running conditions. In fact, different manufacture needs, such as the changing of one or more molds, would involve some procedure variations in the sequences described which however would not modify in any way the vulcanisation method according to the invention.

In the case wherein m is equal to 2, with reference to the vulcanisation module 2 of figure 2, according to the description above, it is possible to resume the controlling operative modes, in the scope of the present vulcanisation method, as follows.

Supposing that the three molds 4 are initially unloaded, the moving device 6, for example in the form of a robotised arm, will cooperate with the mold opening and closing device to load a first green tyre in a first mold positioned in the prevulcanisation

and molding station 3. The mold is closed and as described previously, the steps of prevulcanisation, molding and starting the vulcanisation are carried out. When the time t2 is completed, the first mold is moved by the transfer device 5 towards the first vulcanisation station 3' where the vulcanisation is completed, while a second mold arriving therefrom is moved by the same transfer device 5, for example on a parallel path, towards the prevulcanisation and molding station 3. Here, a second tyre is loaded into a second mold to start its own prevulcanisation, molding and starting vulcanisation step. When this operation is completed, after a further time lapse t2, the second mold is moved by the transfer device 5 towards a second vulcanisation station 3' where the vulcanisation is completed, while a third mold arriving therefrom is moved by the same transfer device 5 for example on a parallel path, towards the prevulcanisation and molding station 3. A third tyre is then loaded on said third mold to start its prevulcanisation, molding and starting vulcanisation step. When this is completed after a further time lapse t2, the third mold is moved by the transfer device 5 towards the first vulcanisation station 3' where it completes its vulcanisation, while the first mold arriving therefrom, when the vulcanisation step is completed (in fact, for the hypothesis made t1=2* t2) is moved towards the prevulcanisation and molding station 3. Here the mold opening and closing device collaborating with the moving device 6 extracts the first vulcanised tyre and inserts a fourth tyre to be vulcanised. The vulcanisation module 2 therefore continues its own controlling operative mode steps, within the scope of the present vulcanisation method, as described above.

It should be noted that the operational organisation here described for each vulcanisation module 2 is provided simply as an example for manufacture running conditions. In fact, different manufacture needs, such as the changing of one or more molds, would involve some procedure variations in the sequences described, which however, would not modify the vulcanisation method according to the invention in any way.

In the case wherein m is equal to 3, the controlling operative modes of the vulcanisation module 2 shown in figure 3 in the vulcanisation method are substantially the same as those described above.

Preferably, the stop time of a vulcanisation mold in each work station is comprised between 9 and 15 minutes, but obviously it will vary according to the type and size of the tyre to be vulcanised.

With reference to figure 4, according to the description above, the controlling operative modes of each vulcanisation module 2 of the vulcanisation apparatus 1, in the

vulcanisation method described above, can be summarised as follows. At the beginning of the vulcanisation method there are, for example, six empty molds 4, each one in a respective work station. The transfer device 6, for example in the form of a rotating arm, picks up a first mold from a first prevulcanisation station 3 moving it to the loading and unloading station 3''. The moving device 6, for example, in the form of a robotised arm, cooperates with the loading and unloading station 3'' inserting into said first mold in open modality, a green tyre built on a respective toroidal support. The first mold is closed and then the rotating arm moves said first mold containing the green tyre to the prevulcanisation and molding station 3 from where it was taken previously. Here, according to the description above, the prevulcanisation, molding and starting vulcanisation steps are carried out. Meanwhile a second mold taken from the second prevulcanisation and molding station 3, is transported to the loading and unloading station 3'', where a second green tyre is placed thereinside by the robotised arm. Also this second mold is picked up by the rotating arm to be moved back to the second prevulcanisation and molding station 3 from where it was picked up previously. Meanwhile a third mold is picked up from a first vulcanisation station 3' and taken to the loading and unloading station 3'' to receive the third green tyre. Once the prevulcanisation and molding has been completed in the first mold, this is transferred by the rotating arm to the first vulcanisation station 3' which has just been vacated, and here the first tyre completes its vulcanisation cycle according to the modalities described above. Meanwhile the third mold is placed in the first prevulcanisation and molding station 3 vacated by the first mold, to carry out the prevulcanisation, molding and starting vulcanisation steps. A fourth mold is transferred from the second vulcanisation station 3' to the loading and unloading station 3'' and then, the second mold, having completed the prevulcanisation, molding and starting vulcanisation step, is moved to the second vulcanisation station 3', vacated by the fourth mold, to complete the vulcanisation step. Proceeding in an analogous manner two other green tyres are loaded on a fifth and sixth mold, and then the corresponding prevulcanisation, molding and starting vulcanisation steps in the respective first and second prevulcanisation and molding stations 3, while the third and fourth molds, having completed the prevulcanisation, molding and starting vulcanisation steps, reach the third and fourth vulcanisation stations 3' vacated by the fifth and sixth molds respectively. Therefore in this condition, there are six loaded molds, four of which are undergoing vulcanisation while two are undergoing prevulcanisation, molding and starting vulcanisation. When the first mold has completed the vulcanisation step, it is moved to the loading and unloading station 3''. Said first mold is then opened and the first vulcanised tyre is picked up by the robotised arm and transferred to an area, not shown, where it is removed from its toroidal support. Meanwhile the fifth mold is transferred to the first

