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(54) **Title**: EXPANDABLE DRUM HAVING IRREGULAR SEGMENT PROFILES

(57) **Abstract**: An improved belt and tread drum incorporating an improved segment is disclosed. Segments are mounted in side-by-side relationship about a central axis for radial movement inwardly and outwardly with respect to the central axis and include arcuate outer surfaces that collectively define an outer circumferential working surface of the drum. The segments each define opposite first and second longitudinal side margins, at least one of the first and second longitudinal side margins defining an irregular longitudinal profile.

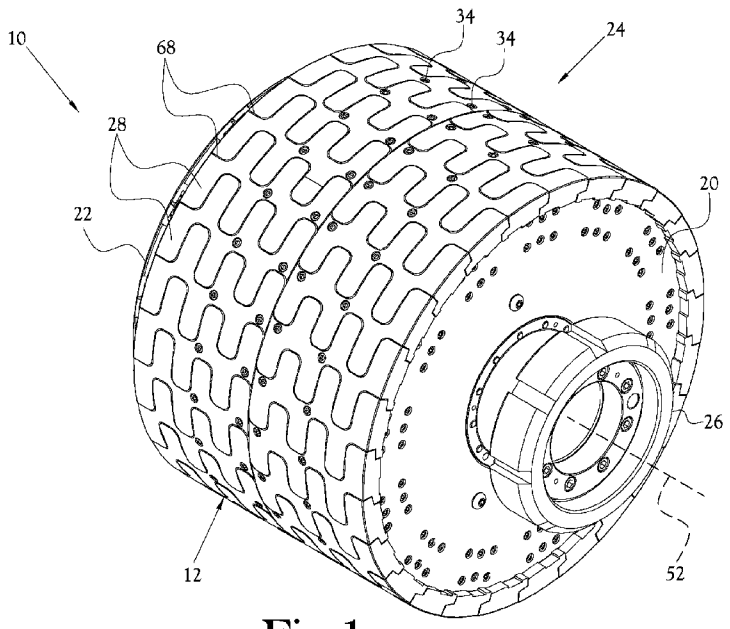


Fig.1

WO 2015/126650 A1

— *with information concerning one or more priority claims considered void (Rule 26bis.2(d))*

TITLE OF INVENTION

EXPANDABLE DRUM HAVING IRREGULAR SEGMENT PROFILES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Patent Application Number 13/964,387, filed on August 12, 2013, and United States Provisional Patent Application Number 61/937,105, filed on February 7, 2014.

STATEMENT REGARDING FEDERALLY-SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of Invention

[0001] The present general inventive concept relates to devices that are useful in the manufacture of vehicle tires. More particularly, the present general inventive concept relates to an improved belt and tread drum having irregular segment profiles.

2. Description of the Related Art

[0002] The manufacture of a vehicle tire commonly includes the steps of forming a tire carcass, forming a toroid-shaped belt and tread "package" of the tire separately from the carcass, and thereafter marrying the belt and tread package to the tire carcass to form a "green" tire. The green tire is thereafter treated to form the tread and various other features of a finished tire. Other supplementary steps, such as bonding the belt and tread package to the tire carcass (often referred to as "stitching" the belt and tread package), may be performed during the course of, or following, one or more of the aforementioned steps.

[0003] The formation of a tire carcass is typically performed using a tire building drum, of the type described in United States Patent No. 6,457,505. Such a tire building drum typically defines a radially expandable and contractible cylindrical working surface upon which a tire carcass is formed. Subsequent to the formation of the tire carcass on the

cylindrical working surface, such tire carcass may be transferred to an expansion drum, of the type discussed in United States Patent No. 6,602,372. The tire carcass is positioned surrounding the expansion drum, and a portion of the tire carcass is overlaid with the belt and tread package. The tire carcass is then inflated to a toroid shape resembling, though often not identical to, the shape of a finished tire. While the tire carcass is inflated, the belt and tread package is joined to the tire carcass.

[0004] Formation of a belt and tread package of a tire is typically accomplished using a belt and tread drum, of the type disclosed in United States Patent No. 6,013,147. Such a belt and tread drum typically has an outer cylindrical surface, or circumference, comprising a plurality of elongated segments, about which one or more layers of the tire belt material (comprising, for example, reinforcement cords embedded in a polymeric binder) are laid to define the belt and tread package. The circumference of the belt and tread drum is preferably capable of expanding and contracting to allow, for example, removal of a completed belt and tread package from the drum. A completed belt and tread package is typically essentially nonexpandable radially. However, a completed belt and tread package is typically flexible to the extent that, when unsupported, the toroid-shaped belt and tread package will deform and sag under the influence of gravity. Also, desirably, the adjustable circumference of the belt and tread drum enables a single drum to be used to form belt and tread packages of alternative diameters.

[0005] During formation of the belt and tread package on the belt and tread drum, it is not uncommon for the belt and tread drum and accompanying tooling to be configured such that the elongated segments of the belt and tread drum apply considerable pressure to interior surfaces of the belt and tread package, in part to assist in maintaining a uniform toroid shape of the tire component during formation. Such high pressures applied to the interior surfaces of the tire component can result in at least a portion of the arced exterior surfaces of the elongated segments becoming at least partially imprinted in the tire component, resulting in the formation of very slight imprints of the arcuate exterior surfaces of the elongated segments, and corresponding very slight bulges adjacent the imprints, in the tire component. Further, it is known that the radius of curvature of the various arcuate segments forming the belt and tread drum's outer cylindrical surface is fixed by the rigidity of the segments, thus rendering it impossible for the segments to be moved between radially expanded and

contracted positions and collectively provide perfectly-formed cylindrical surfaces at each of these two positions. If, for example, the circumference of the drum is adjusted to a size at which the segments are positioned at a distance from the longitudinal axis which exceeds the radius of curvature of each segment arc, there will exist regions about the drum circumference where the interface between each adjacent arcuate surface curves very slightly radially inwardly from the central portions of the segments. Conversely, if the circumference of the drum is adjusted to a size at which the segments are positioned at a distance from the longitudinal axis less than the radius of curvature of each segment arc, there will exist regions about the drum circumference where the interface between each adjacent arcuate surface curves very slightly radially outwardly from the central portions of the segments. In either case, the outer circumference of the belt and tread drum will be very slightly out-of-round. If these out-of-round regions are large enough (as may occur, for example, when the drum is expanded to accommodate a tire of relatively large diameter), it is possible that the drum may produce undesirable alternating imprints and bulges of the slightly out-of-round exterior surface of the tire building drum on a tire constructed with the drum. Such imprints and bulges are undesirable in that they may later manifest as irregularities in a finished tire, which may, in certain circumstances, produce undesirable effects, such as for example vibration, noise, and/or resonance of the rolling tire.

[0006] In light of the above, an improved segment for a belt and tread drum, and a belt and tread drum which includes features for limiting resonance of a tire manufactured using the belt and tread drum, are desired.

BRIEF SUMMARY OF THE INVENTION

[0007] The present general inventive concept, in various example embodiments, provides a segment defining a portion of an outer circumferential working surface of a tire building drum. In various embodiments, the segment has an arcuate outer surface and defines opposite first and second longitudinal side margins. At least one of the first and second longitudinal side margins may define an irregular longitudinal profile.

[0008] In various embodiments, the at least one longitudinal side margin may define a plurality of alternating slots and fingers extending therefrom along an arcuate dimension of

the segment. In some embodiments, at least one of the fingers may have a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger. In other embodiments, each of the fingers may have a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger. In still other embodiments, each of the fingers may have a length along the arcuate dimension of the segment differing from the lengths of the remaining fingers along the at least one longitudinal side margin.

[0009] In certain embodiments, the first longitudinal side margin may define a first set of alternating slots and fingers extending therefrom along an arcuate dimension of the segment and the second longitudinal side margin defines a second set of alternating slots and fingers extending therefrom along an arcuate dimension of the segment. In some embodiments, each of the fingers of the first set may have a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger. In some embodiments, each of the fingers of the second set may have a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger. In some embodiments, the slots of the first set may be shaped for mating engagement with the fingers of the second set, and the slots of the second set may be shaped for mating engagement with the fingers of the first set. In some embodiments, each finger of the first set may have a length along the arcuate dimension of the segment differing from the lengths of the remaining fingers of the first set, and each finger of the second set may have a length along the arcuate dimension of the segment differing from the lengths of the remaining fingers of the second set.

[0010] In various example embodiments of the present general inventive concept, an improvement may be provided to a segment forming a portion of an outer cylindrical working surface of a belt and tread drum of the type useful for manufacturing vehicle tires. In certain embodiments, the segment may comprise an outer surface defining a portion of the cylindrical working surface, the outer surface having a longitudinal dimension parallel to a central axis of the cylindrical working surface and a circumferential dimension along a circumference of the cylindrical working surface. A plurality of alternating slots and fingers may be defined along the outer surface and may extend along the circumferential dimension of the segment. Each finger may be sized and shaped to at least partially mate with a

corresponding slot of an adjacent segment. In various embodiments, longitudinally adjacent slots and fingers along the outer surface have non-uniform circumferential lengths.

[0011] In some embodiments, the outer surface may have opposite first and second longitudinal side margins, wherein the plurality of alternating slots and fingers are arranged along both first and second longitudinal side margins of the outer surface. Each finger of the first side margin may be sized and shaped to at least partially mate with a corresponding slot of a second side margin of an adjacent segment, and each slot of the first side margin may be sized and shaped to at least partially mate with a corresponding finger of a second side margin of an adjacent segment. Each finger may have a length along the circumferential dimension of the segment differing from a length of a longitudinally adjacent finger. Each finger of the first side margin may have a length along the circumferential dimension of the segment differing from the lengths of the remaining fingers of the first side margin, and each finger of the second side margin may have a length along the circumferential dimension of the segment differing from the lengths of the remaining fingers of the second side margin.

[0012] In various embodiments of the present general inventive concept, a belt and tread drum for use in the manufacture of vehicle tires may be provided. The drum may comprise a plurality of segments mounted in side-by-side relationship about a central axis for radial movement inwardly and outwardly with respect to the central axis. The segments may include arcuate outer surfaces which collectively define an outer circumferential working surface of the drum. Each segment may define a plurality of alternating slots and fingers extending from each of opposite first and second longitudinal side margins of the segment along a circumferential dimension of the drum, each finger of each first side margin being sized and shaped to at least partially mate with a corresponding slot of a second side margin of an adjacent segment, and each slot of each the first side margin being sized and shaped to at least partially mate with a corresponding finger of a second side margin of an adjacent segment. At least one finger along at least one of the first and second side margins of at least one segment may have a circumferential length differing from the lengths of the remaining fingers along the side margin.

