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(54) Title: AGRICULTURAL TIRE TREAD

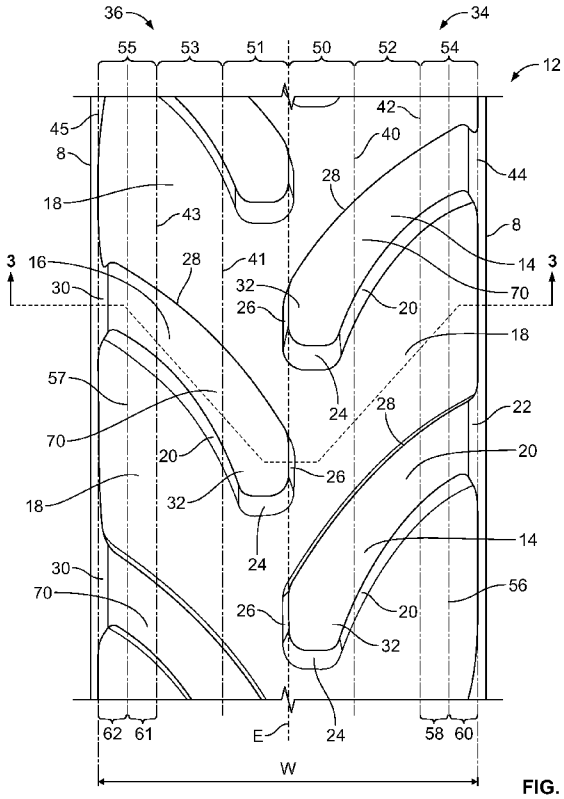

FIG. 2

(57) Abstract: An agricultural tire has an equatorial plane separating first and second sides. First and second inner sixths of the treads extend between the equatorial plane and circumferential reference planes disposed axially one-sixth of a tread width on either side of the equatorial plane. First and second middle sixths of the tread extend between inner circumferential planes and middle circumferential reference planes one-sixth of the tread width from the inner circumferential reference planes. Outer sixths extend between the middle circumferential reference planes and outer circumferential reference planes disposed one-sixth of the tread width from the middle planes. Net tread volume ratio is approximately 40 percent, where between 36 and 39 percent of lug volume is in the inner sixths, between 32 to 35 percent in the middle sixths, and 27 to 30 percent in the outer sixths of the tread.

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AGRICULTURAL TIRE TREAD

Field of Invention

[0001] The present disclosure is directed to a tire for agricultural use, and in particular to agricultural tires suitable for use in muddy or loose soil.

Background

[0002] Agricultural tires often have treads with relatively deep lugs that provide traction in muddy or loose soil conditions where conventional tires would be unable to operate. Such lugs however, are not ideal for travel on hard surfaces such as on paved roads between work sites. Use on such surfaces causes wear that can quickly and undesirably reduce lug depth, thereby rendering the tire less effective in muddy or loose soil conditions.

Summary

[0003] A pneumatic agricultural tire has an equatorial plane separating a first side and a second side, the lugs having an R-1W tread depth. First and second inner sixth of the treads tread extend between the equatorial plane and a first circumferential reference planes on disposed axially one-sixth of a tread width from the equatorial plane. First and second middle sixths of the tread extend between inner circumferential reference planes and middle circumferential reference planes disposed axially one-sixth of the tread width from the inner circumferential reference planes. Outer sixths of the tread extend between the middle circumferential reference planes and a outer circumferential reference planes disposed axially one-sixth of the tread width from the middle circumferential reference planes. A net tread volume ratio is approximately 40 percent, where between 36 and 39 percent of a volume of the lugs is in the inner sixths, between 32 to 35 percent in the middle sixths, and 27 to 30 percent in the outer sixths of the tread.

Brief Description Of The Drawings

[0004] In the accompanying drawings, structures are illustrated that, together with the detailed description provided below, describe exemplary embodiments of a tire tread for agricultural tires. One of ordinary skill in the art will appreciate that a single component may be designed as multiple components or that multiple components may be designed as a single component. Further, in the accompanying drawings and description that follow, like parts are indicated throughout the drawings and written description with the same reference numerals, respectively.

[0005] **Figure 1** illustrates a perspective view of a tire according to one example embodiment.

[0006] **Figure 2** illustrates a top view of a portion of a tire tread according to one example embodiment.

[0007] **Figure 3** illustrates a cross sectional view of a an exemplary tire tread along the line **3-3** shown in **Figure 2**.

Detailed Description

[0008] The following includes definitions of selected terms employed herein. The definitions include various examples and/or forms of components that fall within the scope of a term and that may be used for implementation. The examples are not intended to be limiting. Both singular and plural forms of terms may be within the definitions.