vulcanisation station 3' vacated by the first mold in order to continue its vulcanisation cycle. Therefore the first mold receives a seventh tyre and will begin a new prevulcanisation, molding and starting vulcanisation in the first prevulcanisation and molding station 3 vacated by the fifth mold. The second mold, having completed its vulcanisation step, vacates the second vulcanisation station 3' which is then occupied by the sixth mold, which vacates the second prevulcanisation and molding station 3. A second tyre is then extracted from the second mold and an eighth tyre is placed thereinside to begin the cycle again in the second prevulcanisation and molding station 3 vacated by the sixth mold. The controlling operative modes of vulcanisation module 2, in the vulcanisation method, therefore continue as described above. At the same time, also the other vulcanisation module 2 vulcanises analogously the green tyres sent thereto.

It should be noted that the operational organisation here described for each vulcanisation module 2 is provided simply as an example for manufacture running conditions. In fact, different manufacture needs, such as the changing of one or more molds, would involve some procedure variations in the sequences described, which however, would not modify the vulcanisation method according to the invention in any way.

In the scope of the present above description and in the following claims, all the numerical measurements indicating quantity, parameters, percentages, etc, are to be considered as preceded by the term "about" unless specified otherwise. Moreover, all the intervals of numerical measurement include all possible combinations of maximum and minimum numerical value, as well as all the possible intermediate intervals, other than those specifically indicated in the text.

CLAIMS

1. A vulcanisation method for tyres for vehicle wheels comprising the following steps:

a) placing a green tyre, arranged on a toroidal support, inside a vulcanisation mold (4) which may be operably associated with a plurality of work stations (3, 3', 3'', 3''') defined in at least one vulcanisation module (2);

b) closing said vulcanisation mold (4);

c) connecting a supplying device of at least one pressurised primary working fluid and a supplying device of at least one pressurised secondary working fluid to the vulcanisation mold (4) in a prevulcanisation and molding station (3);

d) at least partially vulcanising a radially internal portion of the green tyre on the toroidal support by the pressing said pressurised secondary working fluid on a radially internal surface of said green tyre towards an external surface of the toroidal support, and supplying heat to said portion of the tyre;

e) molding and continuing the vulcanisation of the aforesaid tyre by supplying at least one pressurised primary working fluid inside the toroidal support pressing a radially external surface of the green tyre towards the internal walls of the vulcanisation mold (4);

f) disconnecting the supplying device of said at least one pressurised primary working fluid and the supplying device of said at least one pressurised secondary working fluid from the vulcanisation mold (4);

g) transferring the mold to a vulcanisation station (3');

h) connecting a respective supplying device of at least one pressurised primary working fluid to the vulcanisation mold (4) in said vulcanisation station (3');

i) completing the vulcanisation of the tyre molded and prevulcanised during steps d) and e), supplying said at least one pressurised primary working fluid inside the toroidal support, pressing a radially external surface of the green tyre towards the internal walls of the vulcanisation mold (4) and supplying heat to the aforesaid tyre;

j) disconnecting the supplying device of said at least one pressurised primary working fluid;

k) opening the mold (4) and unloading the molded and vulcanised tyre from the vulcanisation mold (4).

2. A vulcanisation method for tyres for vehicle wheels according to claim 1, wherein said step k) of opening the vulcanisation mold (4) and unloading the tyre, is carried out at a work station (3, 3', 3'', 3''') provided with at least one mold opening and closing device.

3. A vulcanisation method for tyres for vehicle wheels according to claim 2, wherein said mold opening and closing device is integrated in said prevulcanisation and molding station (3).