[0013] In various example embodiments, each of the fingers along at least one side margin of at least one segment may have a circumferential length differing from the

circumferential length of a longitudinally adjacent finger. Each side margin of each segment may define at least one finger having a circumferential length differing from the circumferential length of at least one longitudinally adjacent finger. In some embodiments, each pattern of alternating slots and fingers of non-uniform circumferential lengths of each first side margin of each segment may differ from the pattern of alternating slots and fingers of non-uniform circumferential lengths of the first side margin of an adjacent segment. In some embodiments, each of the fingers along each side margin of each segment may have a circumferential length differing from the circumferential length of a longitudinally adjacent finger.

[0014] Additional aspects and advantages of the present general inventive concept will be set forth in part in the description which follows, and, in part, will be obvious from the description, or may be learned by practice of the present general inventive concept.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0015] The following example embodiments are representative of example techniques and structures designed to carry out the objects of the present general inventive concept, but the present general inventive concept is not limited to these example embodiments. In the accompanying drawings and illustrations, the sizes and relative sizes, shapes, and qualities of lines, entities, and regions may be exaggerated for clarity. A wide variety of additional embodiments will be more readily understood and appreciated through the following detailed description of the example embodiments, with reference to the accompanying drawings in which:

FIG. 1 is a perspective view showing one embodiment of an expandable belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept;

FIG. 2 is another perspective view of the expandable belt and tread drum of **FIG. 1**, showing the drum in an expanded position;

FIG. 3 is a cross-sectional side view of the expandable belt and tread drum of **FIG. 1**, showing the drum in a collapsed position;

FIG. 4 is another cross-sectional side view of the expandable belt and tread drum of **FIG. 1**, showing the drum in an expanded position;

FIG. 5 is an end view of the expandable belt and tread drum of **FIG. 1**, showing the drum in an expanded position;

FIG. 6 is a top plan view showing one embodiment of a segment for a belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept;

FIG. 7 is a perspective view of two of the segments as shown in **FIG. 6**, showing the segments in adjacent relation to one another in a partially expanded position;

FIG. 8 is a perspective view of another embodiment of an expandable belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept;

FIG. 9 is a top plan view showing another embodiment of a segment for a belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept;

FIG. 10 is a perspective view showing two mating portions of segments of the type shown in **FIG. 9**;

FIG. 11 is a top plan view showing another embodiment of a segment for a belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept;

FIG. 12 is a top plan view showing another embodiment of a segment for a belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept; and

FIG. 13 is a top plan view showing another embodiment of a segment for a belt and tread drum having irregular segment profiles constructed in accordance with several features of the present general inventive concept.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Reference will now be made to the example embodiments of the present general inventive concept, examples of which are illustrated in the accompanying drawings and illustrations. The example embodiments are described herein in order to explain the present general inventive concept by referring to the figures. The following detailed

description is provided to assist the reader in gaining a comprehensive understanding of the structures and fabrication techniques described herein. Accordingly, various changes, modification, and equivalents of the structures and fabrication techniques described herein will be suggested to those of ordinary skill in the art. The progression of fabrication operations described are merely examples, however, and the sequence type of operations is not limited to that set forth herein and may be changed as is known in the art, with the exception of operations necessarily occurring in a certain order. Also, description of well-known functions and constructions may be omitted for increased clarity and conciseness.

[0017] Note that spatially relative terms, such as "up," "down," "right," "left," "beneath," "below," "lower," "above," "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over or rotated, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0018] Referring now to the Figures in which like reference numerals indicate like or corresponding features, there is shown in **FIGS. 1-5** a belt and tread drum **10** within which features of the present general inventive concept are embodied. The belt and tread drum **10**, or "drum," defines generally an outer circumference comprising a plurality of arcuate, circumference-defining segments **28** arranged in a side-by-side relationship to form an outer circumferential working surface **12** of the drum **10**. The segments **28** are mounted such that they may be moved radially inward and outward toward and away from a centerline **52** of the drum **10**. Thus, the outer working surface **12** of the drum **10** is capable of expanding to various diameters to accommodate the construction of belt and tread packages for tires of different diameters. Therefore, when tires of various sizes need to be made on a given, or single, drum, the diameter of the circumference of the drum **10** may be adjusted accordingly. Additionally, the drum is able to be collapsed from an expanded condition to permit the belt

and tread package to be removed for transfer to a subsequent stage of the tire making process. As will further be discussed below, in various embodiments, each of the segments **28** of the drum defines an irregular longitudinal profile along a longitudinal dimension of the drum **10**, such that the drum **10** does not produce a regular pattern of imprints or bulges in a tire component manufactured using the drum **10**, thereby limiting resonance in a finished tire manufactured using the tire component.

[0019] With reference to **FIGS. 1-5**, the belt and tread drum **10** is generally of cylindrical geometry, defining respective longitudinal, radial, and circumferential dimensions. The depicted drum **10** includes generally first and second disc-shaped end plates **20** and **22**, respectively, disposed at respective longitudinal ends of the drum **10**, and a central body portion, indicated generally by the numeral **24**, which is disposed between the end plates **20** and **22**. The body portion **24** is made up of a plurality of relatively movable components, the sum of whose movements results in controlled and measured change in the outer circumference of the body portion **24** to accommodate the manufacture of tires of various sizes (i.e. tires of different diameters). Selection and control over the maximum circumference of the drum is provided for externally of the drum by means of an adjustment mechanism **26**.

[0020] More specifically, the body portion **24** of the depicted belt and tread drum **10** includes a plurality of circumference-defining segments **28** whose outer arcuate surfaces collectively define an outer circumferential working surface of the drum **10**. In the illustrated embodiment, the various segments **28** about the circumference of the drum **10** are grouped into a first set of segments **28a**, and a second set of segments **28b**, (see **FIG. 2**) with the segments of the sets **28a**, **28b** alternating about the circumference of the working surface **12**, such that a pair of segments **28a** of the first set lie immediately circumferentially adjacent, and on opposite longitudinal sides of, each segment **28b** of the second set, and vice-versa. Each segment **28a** of the first set of segments is joined, as with the illustrated bolts **34**, a weld, integral connection, or the like, to a planar cam element **38** disposed radially inwardly of the segment **28a**. With reference to **FIGS. 3** and **4**, each cam element **38** defines two opposite side ends **40**, **42** extending radially outwardly from the longitudinal centerline **52** of the drum **10**. In the illustrated embodiment, each side end **40**, **42** of each cam element **38** defines a track **60**, **62** that is slidably engaged by an associated radially-extending cam

member **50**. The various cam members **50** are provided at regular, spaced apart locations about respective circumferential perimeters of the inner surfaces of the opposite end plates **20** and **22**.

[0021] In various embodiments, each of the cam elements **38** defines an inwardly-tapered shape along a radial dimension thereof, such that respective radially-inward ends of corresponding tracks **60**, **62** are closer to one another than respective radially-outward ends. Thus, movement of the first and second end plates **20**, **22** toward one another results in expansion of the cam elements **38** and associated segments **28** axially away from the longitudinal centerline **52** of the drum **10**, while movement of the first and second end plates **20**, **22** away from one another results in contraction of the cam elements **38** and associated segments **28** axially toward the longitudinal centerline **52** of the drum **10**. For example, in the illustrated embodiment, the cam members **50** associated with the first end plate **20** and the corresponding tracks **60** associated with the first side ends **40** of the cam elements **38** each extend directly radially outwardly, at substantially right angles to the longitudinal centerline **52** of the drum **10**, while the cam members **50** associated with the second end plate **22** and the corresponding tracks **62** associated with the second side ends **42** of the cam elements **38** each extend at an angle both radially and longitudinally outwardly, at acute angles to the longitudinal centerline **52** of the drum **10**. In this configuration, each cam element **38** defines a generally trapezoidal shape, with tapered ends of the respective cam elements **38** extending inwardly toward the longitudinal centerline **52**.

[0022] Similarly to the above-discussed segments **28a** of the first set of segments, each segment **28b** of the second set of segments is joined, as with the illustrated bolts **34**, a weld, integral connection, or the like, to a block **48** disposed radially inwardly of the segment **28b**. Each block **48** is linked to the cam elements **38** circumferentially adjacent the block **48** such that the block **48** is maintained circumferentially between its adjacent cam elements **38** as the cam elements **38** are moved radially toward and away from the longitudinal centerline **52** of the drum **10**. Thus, throughout expansion and contraction of the outer circumferential working surface of the drum **10**, the linkage of each block **48** to its circumferentially adjacent cam elements **38** maintains each segment **28b** of the second set of segments in a substantially cylindrical configuration circumferentially between two adjacent segments **28a** of the first set of segments. For example, in the illustrated embodiment, each block **48** defines a plurality of

through bores **64**, each of which is aligned axially with, and is thus in register with, a through bore **76** defined by a circumferentially adjacent cam element **38**. As best shown in **FIG. 5**, for each pair of aligned through bores **64**, **76** of each block **48** and adjacent cam element **38**, a guide bar **78** is provided having a first end **80** fixedly secured within one of the through bores **64**, **76** and an opposite second end **82** slidably received through the other of the through bores **64**, **76**. Each of the guide bars **78** is of a length selected to ensure that its second end **82** remains within its respective through bore throughout expansion and contraction of the drum **10**. Thus, throughout expansion and contraction of the drum **10**, each of the guide bars **78** serves to maintain its associated through bores **64**, **76** in substantial registration with one another. Furthermore, for each of the guide bars **78** extending between any given block **48** and its adjacent cam elements **38**, all such guide bars **78** extend to or from the block **48** at a common angle of extension in relation to a radial plane defined along the longitudinal centerline **52** of the drum **10** and extending radially-outward through a centerline of the block **48**. In this configuration, throughout expansion and contraction of the drum **10**, each block **48** is maintained circumferentially between its adjacent cam elements **38**, and thus, each segment **28b** of the second set of segments is maintained in a cylindrical configuration circumferentially between two adjacent segments **28a** of the first set of segments.

[0023] It will be recognized that additional elements of the above-discussed linkage between the various blocks **48** and their adjacent cam elements **38** may be provided without departing from the spirit and scope of the present general inventive concept. For example, in several embodiments, for each through bore having a guide bar **78** slidably received therein, a bearing **84** is received within the through bore, surrounding the circumference of the guide bar **78**. The bearing **84** may provide a snug, slidable relationship between each guide bar **78** and its associated block **48** or cam element **38**, and may assist in maintaining axial alignment of the through bores **64**, **76** associated with the guide bar **78**. In some embodiments, for each guide bar **78** extending between associated through bores **64**, **76** of adjacent blocks **48** and cam elements **38**, a compression spring (not shown) may be provided, with each compression spring wrapping around its associated guide bar **78** and extending between the through bores **64**, **76** associated therewith. Each compression spring may, in various embodiments, serve to bias the associated block **48** and cam element **38** circumferentially away from one another and radially away from the longitudinal centerline **52** of the drum **10**, thereby assisting in maintaining the cylindrical arrangement of each of the segments **28a**, **28b** by maintaining

each block **48** radially outward from the centerline **52** of the drum **10** and circumferentially between its adjacent cam elements **38**.