[0009] "Axial" or "axially" refer to a direction that is parallel to the axis of rotation of a tire.

[0010] "Circumferential" and "circumferentially" refer to lines or directions extending along the perimeter of the surface of the tread parallel to the equatorial plane perpendicular to the axial direction of the tire.

[0011] "Equatorial plane" refers to the plane that is perpendicular to the tire's axis of rotation and passes through the center of the tire's tread.

[0012] "Lateral" or "laterally" refer to a direction along the tread of the tire going from one sidewall of the tire to the other sidewall.

[0013] "Radial" or "radially" refer to a direction perpendicular to the axis of rotation of the tire.

[0014] "Sidewall" refers to that portion of the tire between the tread and the bead.

[0015] The terms "inward" and "inwardly" refer to a general direction toward the equatorial plane of the tire, whereas "outward" and "outwardly" refer to a general direction away from the equatorial plane of the tire and toward the sidewall of the tire. Thus, when relative directional terms such as "inner" and "outer" are used in connection with an element, the "inner" element is spaced closer to the equatorial plane of the tire than the "outer" element.

[0016] **Figure 1** illustrates a perspective view of an agricultural tire **10** having an exemplary tire tread **12** according to the present disclosure. A pair of sidewalls **8** extend radially inward from tread **12** to a pair of beads **9.** As discussed below with respect to **Figure 2**, an equatorial plane separates first side **34** and second side **36** of tire **10**, with lugs located on the first side denoted first lugs and lugs located on the second side denoted as second lugs. As shown in **Figure 1**, first tread lugs **14** and second tread lugs **16** are evenly spaced around the circumference of tire **10** and extend radially outward from an inner tread surface **18**. First lugs **14** have an arcuate leading edge **20** that extends from a first lateral tread edge **22** to a leading nose edge **24**. As used herein, the term "leading" refers to portions of the lugs that are the first to contact the surface upon which the tire travels, while "trailing" refers to portions of the lug that are the last to leave the surface upon which the tire travels. The leading nose edge **24** extends substantially axially from arcuate leading edge **20** to an inner nose edge **26**, which in turn extends substantially circumferentially from leading nose edge **24** to an arcuate trailing edge **28**. Arcuate trailing edge **28** extends from inner nose edge **26** to first lateral tread edge **22**.

Similarly, second tread lugs **16** have an arcuate leading edge **20** that extends from a second lateral tread edge **30** to a leading nose edge **24.** Leading nose edge **24** extends substantially axially from arcuate leading edge **20** to an inner nose edge **26**, which in turn extends substantially circumferentially from leading nose edge **24** to an arcuate trailing edge **28**. Arcuate trailing edge **28** of second lugs **16** extends from inner nose edge **26** to second lateral tread edge **30**. Each of first **14** and second lugs **16** has a bar nose **32** at the inward portion of lugs **14**, **16**.

[0017] **Figure 2** is a top view of a portion of an exemplary tire tread **12** shown in **Figure 1**. An equatorial plane **E** separates first side **34** and second side **36** of tire **10**. In the preferred embodiment, first **14** and second lugs **16** do not cross equatorial plane **E.** However, in other embodiments, lugs may cross equatorial plane **E**. Tread **12** has a width **W** that extends axially from first lateral tread edge **22** to second lateral tread edge **30**. Several circumferential reference planes that are parallel to the circumferential plane are shown in **Figure 2** dividing tread **12** into zones. First inner reference plane **40**, first middle reference plane **42** and first outer reference plane **44** are on first side **34** of tire **10**, while second inner reference plane **41**, second middle reference plane **43** and second outer reference plane **45** are on second side **36** of tire **10**.

[0018] With continued reference to **Figure 2**, first inner reference plane **40** is spaced a distance equal to one-sixth of tread width **W** from equatorial plane **E**, and along with equatorial plane **E** defines a first inner sixth **50** of tread **12**. Second inner reference plane **41** is spaced a distance equal to one-sixth of tread width **W** from equatorial plane **E**, and along with equatorial plane **E** defines a second inner sixth **51** of tread **12**. First middle reference plane **42** is spaced a distance equal to one-sixth of tread width **W** from first inner reference plane **40**, and together with first inner reference plane **40** defines a first middle sixth **52** of tread **12**. Second middle reference plane **43** is spaced a distance equal to one-sixth of tread width **W** from second inner reference plane **41**, and together with second inner reference plane **41** defines a second middle sixth **53** of tread **12**. First outer reference plane **44** is spaced a distance equal to one-sixth of tread width **W** from first middle reference plane **42**, and together with first middle reference plane **42** defines a first outer sixth **54** of tread **12**. Second outer reference plane **45** is spaced a distance