4. A vulcanisation method for tyres for vehicle wheels according to claim 2, wherein said mold opening and closing device is integrated in a specific loading and unloading station (3'').

5. A vulcanisation method according to any of the previous claims, wherein the heat supplied to said radially internal portion of the green tyre in step d) of partial vulcanisation is supplied by said at least one pressurised primary work fluid supplied into said toroidal support.

6. A vulcanisation method according to any of the previous claims, wherein the heat supplied to said green tyre in the vulcanisation step i), is supplied by feeding said at least one heated pressurised primary work fluid inside said toroidal support.

7. A vulcanisation method according to any of the previous claims, wherein, the total time for carrying out the steps h) + i) + j) being equal to t1, and the total time for carrying out the steps k) + a) + b) + c) + d) + e) + f) being equal to t2, $t1 = m * t2$, where m is a whole number greater than or equal to 1.

8. A vulcanisation method according to claim 7, wherein m is comprised between 2 and 4.

9. A vulcanisation method according to claim 7, wherein the vulcanisation mold (4) stops at each work station (3, 3', 3'', 3''') for a stop time comprised between about 9 and about 15 minutes.

10. A vulcanisation method according to claim 7, wherein the vulcanisation mold (4) stops in the prevulcanisation and molding station (3) for a period of time substantially equal to the time it stops in the vulcanisation station (3').

11. A vulcanisation method according to any of the previous claims, wherein said primary working fluid comprises steam.

12. A vulcanisation method according to any of the previous claims, wherein said primary working fluid comprises an inert gas.

13. A vulcanisation method according to any of the previous claims, wherein said secondary working fluid comprises an inert gas.

14. A vulcanisation apparatus for tyres for vehicle wheels comprising at least one vulcanisation module (2) wherein is defined a plurality of work stations (3, 3', 3'', 3''') to which a plurality of vulcanisation molds (4), each containing a green tyre being processed arranged on a respective toroidal support, may operably be associated, said vulcanisation module comprising the following work stations:

at least one prevulcanisation and molding station (3) provided with a supplying device of at least one pressurised primary work fluid and of a supplying device of at least one pressurised secondary work fluid inside a vulcanisation mold (4) located in said station (3), said pressurised secondary work fluid being adapted to press a radially internal surface of said green tyre towards an external surface of the toroidal support, said pressurised primary work fluid being adapted to press a radially external surface of the green tyre towards the internal walls of the vulcanisation mold (4);

at least one vulcanisation station (3') provided with a respective supplying device of said at least one pressurised primary work fluid inside a vulcanisation mold (4) located in said station (3'), said pressurised primary work fluid being adapted to press said radially external surface of the green tyre towards the internal walls of the vulcanisation mold (4) in order to complete the vulcanisation of the molded and partially vulcanised tyre;

at least one transfer device (5) adapted to sequentially transfer each vulcanisation mold (4) of said plurality of molds from one work station (3, 3') to the subsequent;

at least one moving device (6) adapted to pick up a vulcanised tyre arranged on a respective toroidal support from said at least one vulcanisation module (2) and to place a green tyre arranged on a respective toroidal support in said at least one vulcanisation module (2);

at least one mold opening and closing device for unloading a vulcanised tyre and subsequentially loading a green tyre inside a vulcanisation mold (4).

15. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 14, wherein said mold opening and closing device is integrated in said prevulcanisation and molding station (3).

16. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 14 or 15, wherein said mold opening and closing device cooperates with said moving device (6).

17. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 15 or 16, wherein the number of said vulcanisation stations (3') is comprised between 2 and 4 for each vulcanisation module (2).

18. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 15 or 16, wherein each vulcanisation module (2) comprises a single vulcanisation station (3').

19. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 18, wherein said supplying device of said at least one pressurised primary work fluid and said supplying device of said at least one pressurised secondary work fluid of the prevulcanisation and molding station (3) and said supplying device of said at least one pressurised primary work fluid of said at least one vulcanisation station (3') comprise at least one quick snap-on clutch which may be associated to the vulcanisation mold (4).

20. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 19, wherein said vulcanisation molds (4) are removably connected to said at least one transfer device (5).

21. A vulcanisation apparatus for tyres for vehicle wheels according to any of claims from 14 to 20, wherein said at least one transfer device (5) of the mold (4) from one work station (3, 3') to the subsequent station comprises a turntable adapted to support the vulcanisation molds (4), said turntable being operable in rotation to sequentially bring each vulcanisation mold (4) at each of said work stations (3, 3', 3'', 3''').

22. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 20, wherein said at least one transfer device (5) of the mold (4) from one work station (3, 3') to the subsequent station comprises at least a conveyor belt adapted to support the vulcanisation molds (4) and to sequentially move each vulcanisation mold (4) at each of said work stations (3, 3', 3'', 3''').

23. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 20, wherein said at least one transfer device (5) of the mold (4) from one

work station (3, 3', 3'', 3''') to the subsequent station comprises at least one rotating arm.

24. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 23, wherein said moving device (6) comprises at least one robotised arm.

25. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 24, wherein each vulcanisation station (3') provides for devices for heating the molds.

26. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 25, wherein said prevulcanisation and molding station (3) provides for devices for heating the molds.

27. A vulcanisation apparatus (1) for tyres for vehicle wheels according to either of the claims 25 or 26 wherein said heating devices are associated to said supplying device of said at least one pressurised primary fluid.

28. A vulcanisation apparatus (1) for tyres for vehicle wheels according to either of the claims 25 or 26, wherein said heating devices comprise heating devices in heat exchanging relation with said toroidal support.

29. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 28, wherein said heating devices comprise at least one electrical resistor.

30. A vulcanisation apparatus (1) for tyres for vehicle wheels according to any of claims from 14 to 29, wherein said vulcanisation module (2) comprises at least one mold change station (3''') adapted to replace the vulcanisation mold (4).

31. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 30, wherein said mold change station (3''') is integrated in a vulcanisation station (3').

32. A vulcanisation apparatus (1) for tyres for vehicle wheels according to claim 30, wherein said mold change station (3''') is integrated in a prevulcanisation and molding station (3).