[0024] As noted above, movement of the first and second end plates **20**, **22** toward and away from one another results in adjustment of the overall diameter of the outer circumference of the drum **10**. For example, **FIGS. 1** and **3** depict the drum **10** at its fully collapsed, minimum circumference, with the first and second end plates **20**, **22** separated from one another along the centerline **52** of the drum **10**. By comparison, in **FIGS. 2**, **4**, and **5**, the drum **10** is depicted at its maximum expanded circumference, with the first and second end plates **20**, **22** drawn relatively close to one another. It will further be recognized that additional elements of the adjustment mechanism **26**, such as for example guide rails, shafts, and stops for guiding and limiting movement of the first and second end plates **20**, **22**, and springs and the like for biasing the drum **10** toward a desired expanded or collapsed position, may be provided. However, it will be understood that a complete description of such mechanisms is not necessary for a full understanding of the present general inventive concept.

[0025] As discussed above, there is provided a plurality of the aforementioned arcuate, circumference-defining segments **28** disposed about the circumference of the drum **10**, the cumulative effect of which is to define the overall outer circumferential working surface **12** of the drum **10**. As best shown in **FIG. 6**, each segment **28** of the depicted drum **10** includes first and second longitudinal side margins **44**, **46**. Each longitudinal side margin **44**, **46** defines a plurality of fingers **56** extending along a circumferential dimension of the drum **10**, with alternating circumferentially-extending slots **54** defined between the fingers **56**. The fingers **56** of each segment **28** are sized and shaped to be received within, and to at least partially mate with, the slots **54** of an adjacent segment **28** in order to maintain a semi-continuous outer circumferential surface of the drum **10** throughout expansion and contraction of the drum **10**. For example, in the expanded position of the drum **10** shown in **FIGS. 2**, **4**, and **5**, the fingers **56** of the several segments **28** are withdrawn (partially) from the slots **54** of respective adjacent segments **28**. By comparison, in the fully collapsed position of the drum **10** shown in **FIGS. 1** and **3**, the fingers **56** of the several segments **28** are fully received within the slots **54** of respective adjacent segments **28**.

[0026] In accordance with several features of the present general inventive concept, in various embodiments, at least two of the longitudinally adjacent fingers **56** and/or slots **54** of each side margin **44**, **46** of each segment **28** have non-uniform lengths, such that each longitudinal side margin **44**, **46** of each segment **28** defines a non-uniform, irregular profile. For example, in the embodiment shown in **FIGS. 6** and **7**, each finger **56** and corresponding mating slot **54** along each side margin **44**, **46** of each segment **28** has a length along a circumferential dimension **58** of the drum **10** that differs from the length of the fingers **56** and slots **54** adjacent thereto. Various of these circumferential lengths are illustrated by lines **A-D** in **FIG. 6** and by lines **A-C** in **FIG. 7**. Thus, the various circumferential lengths of the fingers **56** and mating slots **54** along a given side margin **44**, **46** of a given segment **28** are non-uniform. As a result, the interface **68** between the first side margin **44** of each given segment **28b** and the adjacent second side margin **46** of the adjacent segment **28a** defines a relatively tortuous and non-uniform path along the longitudinal dimension of the drum **10**.

[0027] For the sake of convenience and for ease of reference herein, reference is made generally to the interface **68** of each segment **28a** with an adjacent segment **28b**, and to the "shape" of that interface as defined by the first and second side margins **44**, **46** of adjacent segments **28a**, **28b**. It will be understood that the term "interface" may refer either to the interface between immediately adjacent segments, as in the fully collapsed position of the drum **10**, or to the gap or space located between each first side margin **44** of each segment and the second side margin **46** of a circumferentially adjacent segment, as in an expanded position of the drum **10**. It will further be recognized that the shape of each interface **68** is generally defined by the first and second side margins **44**, **46** of adjacent segments **28a**, **28b**. Therefore, to the extent various embodiments of segments **28** defining interfaces **68** having different shapes are discussed herein, it will be understood that such varying shapes of the interfaces **68** correspond generally to the shapes defined by the corresponding first and second side margins **44**, **46** of adjacent segments **28a**, **28b**. Furthermore, it will be recognized that, while preferable, the various fingers **46** of each segment **28** need not necessarily be sized and shaped to conform perfectly with a corresponding slot **44** of an adjacent segment **28** in order to accomplish the present general inventive concept. To this end, in certain embodiments, certain of the fingers **56** comprising an interface **68** may be sized slightly shorter than the corresponding mating slot **54**, such that in the fully collapsed position of the drum **10**, the finger **56** is received only partially into the slot **54**.

[0028] It will be appreciated that the above-discussed tortuous and non-uniform shape of the interface **68** between adjacent segments **28** of the drum **10** may, in several applications, serve to limit, or altogether eliminate, the manifestation of resonance vibrations in a fast-moving tire having components manufactured using the drum **10**. To this end, it will be recognized that the tortuous and non-uniform shapes of the interfaces **68** of the various segments **28** of the drum **10** result in a less uniformly repeating pattern of interfaces along the circumference of the drum **10**, as compared to more traditional tire building drum designs. Thus, to the extent a belt and tread package manufactured using the drum **10** is imparted with any imprints and bulges as a result of the interfaces **68** of the various segments **28** about the circumference of the drum **10**, such imprints and bulges may form a similarly non-uniformly repeating pattern about the circumference of the belt and tread package. Furthermore, to the extent a tire incorporating the belt and tread package is subjected to rolling speeds or other such conditions which may induce pattern-based resonance vibrations in the tire, the non-uniformly repeating pattern of such imprints and bulges about the belt and tread package may discourage, or altogether eliminate, such resonance.

[0029] It will further be recognized that, in various embodiments, the general shape, ordering, and arrangement of the mating fingers **56** and slots **54** along the longitudinal dimension of each segment **28** may take the form of any of a large number of varying configurations without departing from the spirit and scope of the present general inventive concept. For example, in some embodiments, each of the fingers **56** of each first side margin **44**, and the corresponding mating slots **54** of the second side margin **46** of the adjacent segment **28**, may define different circumferential lengths. In such embodiments, the ordering and arrangement of mating fingers **56** and slots **54** can be irregular, such as for example in a randomized pattern, or arranged in order of ascending or descending circumferential length along the longitudinal dimension of the segment **28**. Still further, the mating fingers **56** and slots **54** on a given side margin **44**, **46** of a given segment **28** can be arranged in an order corresponding to alternating circumferential length. In other embodiments, two or more of the fingers **56** of each first side margin **44**, and the corresponding mating slots **54** of the adjacent side margin **46** of the adjacent segment **28**, may define substantially equal lengths, while at least one other finger **56** and corresponding mating slot **54** defines a different length. Again, in such embodiments, the ordering and arrangement of the fingers of substantially equal length and the finger or fingers of one or more different lengths may be irregular or

patterned. Those skilled in the art will recognize other such configurations which are suitable to accomplish the irregular longitudinal profile of the side margins **44**, **46** of the segment **28**, and such configurations may be used without departing from the spirit and scope of the present general inventive concept. Furthermore, it will further be understood that, while **FIGS. 6** and **7** show an elongated segment **28** having seven mating fingers **56** and slots **54**, with each finger **56** and slot **54** being of a relatively uniform longitudinal width, the various mating fingers **56** and slots **54** along each side margin **44**, **46** may define narrower or wider longitudinal widths in relation to one another. It will further be recognized that each side margin **44**, **46** may define a greater or fewer number of mating fingers **56** and slots **54** along the longitudinal dimension thereof.

[0030] In several embodiments, the various segments **28** comprising the outer circumferential working surface **12** of the drum **10** each define similar longitudinal profiles along their respective first and second side margins **44**, **46**, such that each interface **68** between each pair of adjacent segments **28** is shaped similarly to the remaining interfaces **68** about the circumference of the drum **10**. However, in order to further reduce, or eliminate altogether, resonance vibrations that may manifest in a tire manufactured using a drum **10** constructed in accordance with certain features of the present general inventive concept, in several embodiments, each interface **68** of circumferentially adjacent first and second side margins **44**, **46** about the circumference of the drum **10** defines a longitudinal profile differing in shape from the longitudinal profiles of other interfaces **68** about the circumference of the drum **10**. For example, in one embodiment, each interface **68** of segments **28** of the drum **10** defines a longitudinal profile which differs in shape from each other interface **68** about the circumference of the drum **10**. In other embodiments, certain of the interfaces **68** about the drum **10** may be of identical shape to one another, while certain other of the interfaces **68** of the drum may define one or more other shapes. In still other embodiments, certain of the interfaces **68** of the drum **10** may define longitudinal profiles having a regular, patterned shape, while other of the interfaces **68** of the drum **10** may define longitudinal profiles having an irregular longitudinal profile. For example, in one embodiment, only one of the interfaces **68** of the segments **28** about the circumference of the drum **10** defines an irregular longitudinal profile. The remaining interfaces **68** are defined by first and second side margins **44**, **46** of adjacent segments **28** having alternating fingers **56** and slots **54** of substantially equal length, thus defining interfaces **68** having regular,

patterned profile shapes. It will be recognized that, in each of these embodiments, at least one of the various interfaces **68** between the first side margins **44** and second side margins **46** of adjacent segments **28** differs slightly in shape from the remaining interfaces **68** about the circumference of the drum **10**. Thus, a tire component produced using the drum **10** is not imparted with a regular, repeating pattern of imprints or bulges about its circumference. In this way, the irregular longitudinal profile of at least one segment **28** of the drum **10** may assist in minimizing resonance or, ideally, eliminating resonance in a finished tire fabricated from components manufactured using the drum **10**.

[0031] In the illustrated embodiment, notwithstanding the above-discussed irregular longitudinal profiles defined by the circumferentially-extending fingers **56** and slots **54** of the first and second side margins **44**, **46** of each segment **28**, each of the segments **28** defines, overall, a generally elongated shape extending generally parallel to along the longitudinal centerline **52** of the drum **10**. In this embodiment, each segment **28** is secured along a longitudinal centerline of the segment **28** to a radially outer edge of one of the corresponding planar cam elements **38**. By way of illustration, in **FIG. 6**, the longitudinal centerline of the segment **28** is shown as corresponding approximately with the longitudinal centerline **52** of the drum **10**, and each of the above-discussed bolts **34** is located generally along the longitudinal centerline of the segment **28**. However, in other embodiments, each of the segments **28** is secured to a radially outer edge of a corresponding planar cam element **38** at a location along the segment **28** offset from the longitudinal centerline **52** of the segment **28**. For example, in some embodiments, each of the segments **28** defines an overall irregular shape. In these embodiments, the overall irregular shape of each of the segments **28**, and their offset mounting about the drum **10**, may contribute to an irregular spacing of the various interfaces **68** of the segments **28** from one another about the circumference of the drum **10**. This irregular spacing may, in certain embodiments, further contribute to minimizing the presence of regular, repeating patterns of interfaces **68** about the drum **10**, thereby limiting the manifestation of resonance or, ideally, eliminating resonance, in a finished tire manufactured using the drum **10**.