equal to one-sixth of tread width **W** from second middle reference plane **43**, and together with second middle reference plane **43** defines a second outer sixth **55** of tread **12**. A first intermediate plane **56** parallel to equatorial plane **E** is located equidistantly between first middle reference plane **42** and first outer reference plane **44**, and defines a first inner twelfth **58** and first outer twelfth **60**, each having a width of one-twelfth of tread width **W**. A second intermediate plane **57** parallel to equatorial plane **E** is located equidistantly between second middle reference plane **43** and second outer reference plane **45**, and defines a second inner twelfth **61** and second outer twelfth **62**, each having a width of one-twelfth of tread width **W**.

[0019] **Figure 3** illustrates a cross sectional view of tire **10** along the line **3-3** shown in **Figure 2**. A reinforcing belt layer **74**, which may include one or more layers of, for example, reinforcing cords, is shown located radially inward relative to tread **12**. A carcass ply **76** is partially wrapped around bead cores **72** in a conventional manner. As shown in **Figure 3**, first **14** and second lugs **16** extend from inner tread surface **18** to a road contacting surface **70**. In the preferred embodiment, first **14** and second lugs **16** have an R-1W rated depth, which is 120 percent of an R-1 rated depth as promulgated by The Tire and Rim Association, Inc. and published, for example, in its 2010 Year Book, incorporated herein by reference. As used herein, the net tread volume ratio is the volume of first **14** and second lugs **16** between inner tread surface **18** and road contacting surface **70**, and between first lateral tread edge **22** and second lateral tread edge **30**, divided by the volume of an envelope defined by inner tread surface **18**, road contacting surface **70**, first lateral tread edge **22** and second lateral tread edge **30**, rotated about the axis of rotation of tire **10**. In the preferred embodiment, the net tread volume ratio is within the range of 38 to 42 percent, and is preferably approximately 40 percent.

[0020] With reference to **Figures 2** and **3**, the total relative volume of lugs located in first **50** and second inner sixths **51** is between 36 and 39 percent of the total lug volume of tire **10**, and preferably approximately 38 percent of the total lug volume. The total relative volume of lugs located in first **52** and second middle sixths **53** is between 32 and 35 percent of the total lug volume, and preferably approximately 34 percent of the total lug volume. The total relative volume of lugs located in first **54** and second outer sixths

55 is between 27 and 30 percent of the total lug volume, and preferably approximately 28 percent of the total lug volume. In addition, in the illustrated embodiment, between 12 to 14 percent of the total lug volume is in first **58** and second inner twelfths **61** and between 14 to 16 percent of the total lug volume is in first **60** and second outer twelfths **62**.

[0021] In one preferred embodiment, first **14** and second tread lugs **16** are configured such that upon a reduction of tread volume of 50 percent caused by normal wear conditions, the tread depth will be greater than 46 percent of the original tread depth found on the exemplary tire prior to use. In another embodiment, upon a reduction of tread volume of 50 percent caused by normal wear conditions, the tread depth will be approximately 50 percent of the original tread depth found on the exemplary tire prior to its use.

[0022] For the purposes of this disclosure and unless otherwise specified, "a" or "an" means "one or more." To the extent that the term "includes" or "including" is used in the specification or the claims, it is intended to be inclusive in a manner similar to the term "comprising" as that term is interpreted when employed as a transitional word in a claim. Furthermore, to the extent that the term "or" is employed (e.g., A or B) it is intended to mean "A or B or both." When the applicants intend to indicate "only A or B but not both" then the term "only A or B but not both" will be employed. Thus, use of the term "or" herein is the inclusive, and not the exclusive use. See, Bryan A. Garner, A Dictionary of Modern Legal Usage 624 (2d. Ed. 1995). Also, to the extent that the terms "in" or "into" are used in the specification or the claims, it is intended to additionally mean "on" or "onto." Furthermore, to the extent the term "connect" is used in the specification or claims, it is intended to mean not only "directly connected to," but also "indirectly connected to" such as connected through another component or multiple components.

[0023] While the present disclosure illustrates various embodiments, and while these embodiments have been described in some detail, it is not the intention of the applicant to restrict or in any way limit the scope of the claimed invention to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details and illustrative examples shown and described. Accordingly, departures may be made from such details

without departing from the spirit or scope of the applicant's claimed invention. Moreover, the foregoing embodiments are illustrative, and no single feature or element is essential to all possible combinations that may be claimed in this or a later application.