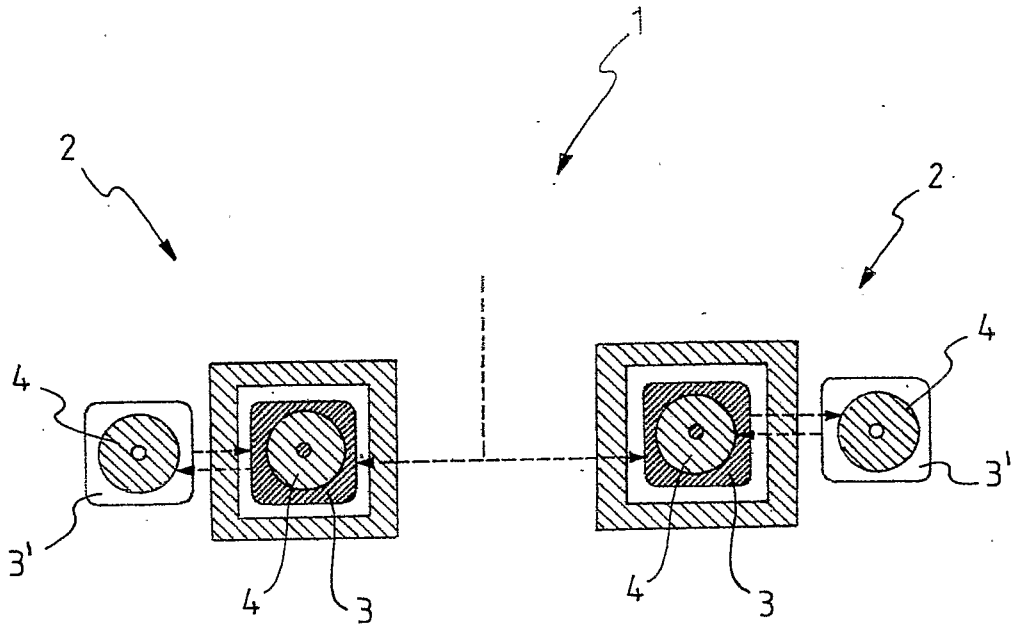


Fig. 1

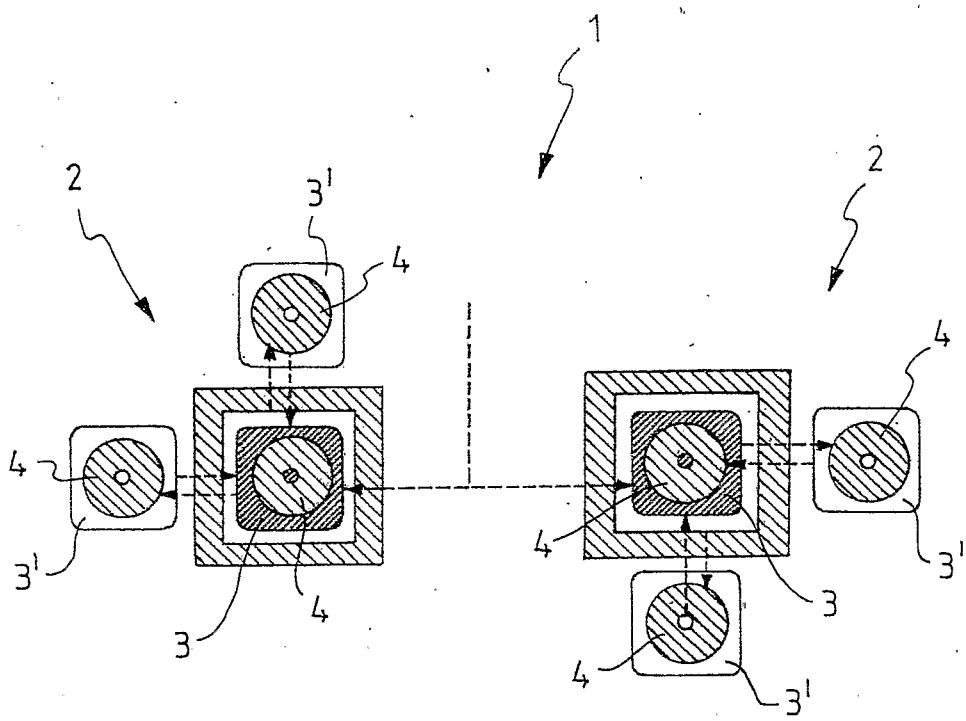


Fig. 2

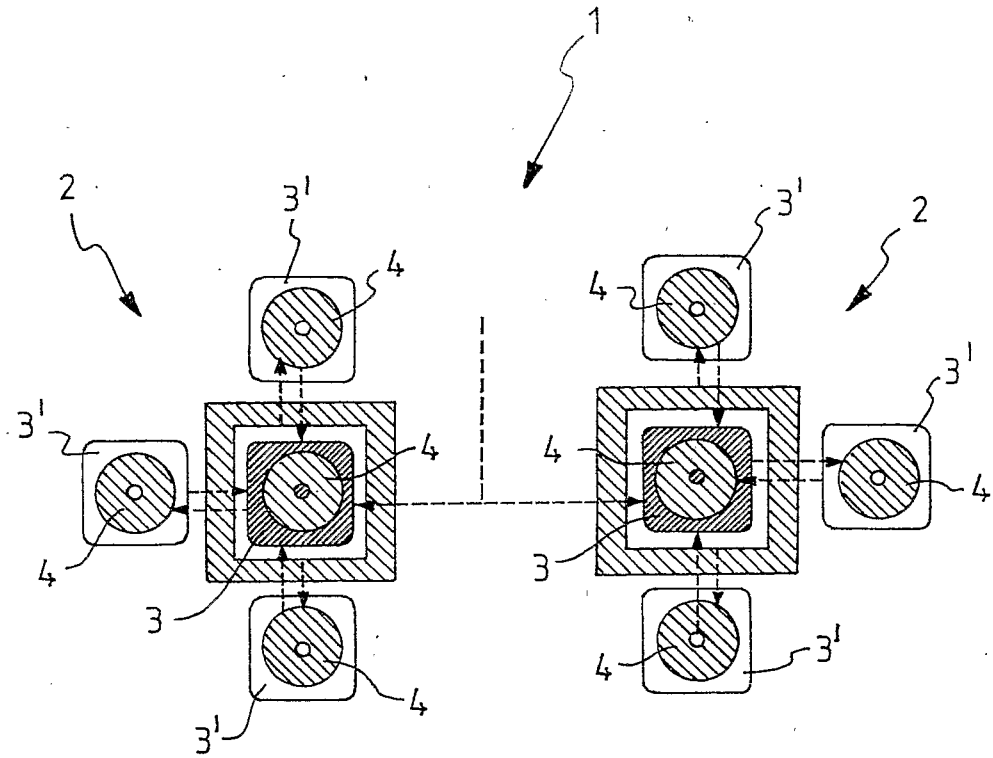


Fig. 3

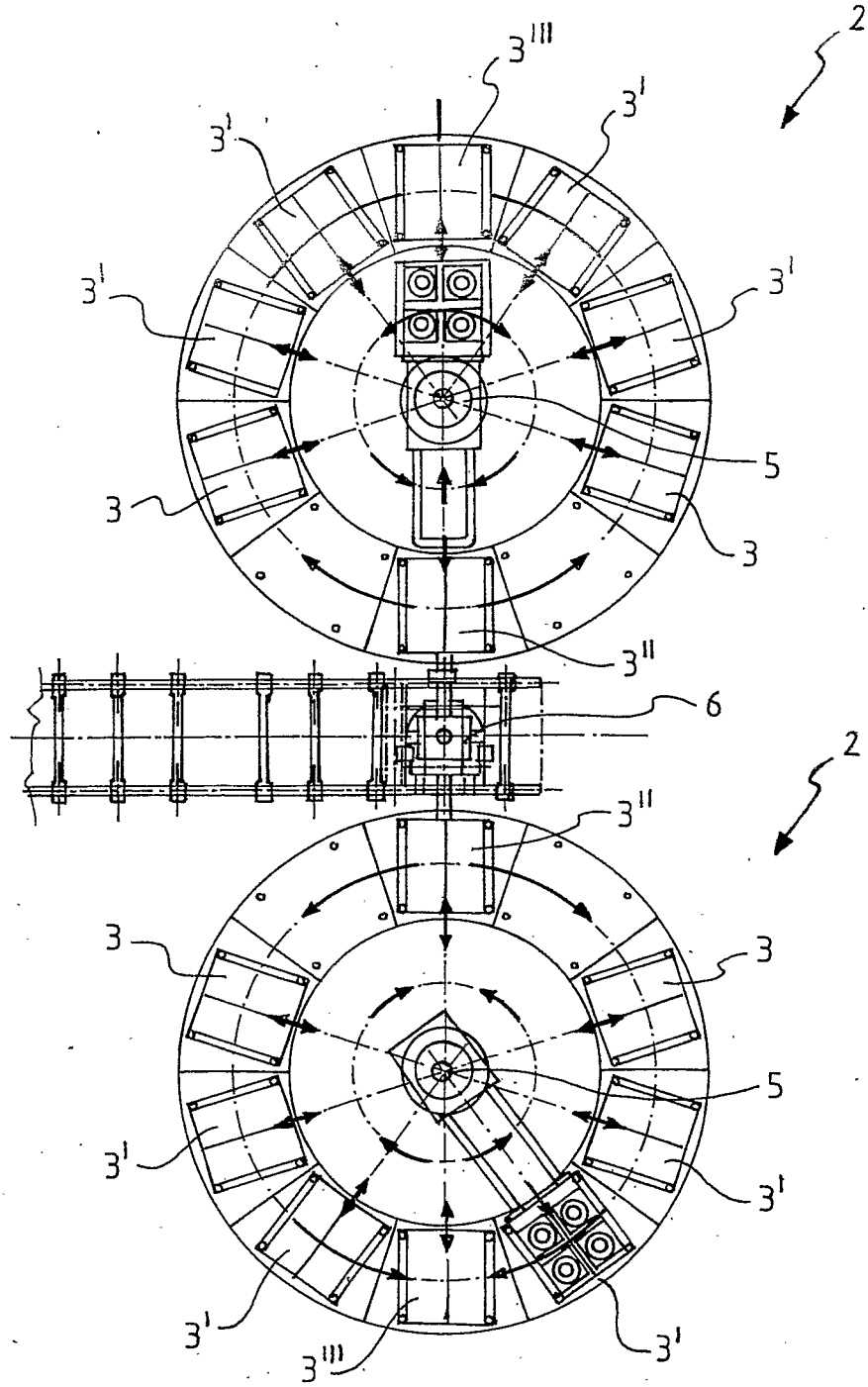


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
../IT2005/000461

A. CLASSIFICATION OF SUBJECT MATTER
B29D30/06

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

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 practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004/045837 A1 (PIRELLI) 3 June 2004 (2004-06-03) cited in the application claims; figures	1-32
A	WO 03/092988 A (PIRELLI PNEUMATICI S.P.A; CARETTA, RENATO; MARCHINI, MAURIZIO) 13 November 2003 (2003-11-13) page 4, line 32 - page 15, line 31; claims; figures	1-32
A	US 5 622 669 A (DAILLIEZ ET AL) 22 April 1997 (1997-04-22) column 3, line 41 - column 5, line 50; figure	1-32

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[X] Further documents are listed in the continuation of Box C.

[X] 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

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 February 2006	16/02/2006

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2005/000461

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No
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