[0032] **FIGS. 8-10** illustrate another embodiment of a drum **10a** constructed in accordance with several features of the present general inventive concept. In the embodiment of **FIGS. 8-10**, the body portion **24** of the depicted belt and tread drum **10a** includes a

plurality of circumference-defining, multi-sectioned segments **28c** whose outer arcuate surfaces collectively define a portion of the outer circumferential working surface **12a** of the drum **10a**. As best shown in **FIG. 9**, each segment **28c** of the depicted drum **10a** includes a first side section **29**, a second side section **31** and an intermediate section **33** disposed between the side sections **29** and **31**. Each side section **29**, **31** of each segment **28a** defines a plurality of slots **54a** along a circumferentially outer one of its longitudinal side margins. Defined between these slots **54a** are alternating fingers **56a** that are designed to be received within the slots **54a** of the side section **29**, **31** of an adjacent segment **28c**. In **FIG. 8**, the drum **10a** is again depicted in its collapsed position, at its minimum circumference, with the fingers **56a** of the several segments **28c** being received within the slots **54a** of respective adjacent segments **28c**.

[0033] With reference to **FIGS. 9** and **10**, each side section **29**, **31** extends along almost the entire longitudinal dimension of the drum **10a** and defines an outer arcuate surface **61**. In addition, each side section **29** and **31** includes a stepped marginal edge opposite the fingers **56a** having a lip **65**. There is provided in each end of the lip **65** a bore **67** which is used to hingedly attach the side section **29**, **31** to the intermediate section **33** through an appropriate hinge connection (not shown). The intermediate section **33** extends along substantially the entire length of the drum **10a** and includes an outer arcuate surface **69**. Furthermore, each intermediate section **33** includes a stepped marginal surface extending along the circumferential sides thereof and which includes a lip **71**. As depicted in **FIG. 9**, provided along one side of each lip **71** are a pair of internally-threaded openings **73** used in the hinged attachment of the intermediate section **33** to a corresponding one of the side sections **29**, **31**. Defined in the outer surface **66** of the intermediate section **33** and adjacent the ends thereof are through-bores **75** for accepting the bolts **34** with which the segment **28c** is attached to a corresponding cam element.

[0034] Similarly to the above-discussed embodiment, in the embodiment of **FIGS. 8-10**, at least one slot **54a** of each side section **29**, **31**, along with its corresponding mating finger **56a** of its adjacent side section **29**, **31**, has a circumferential length differing from the circumferential length of at least one of the other slots **54a** and fingers **56a** longitudinally adjacent thereto. Thus, the circumferential lengths of the slots **54a** and fingers **56a** along a given side section **29**, **31** are non-uniform. Various of these different circumferential lengths

are illustrated by lines **A-E** in **FIG. 10**. It will be appreciated that, similarly to the above-discussed embodiment, the ordering of the mating slots **54a** and fingers **56a** can vary, and may for example be irregular, such as for example in a randomized pattern, in ascending or descending circumferential length order, or in other patterns or configurations. Still further, the slots **54a** and fingers **56a** along a given side section **29**, **31** may be arranged in alternating circumferential length order. Those skilled in the art will recognize other configurations which are suitable, and such configurations may be used without departing from the spirit and scope of the present general inventive concept. It will further be understood that, while **FIGS. 8-10** show an elongated segment **422** having six slots **54a** and fingers **56a** of a selected longitudinal width, the slots **54a** and fingers **56a** could have narrower or wider longitudinal widths allowing for a greater or fewer number of slots **54a** and fingers **56a** along each side section **29**, **31**.

[0035] **FIGS. 11-13** depict various example embodiments of the above-discussed side sections **29**, **31**, and illustrate various example arrangements and configurations of mating slots **54a** and fingers **56a** of differing lengths which may be utilized in achieving one or more embodiments of a segment pursuant to the present general inventive concept. In the embodiment of **FIG. 11**, partially mated first and second side sections **29a**, **31a** are depicted. In the embodiment of **FIG. 11**, the ordering of the mating slots and fingers along the longitudinal dimension of the side sections **29a**, **31a** defines an irregular, randomized pattern. **FIG. 12** illustrates partially mated first and second side sections **29b**, **31b**. In the embodiment of **FIG. 12**, the ordering of the mating slots and fingers along the longitudinal dimension of the side sections **29b**, **31b** defines an alternating pattern of first and second circumferential lengths. **FIG. 13** illustrates partially mated first and second side sections **29c**, **31c**, in which the ordering of the mating slots and fingers along the longitudinal dimension of the side sections **29c**, **31c** defines an ascending pattern of circumferential lengths. Those skilled in the art will recognize other arrangements and configurations of the slots **54a** and fingers **56a** which may be used without departing from the spirit and scope of the present general inventive concept.

[0036] From the foregoing description, it will be recognized by those skilled in the art that a belt and tread drum has been provided which incorporates irregular shaping of segments forming an outer circumference of the drum in order to reduce the formation of

repeating imprint patterns in a tire component manufactured using the drum. It is noted that the simplified diagrams and drawings do not illustrate all the various connections and assemblies of the various components, however, those skilled in the art will understand how to implement such connections and assemblies, based on the illustrated components, figures, and descriptions provided herein, using sound engineering judgment. Numerous variations, modifications, and additional embodiments are possible, and accordingly, all such variations, modifications, and embodiments are to be regarded as being within the spirit and scope of the present general inventive concept. For example, regardless of the content of any portion of this application, unless clearly specified to the contrary, there is no requirement for the inclusion in any claim herein or of any application claiming priority hereto of any particular described or illustrated activity or element, any particular sequence of such activities, or any particular interrelationship of such elements. Moreover, any activity can be repeated, any activity can be performed by multiple entities, and/or any element can be duplicated. However, while the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept.

CLAIMS

Having thus described the aforementioned invention, what is claimed is:

1. A segment defining a portion of an outer circumferential working surface of a tire building drum, the segment having an arcuate outer surface and defining opposite first and second longitudinal side margins, at least one of the first and second longitudinal side margins defining an irregular longitudinal profile.

2. The segment of Claim 1, the at least one longitudinal side margin defining a plurality of alternating slots and fingers extending therefrom along an arcuate dimension of the segment.

3. The segment of Claim 2, wherein at least one of the fingers has a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger.

4. The segment of Claim 3, each of the fingers having a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger.

5. The segment of Claim 4, each of the fingers having a length along the arcuate dimension of the segment differing from the lengths of the remaining fingers along the at least one longitudinal side margin.

6. The segment of Claim 1, wherein the first longitudinal side margin defines a first set of alternating slots and fingers extending therefrom along an arcuate dimension of the segment and the second longitudinal side margin defines a second set of alternating slots and fingers extending therefrom along an arcuate dimension of the segment.

7. The segment of Claim 6, wherein each of the fingers of the first set of alternating fingers and slots has a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger.

8. The segment of Claim 7, wherein each of the fingers of the second set of alternating fingers and slots has a length along the arcuate dimension of the segment differing from a length of a longitudinally adjacent finger.

9. The segment of Claim 8, the slots of the first set of alternating fingers and slots being shaped for mating engagement with the fingers of the second set of alternating fingers and slots, and the slots of the second set of alternating fingers and slots being shaped for mating engagement with the fingers of the first set of alternating fingers and slots.

10. The segment of Claim 9, each finger of the first set of alternating fingers and slots having a length along the arcuate dimension of the segment differing from the lengths of the remaining fingers of the first set of alternating fingers and slots, and each finger of the second set of alternating fingers and slots having a length along the arcuate dimension of the segment differing from the lengths of the remaining fingers of the second set of alternating fingers and slots.

11. In a segment forming a portion of an outer cylindrical working surface of a belt and tread drum of the type useful for manufacturing vehicle tires, wherein the segment comprises an outer surface defining a portion of the cylindrical working surface, the outer surface having a longitudinal dimension parallel to a central axis of the cylindrical working surface and a circumferential dimension along a circumference of the cylindrical working surface, the improvement comprising:

a plurality of alternating slots and fingers defined along the outer surface and extending along the circumferential dimension, each finger being sized and shaped to at least partially mate with a corresponding slot of an adjacent segment; and

wherein longitudinally adjacent slots and fingers along the outer surface have non-uniform circumferential lengths.

12. The segment of Claim 11, the outer surface having opposite first and second longitudinal side margins, wherein the plurality of alternating slots and fingers are arranged along both first and second longitudinal side margins of the outer surface.

13. The segment of Claim 12, each finger of the first side margin being sized and shaped to at least partially mate with a corresponding slot of a second side margin of an adjacent segment, and each slot of the first side margin being sized and shaped to at least partially mate with a corresponding finger of a second side margin of an adjacent segment.

14. The segment of Claim 13, each finger having a length along the circumferential dimension of the segment differing from a length of a longitudinally adjacent finger.

15. The segment of Claim 13, each finger of the first side margin having a length along the circumferential dimension of the segment differing from the lengths of the remaining fingers of the first side margin, and each finger of the second side margin having a length along the circumferential dimension of the segment differing from the lengths of the remaining fingers of the second side margin.

16. A belt and tread drum for use in the manufacture of vehicle tires comprising:

a plurality of segments mounted in side-by-side relationship about a central axis for radial movement inwardly and outwardly with respect to the central axis, the segments including arcuate outer surfaces which collectively define an outer circumferential working surface of the drum, each segment defining a plurality of alternating slots and fingers extending from each of opposite first and second longitudinal side margins of the segment along a circumferential dimension of the drum, each finger of each first side margin being sized and shaped to at least partially mate with a corresponding slot of a second side margin of an adjacent segment, and each slot of each the first side margin being sized and shaped to at least partially mate with a corresponding finger of a second side margin of an adjacent segment, wherein at least one finger along at least one of the first and second side margins of at least one segment has a circumferential length differing from the lengths of the remaining fingers along the side margin.

17. The belt and tread drum of Claim 16, wherein each of the fingers along at least one side margin of at least one segment has a circumferential length differing from the circumferential length of a longitudinally adjacent finger.

18. The belt and tread drum of Claim 16, wherein each side margin of each segment defines at least one finger having a circumferential length differing from the circumferential length of at least one longitudinally adjacent finger.