Claims

1. A pneumatic agricultural tire having an equatorial plane separating a first side and a second side of the tire, comprising:

a tread having an inner tread surface, first lugs on the first side of the tire extending from a first lateral tread edge toward the equatorial plane and second lugs on the second side of the tire extending from the second lateral tread edge toward the equatorial plane, the first and second lugs extending radially outward from the inner tread surface and having an R-1W depth;

a first inner sixth of the tread extending between the equatorial plane and a first inner circumferential reference plane on the first side disposed axially one-sixth of a tread width from the equatorial plane;

a second inner sixth of the tread extending between the equatorial plane and a second inner circumferential reference plane on the second side disposed axially one-sixth of the tread width from the equatorial plane;

a first middle sixth of the tread extending between the first inner circumferential reference plane and a first middle circumferential reference plane on the first side disposed axially one-sixth of the tread width from the first inner circumferential reference plane;

a second middle sixth of the tread extending between the second inner circumferential reference plane and a second middle circumferential reference plane on the second side disposed axially one-sixth of the tread width from the second inner circumferential reference plane;

a first outer sixth of the tread extending between the first middle circumferential reference plane and a first outer circumferential reference plane on the first side disposed axially one-sixth of the tread width from the first middle circumferential reference plane;

a second outer sixth of the tread extending between the second middle circumferential reference plane and a second outer circumferential reference plane on the second side disposed axially one-sixth of the tread width from the second middle circumferential reference plane; and

a net tread volume ratio of the first and second lugs is approximately 40 percent, and between 36 and 39 percent of a volume of the first and second lugs is in the first and second inner sixths of the tread, between 32 to 35 percent of the volume of the first and second lugs is in the first and second middle sixths of the tread; and 27 to 30 percent of the volume of the first and second lugs is in the first and second outer sixths of the tread.

2. The tire of claim 1 wherein approximately 38 percent of the volume of the first and second lugs is in the first and second inner sixths of the tread, approximately 34 percent of the volume of the first and second lugs is in the first and second middle sixths of the tread; and approximately 28 percent of the volume of the first and second lugs is in the first and second outer sixths of the tread.

3. The tire of claim 1 further comprising:

a first inner twelfth and first outer twelfth of the tread, the first inner twelfth disposed between the first middle circumferential reference plane and a first intermediate circumferential reference plane disposed one-twelfth of the tread width from the first middle circumferential reference plane and the first outer circumferential reference plane, the first outer twelfth disposed between the first intermediate circumferential reference plane and first outer circumferential reference plane;

a second inner twelfth and second outer twelfth of the tread, the second inner twelfth disposed between the second middle circumferential reference plane and a second intermediate circumferential reference plane disposed one-twelfth of the tread width from the second middle circumferential reference plane and the second outer circumferential reference plane, the second outer twelfth disposed between the second intermediate circumferential reference plane and second outer circumferential reference plane; and

between 12 to 14 percent of the volume of the first and second lugs is in the first and second inner twelfth and between 14 to 16 percent of volume of the first and second lugs is in the first and second outer twelfth.

4. The tire of claim 3 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be greater than 46 percent of the original tread depth.

5. The tire of claim 4 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be approximately 50 percent of the original tread depth.

6. The tire of claim 1 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be greater than 46 percent of the original tread depth.

7. The tire of claim 6 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be approximately 50 percent of the original tread depth.

8. A pneumatic agricultural tire having an equatorial plane separating a first side and a second side of the tire, comprising:

a tread having an inner tread surface, first lugs on the first side of the tire extending from a first lateral tread edge toward the equatorial plane and second lugs on the second side of the tire extending from a second lateral tread edge toward the equatorial plane, the first and second lugs extending radially outward from the inner tread surface and having an R-1W depth;

a first inner sixth of the tread extending between the equatorial plane and a first inner circumferential reference plane on the first side disposed axially one-sixth of a tread width from the equatorial plane;

a second inner sixth of the tread extending between the equatorial plane and a second inner circumferential reference plane on the second side disposed axially one-sixth of the tread width from the equatorial plane;

a first middle sixth of the tread extending between the first inner circumferential reference plane and a first middle circumferential reference plane on the first side disposed axially one-sixth of the tread width from the first inner circumferential reference plane;

a second middle sixth of the tread extending between the second inner circumferential reference plane and a second middle circumferential reference plane on the second side disposed axially one-sixth of the tread width from the second inner circumferential reference plane;

a first outer sixth of the tread extending between the first middle circumferential reference plane and a first outer circumferential reference plane on the first side disposed axially one-sixth of the tread width from the first middle circumferential reference plane;

a second outer sixth of the tread extending between the second middle circumferential reference plane and a second outer circumferential reference plane on the second side disposed axially one-sixth of the tread width from the second middle circumferential reference plane;

a net-to-gross volume ratio of the first and second lugs is approximately 40 percent, and between 36 and 39 percent of a volume of the first and second lugs is in the first and second inner sixths of the tread, between 32 to 35 percent of the volume of the first and second lugs is in the first and second middle sixths of the tread; and 27 to 30 percent of the volume of the first and second lugs is in the first and second outer sixths of the tread and wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be greater than 46 percent of the original tread depth.

9. The tire of claim 8 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal

wear conditions occurs, the tread depth will be approximately 50 percent of the original tread depth.

10. The tire of claim 8 wherein approximately 38 percent of the volume of the first and second lugs is in the first and second inner sixths of the tread, approximately 34 percent of the volume of the first and second lugs is in the first and second middle sixths of the tread; and approximately 28 percent of the volume of the first and second lugs is in the first and second outer sixths of the tread.

11. The tire of claim 8 further comprising:

a first inner twelfth and first outer twelfth of the tread, the first inner twelfth disposed between the first middle circumferential reference plane and a first intermediate circumferential reference plane disposed one-twelfth of the tread width from the first middle circumferential reference plane and the first outer circumferential reference plane, the first outer twelfth disposed between the first intermediate circumferential reference plane and first outer circumferential reference plane;

a second inner twelfth and second outer twelfth of the tread, the second inner twelfth disposed between the second middle circumferential reference plane and a second intermediate circumferential reference plane disposed one-twelfth of the tread width from the second middle circumferential reference plane and the second outer circumferential reference plane, the second outer twelfth disposed between the second intermediate circumferential reference plane and second outer circumferential reference plane;

between 12 to 14 percent of the volume of the first and second lugs is in the first and second inner twelfth and between 14 to 16 percent of the volume of the first and second lugs is in the first and second outer twelfth.

12. The tire of claim 11 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear

conditions occurs, the tread depth will be approximately 50 percent of the original tread depth.

13. A pneumatic agricultural tire having an equatorial plane separating a first side and a second side of the tire, comprising:

a tread having an inner tread surface, first lugs on the first side of the tire extending from a first lateral tread edge toward the equatorial plane and second lugs on the second side of the tire extending from a second lateral tread edge toward the equatorial plane, the first and second lugs having an arcuate leading edge extending from one of the first and second lateral tread edge to a leading nose edge extending substantially axially from the arcuate leading edge to an inner nose edge, the inner nose edge extending substantially circumferentially from the leading nose edge to an arcuate trailing edge extending from the inner nose edge to the one of the first and second lateral tread edge;

a first inner sixth of the tread extending between the equatorial plane and a first inner circumferential reference plane on the first side disposed axially one-sixth of a tread width from the equatorial plane;

a second inner sixth of the tread extending between the equatorial plane and a second inner circumferential reference plane on the second side disposed axially one-sixth of the tread width from the equatorial plane;

a first middle sixth of the tread extending between the first inner circumferential reference plane and a first middle circumferential reference plane on the first side disposed axially one-sixth of the tread width from the first inner circumferential reference plane;

a second middle sixth of the tread extending between the second inner circumferential reference plane and a second middle circumferential reference plane on the second side disposed axially one-sixth of the tread width from the second inner circumferential reference plane;

a first outer sixth of the tread extending between the first middle circumferential reference plane and a first outer circumferential reference plane

on the first side disposed axially one-sixth of the tread width from the first middle circumferential reference plane;

a second outer sixth of the tread extending between the second middle circumferential reference plane and a second outer circumferential reference plane on the second side disposed axially one-sixth of the tread width from the second middle circumferential reference plane; and

a net tread volume ratio of the first and second lugs is approximately 40 percent, and between 36 and 39 percent of a volume of the first and second lugs is in the first and second inner sixths of the tread, between 32 to 35 percent of the volume of the first and second lugs is in the first and second middle sixths of the tread; and 27 to 30 percent of the volume of the first and second lugs is in the first and second outer sixths of the tread.

14. The tire of claim 13 wherein approximately 38 percent of the volume of the first and second lugs is in the first and second inner sixths of the tread, approximately 34 percent of the volume of the first and second lugs is in the first and second middle sixths of the tread; and approximately 28 percent of the volume of the first and second lugs is in the first and second outer sixths of the tread.