19. The belt and tread drum of Claim 18, wherein each pattern of alternating slots and fingers of non-uniform circumferential lengths of each first side margin of each segment differs from the pattern of alternating slots and fingers of non-uniform circumferential lengths of the first side margin of an adjacent segment.

20. The belt and tread drum of Claim 19, wherein each of the fingers along each side margin of each segment has a circumferential length differing from the circumferential length of a longitudinally adjacent finger.

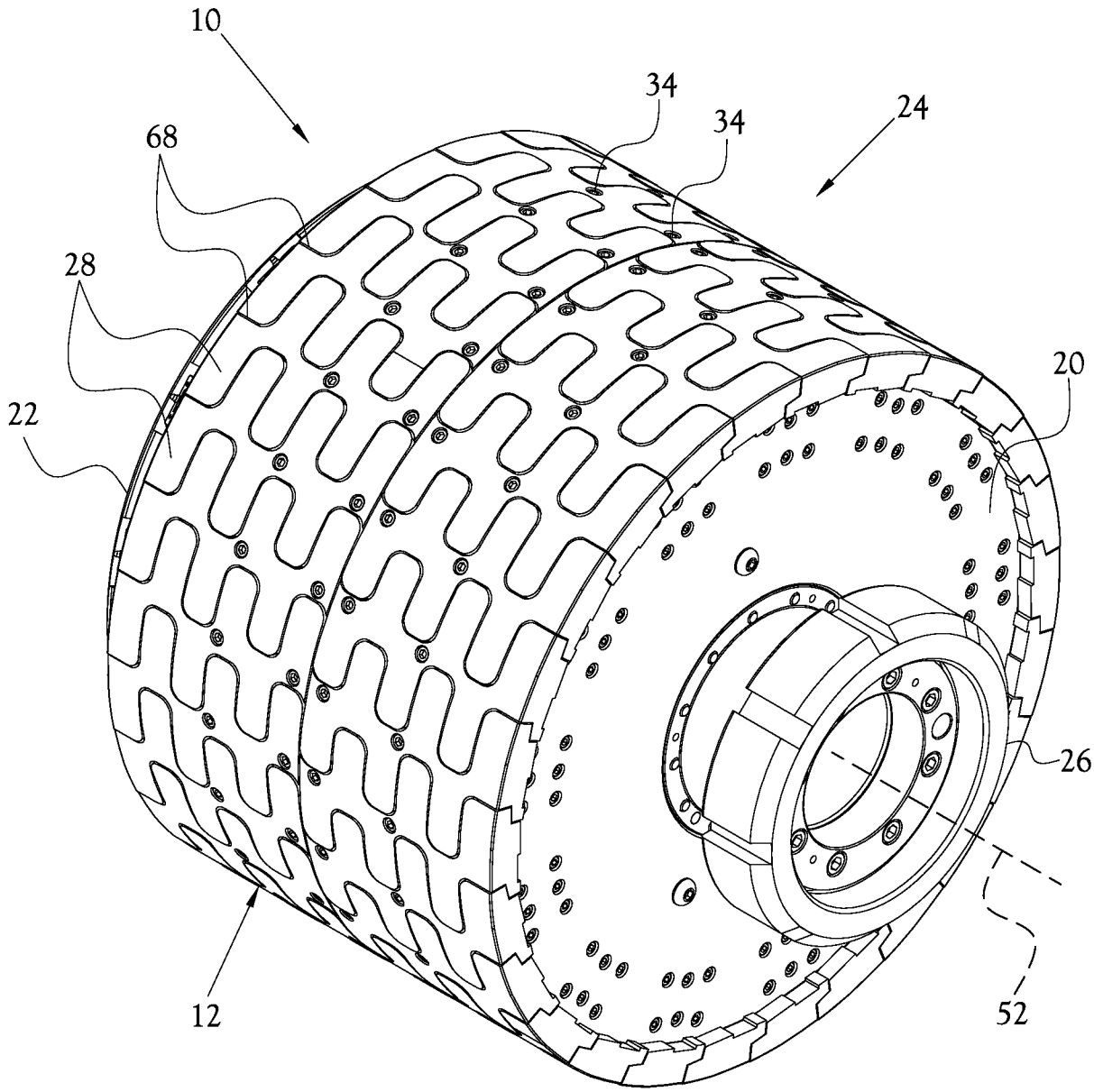


Fig.1

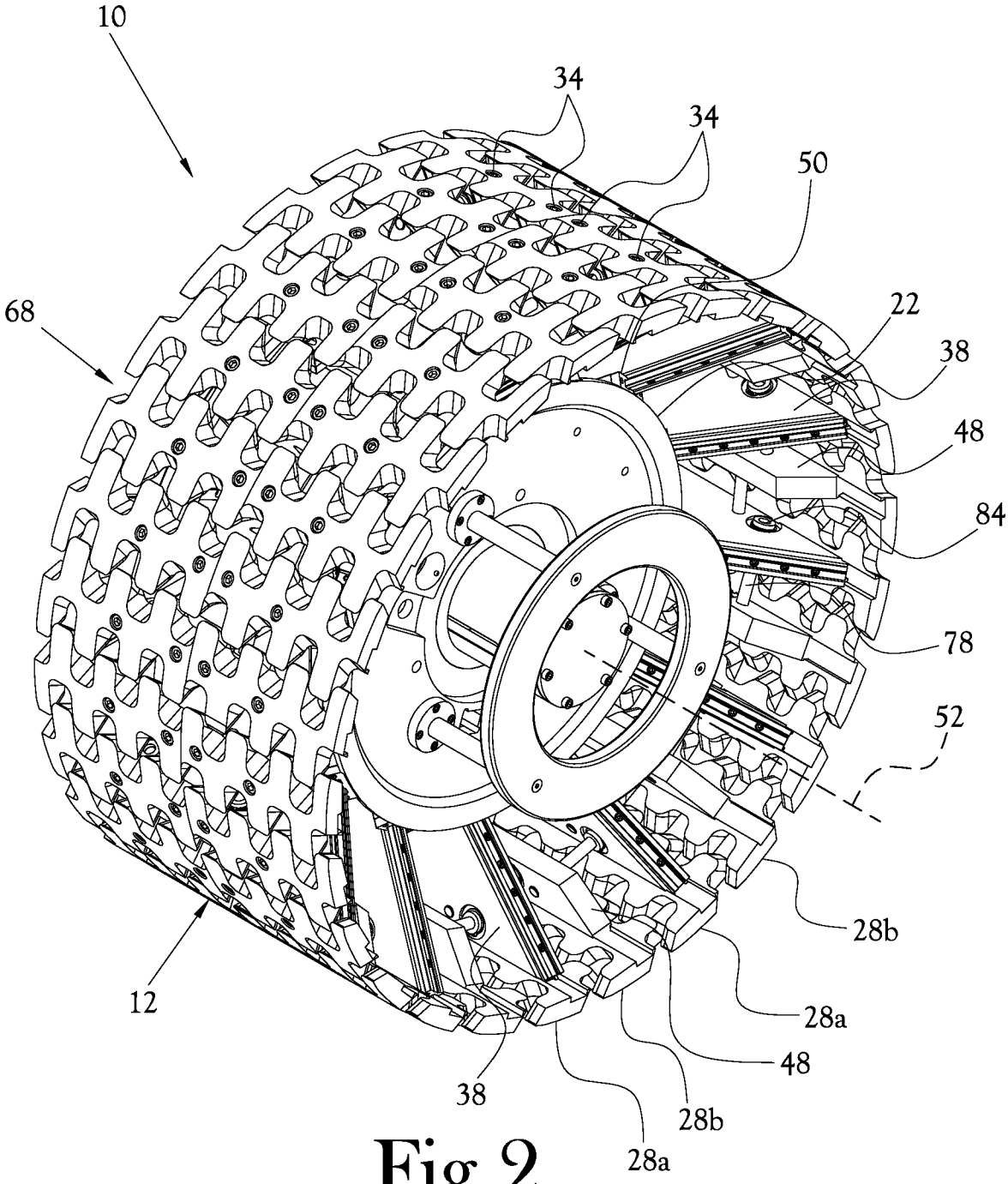


Fig.2

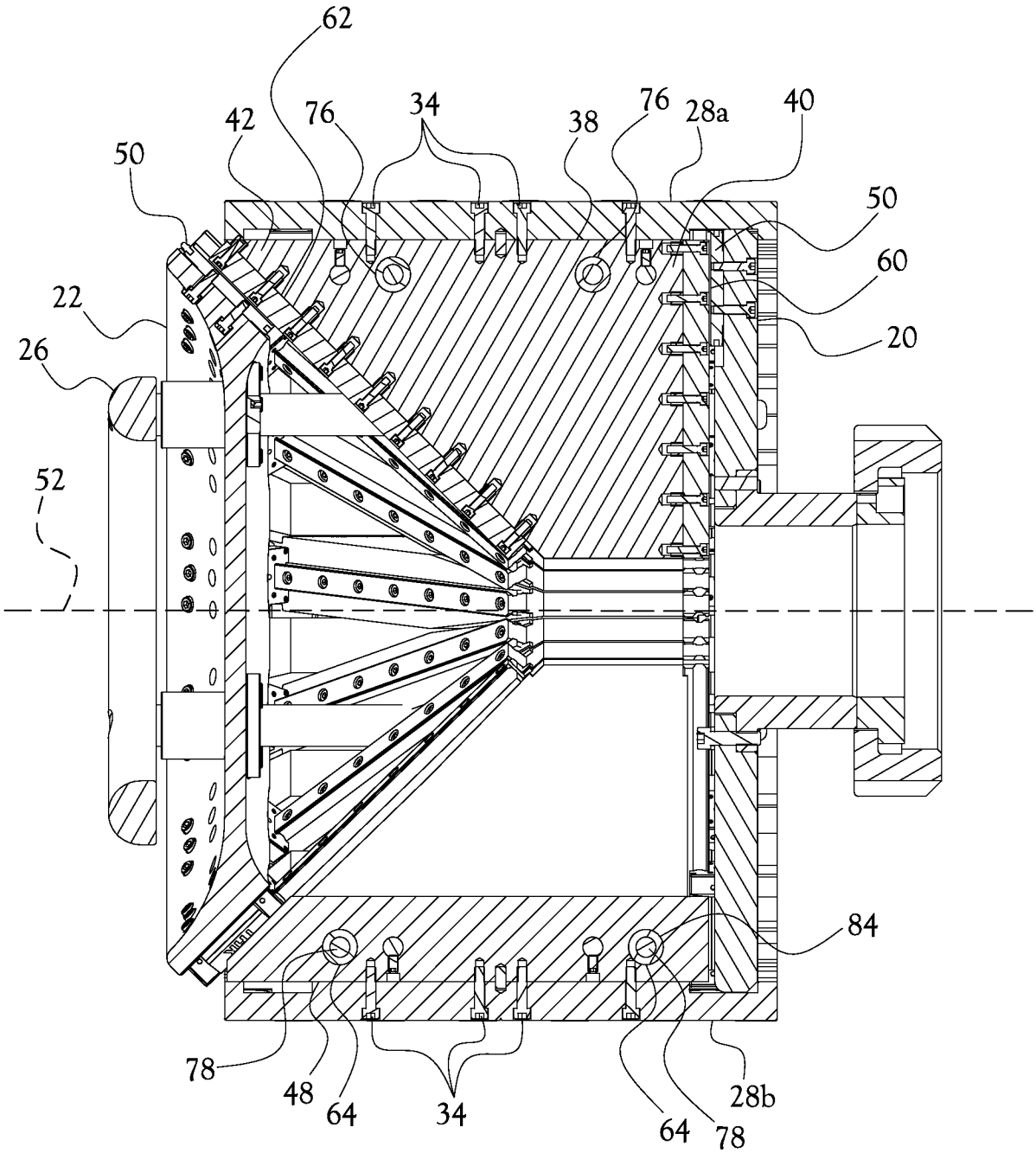


Fig.3