15. The tire of claim 13 further comprising:

a first inner twelfth and first outer twelfth of the tread, the first inner twelfth disposed between the first middle circumferential reference plane and a first intermediate circumferential reference plane disposed one-twelfth of the tread width from the first middle circumferential reference plane and the first outer circumferential reference plane, the first outer twelfth disposed between the first intermediate circumferential reference plane and first outer circumferential reference plane;

a second inner twelfth and second outer twelfth of the tread, the second inner twelfth disposed between the second middle circumferential reference plane and a second intermediate circumferential reference plane disposed one-twelfth of the tread width from the second middle circumferential reference plane and the

second outer circumferential reference plane, the second outer twelfth disposed between the second intermediate circumferential reference plane and second outer circumferential reference plane; and

between 12 to 14 percent of the volume of the first and second lugs is in the first and second inner twelfth and between 14 to 16 percent of the volume of the first and second lugs is in the first and second outer twelfth.

16. The tire of claim 15 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be greater than 46 percent of the original tread depth.

17. The tire of claim 16 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be approximately 50 percent of the original tread depth.

18. The tire of claim 13 herein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be greater than 46 percent of the original tread depth.

19. The tire of claim 18 wherein the first and second lugs are configured such that when a reduction of 50 percent of the volume of the first and second lugs under normal wear conditions occurs, the tread depth will be approximately 50 percent of the original tread depth.

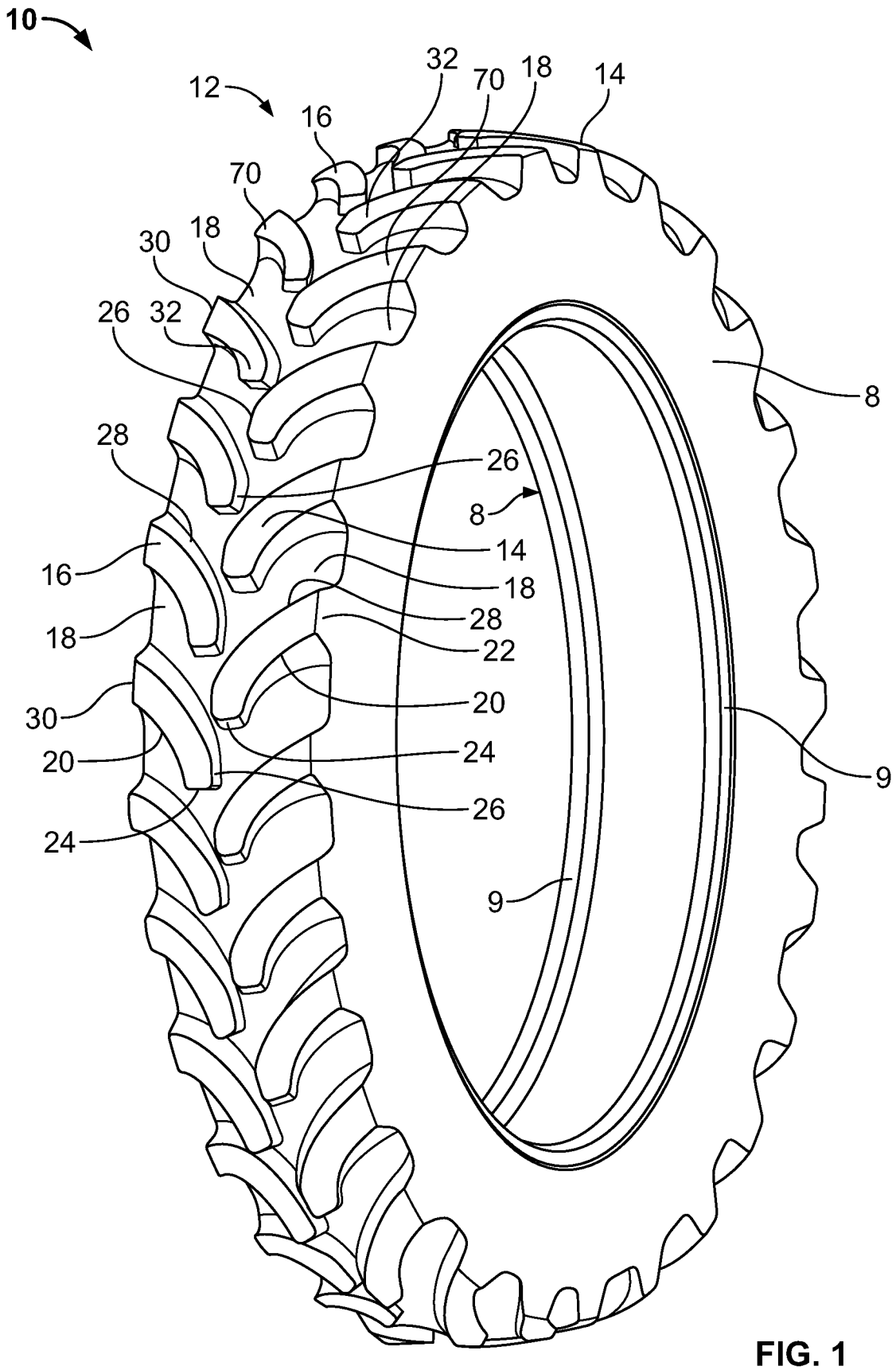
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FIG. 1

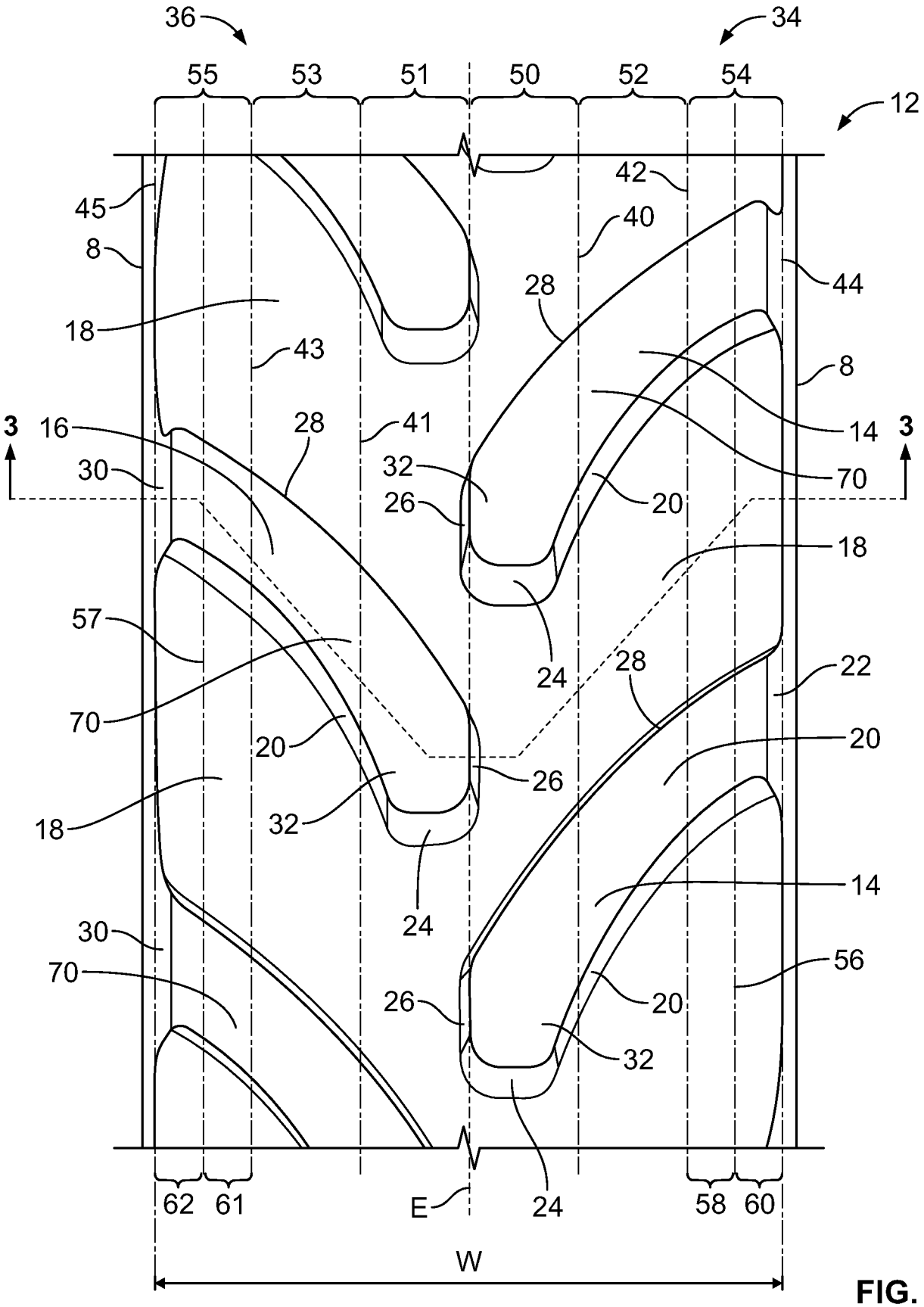
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FIG. 2