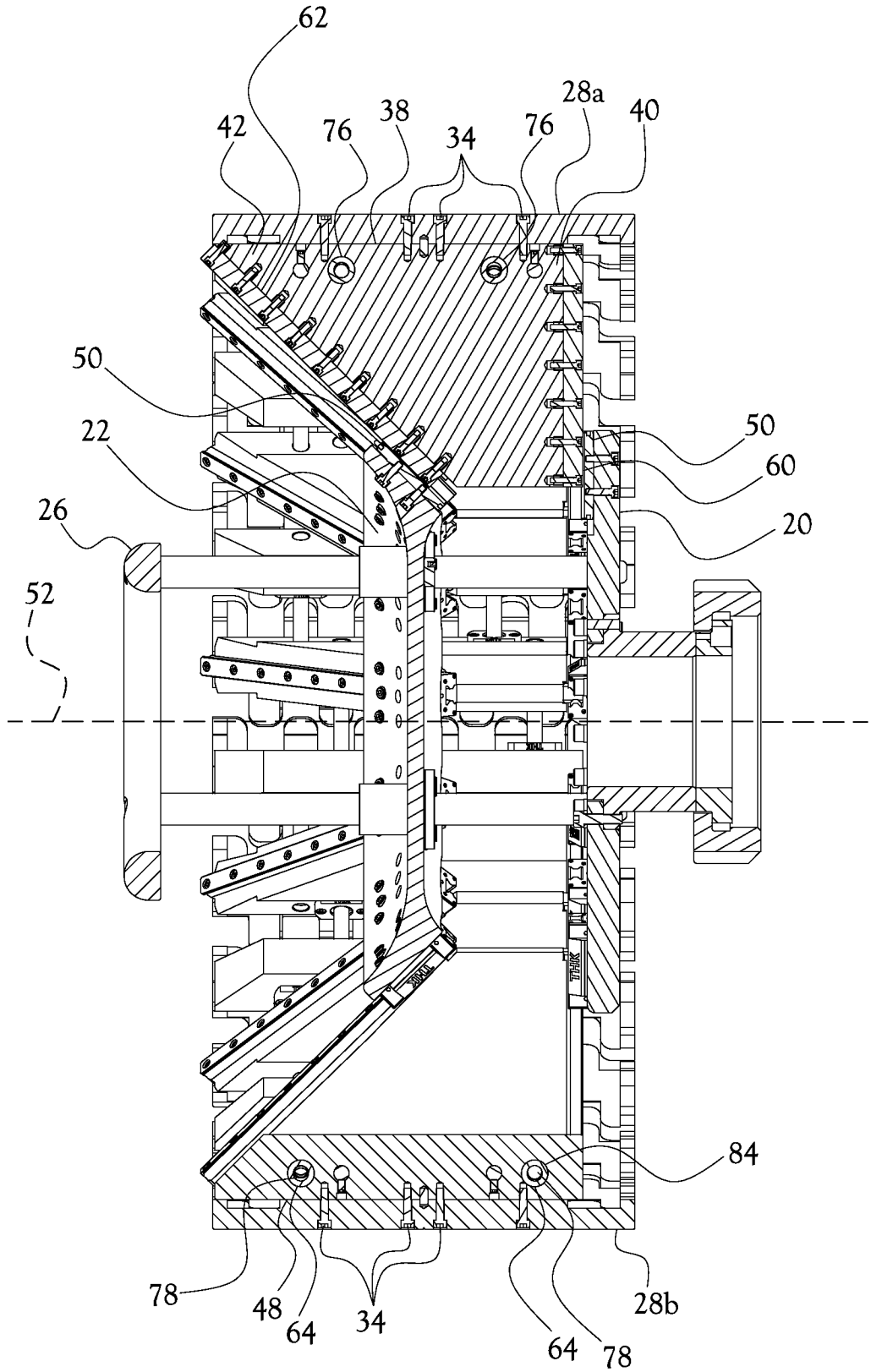


Fig.4

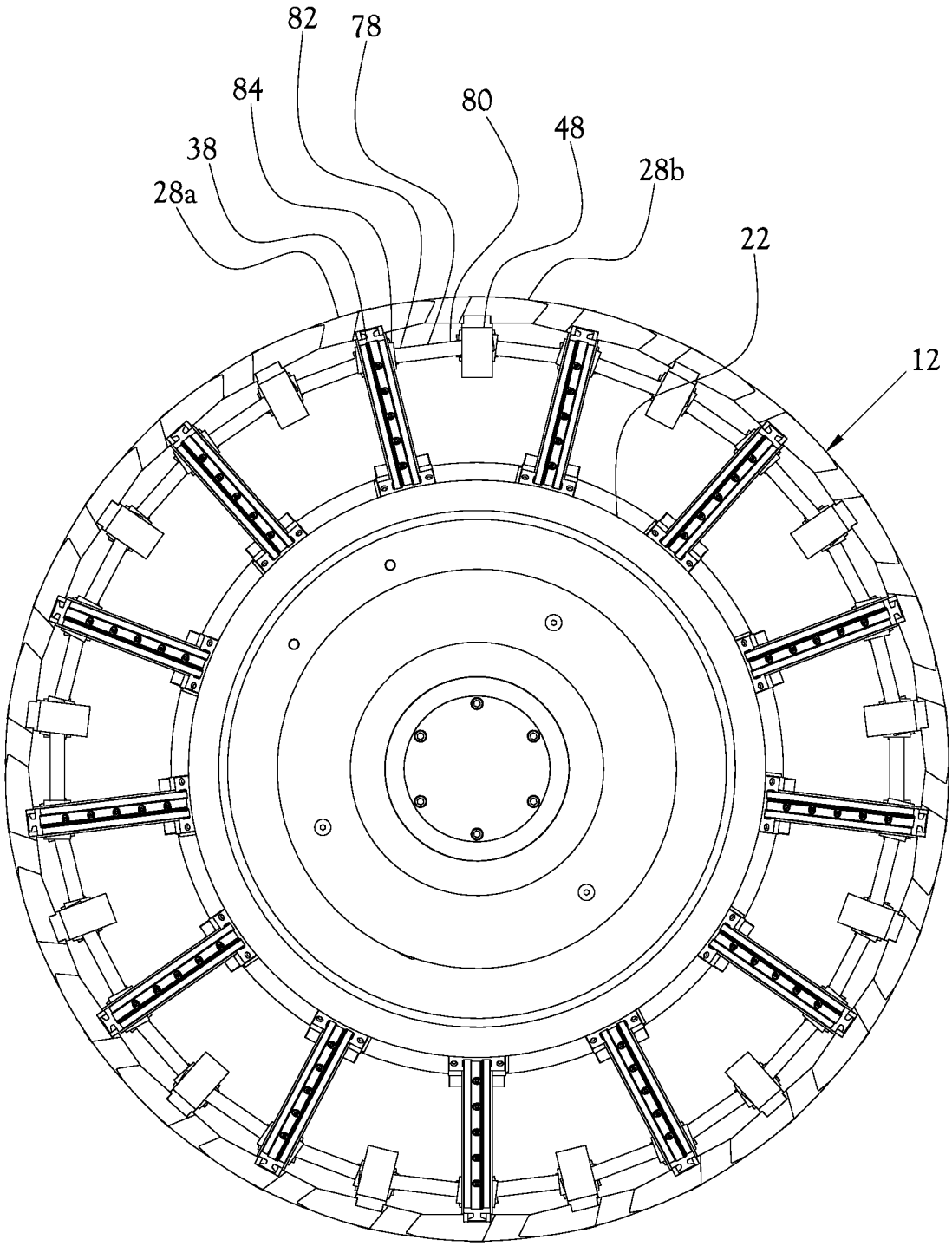


Fig.5

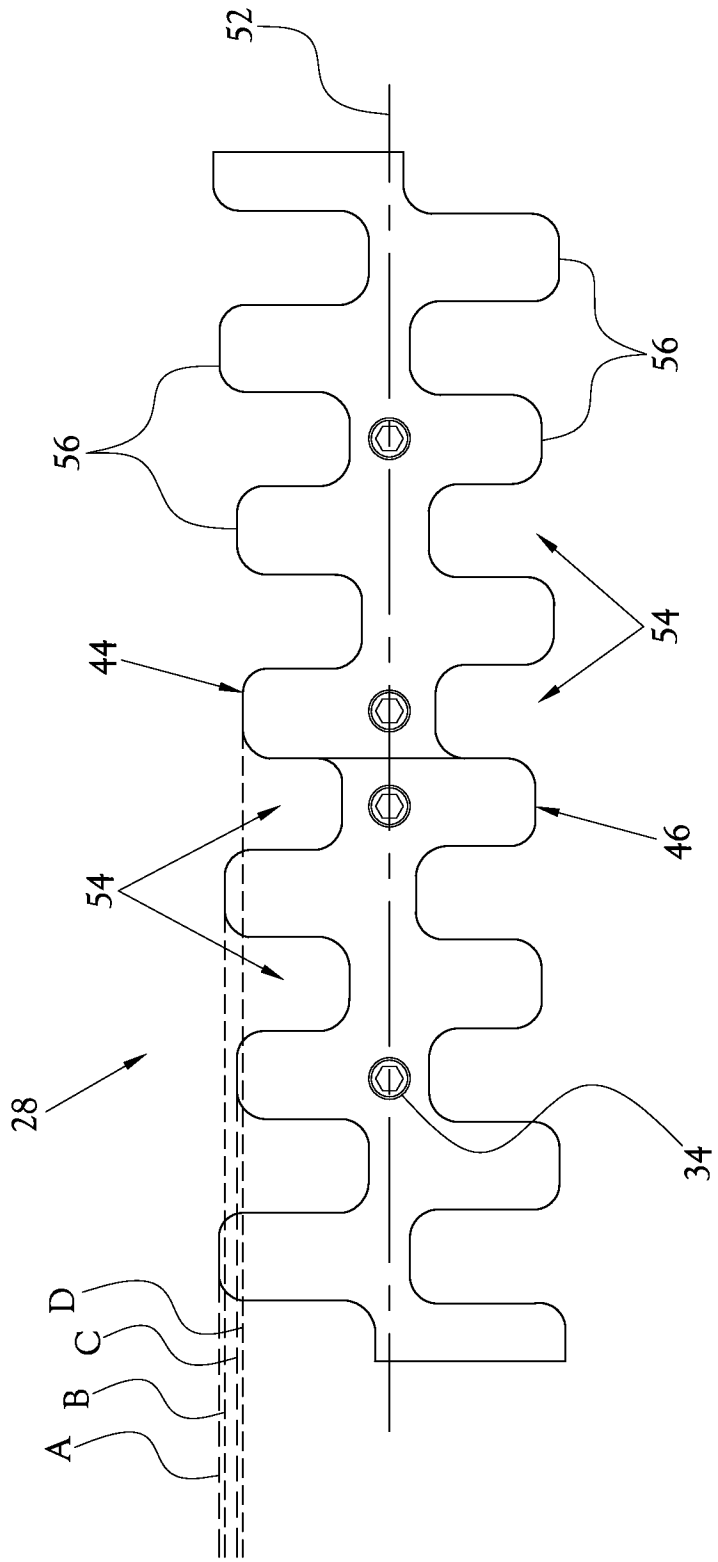


Fig.6

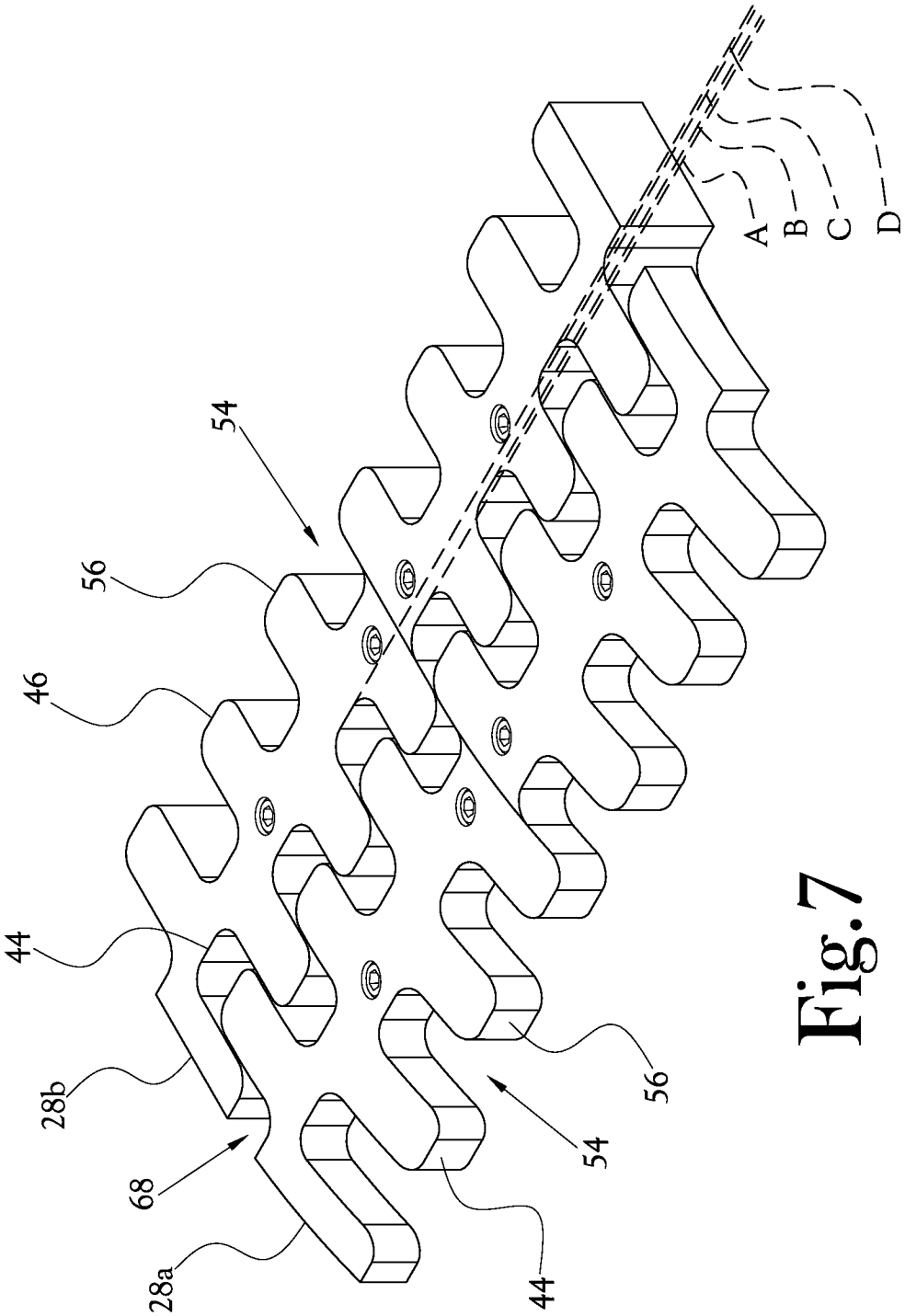


Fig.7

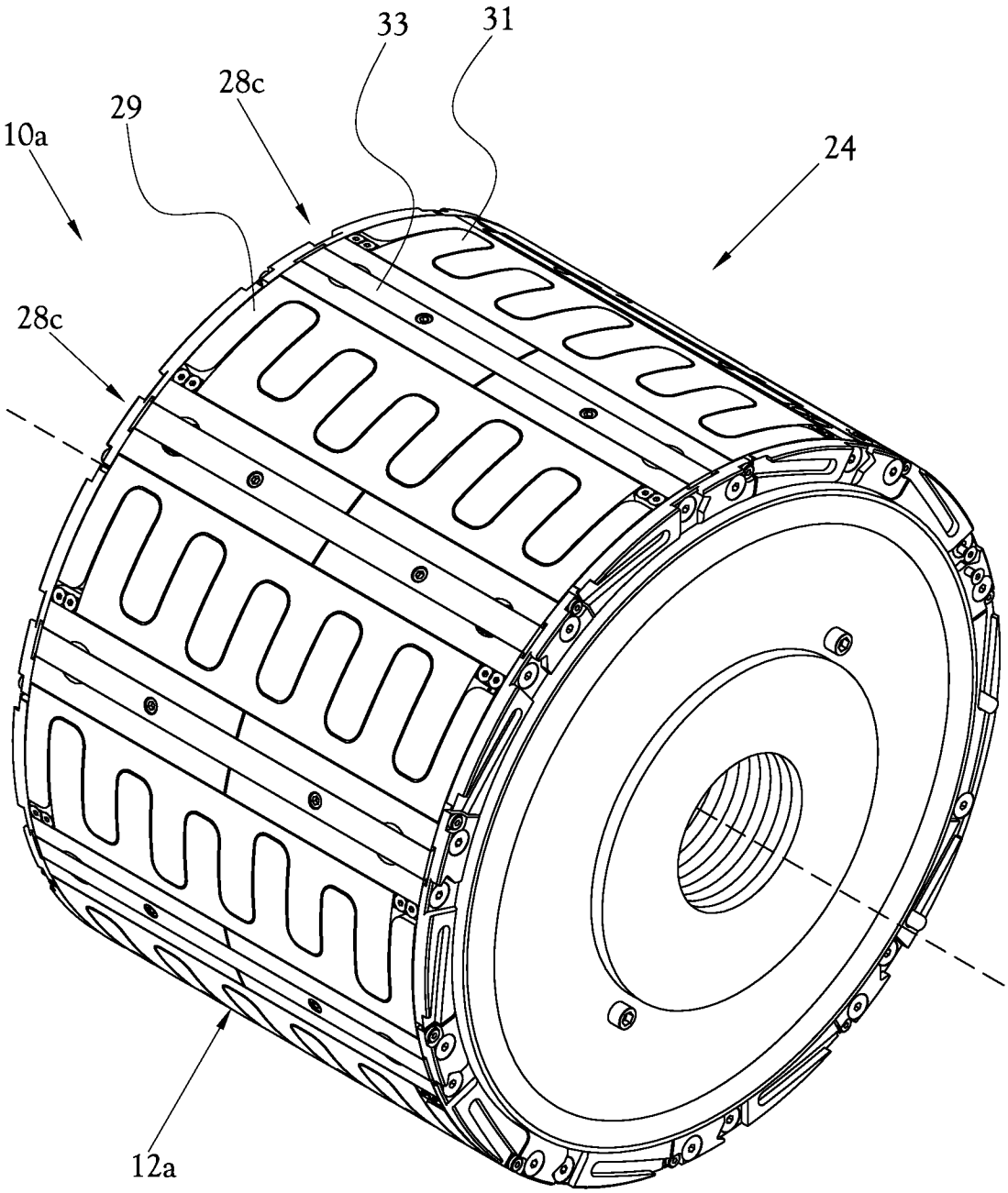


Fig.8

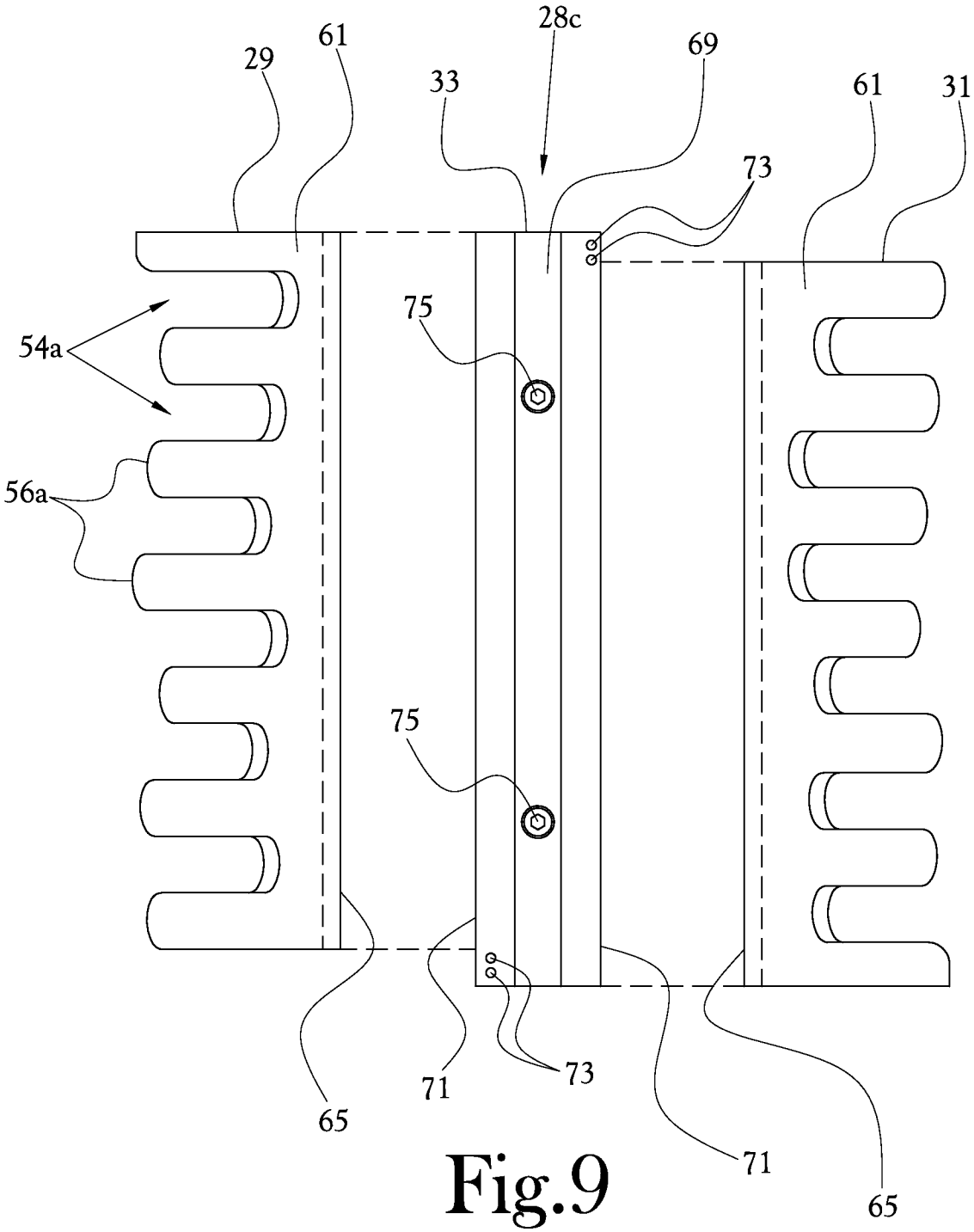


Fig.9

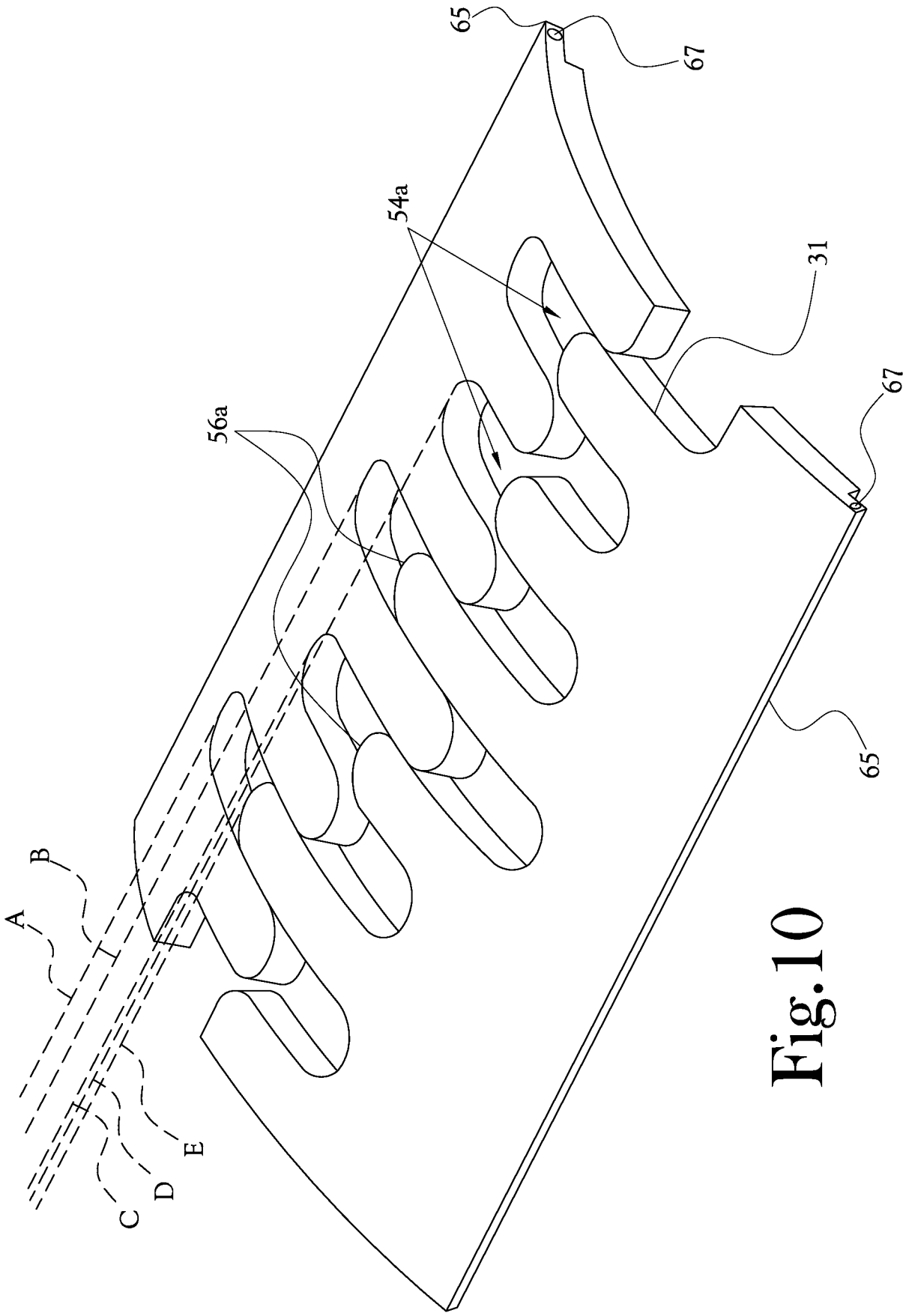


Fig.10

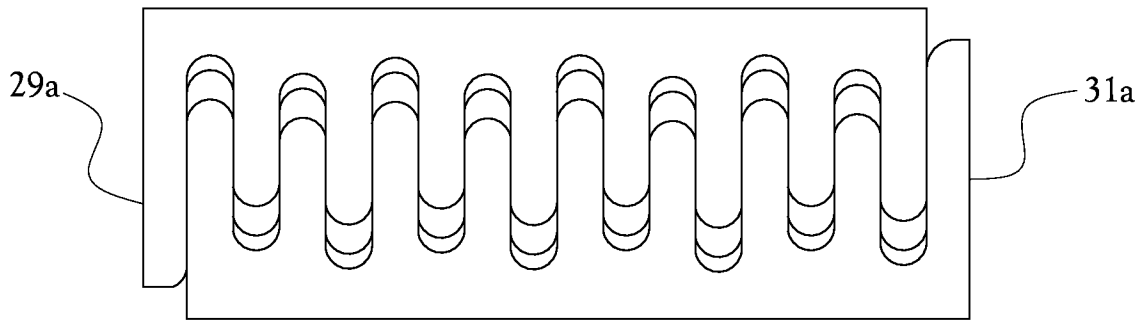


Fig.11

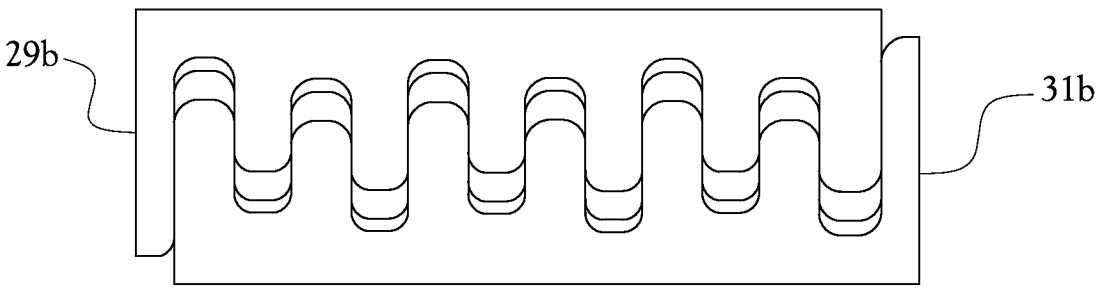


Fig.12

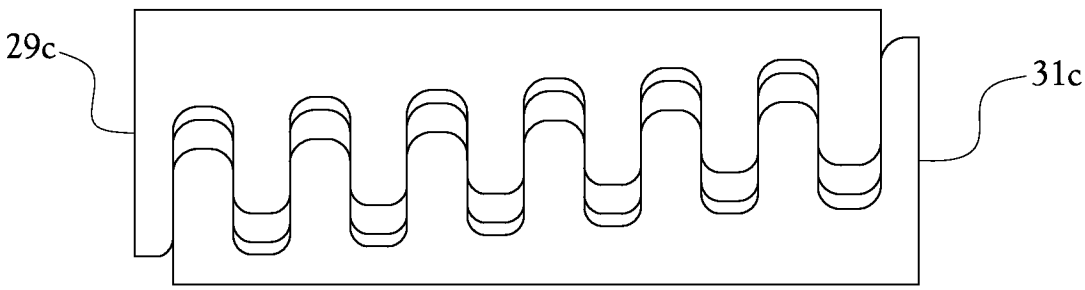


Fig.13

INTERNATIONAL SEARCH REPORT

PCT/US15/15010

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B29D 30/24, 30/26 (2015.01)

CPC - B29D 30/242

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)

IPC(8) Classification(s): B29D 30/24, 30/26 (2015.01)
CPC Classification(s): B29D 30/242

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

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

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data): tire, tyre, drum, manufacturing, tread, belt, producing, forming, building, arcuate, expand, collapse, radial, slots, grooves, tracks, slide, fingers, protrusions, interfit, interconnect, size, length, shape, contour, profile, differ, change, vary, adjust

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,635,016 A (BYERLEY M. S.) June 03, 1997; figures 1-6; column 6, lines 30-45	1-3, 6, 11-13, 16, 18
A	US 6,013,147 A (BYERLEY M. S.) January 11, 2000; entire document	1-20
A	US 4,547,251 A (LANDSNESS C. A.) October 15, 1985; entire document	1-20

☐ 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 another citation or other special reason (as specified)

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

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

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

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

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Date of the actual completion of the international search	Date of mailing of the international search report
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