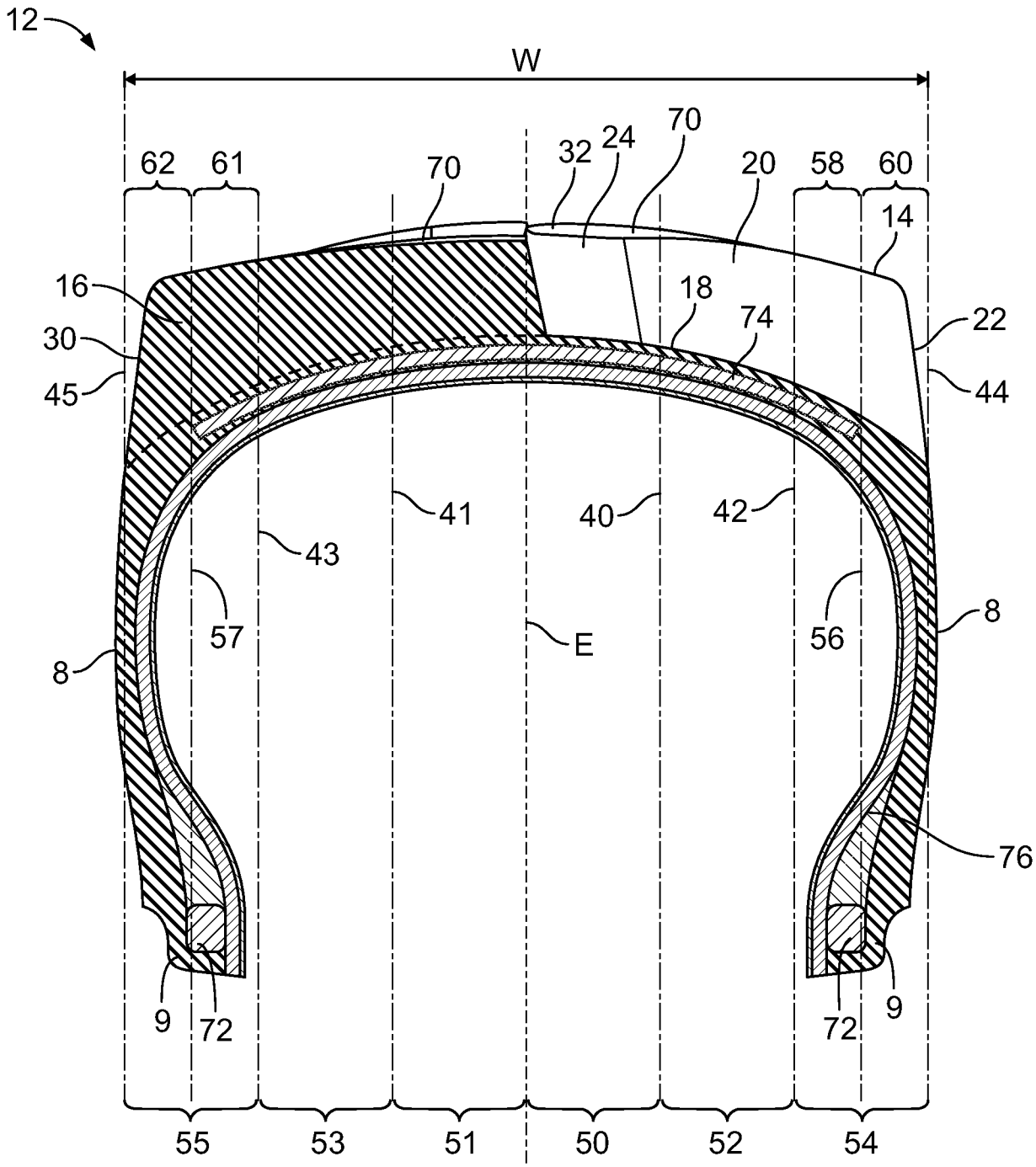
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FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/023701

A. CLASSIFICATION OF SUBJECT MATTER

B60C 11/03(2006.01)i, B60C 11/11(2006.01)i

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)

B60C 11/03; B60C 11/00; B60C 11/11; B60C 107/02; B60C 11/08; B60C 113/00

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: agricultural tire, tread, lug, and volume

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,337,814 A (BONKO, MARK L.) 16 August 1994 See column 5, line 60 - column 6, line 17; figures 2,3.	1-19
A	EP 0600265 A1 (THE GOODYEAR TIRE & RUBBER COMPANY) 08 June 1994 See column 4, line 46 - column 5, line 27; figure 1.	1-19
A	US 5,733,394 A (BAUS et al.) 31 March 1998 See column 5, line 62 - column 8, line 17; figures 4-7.	1-19
A	JP 2008-024270 A (SUMITOMO RUBBER IND., LTD.) 07 February 2008 See paragraphs [0008],[0009]; figure 1.	1-19
A	US 5,056,573 A (O' BRIEN et al.) 15 October 1991 See column 3, lines 28-59; figure 3.	1-19

☐ 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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 May 2013 (13.05.2013)	**14 May 2013 (14.05.2013)**

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/023701

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