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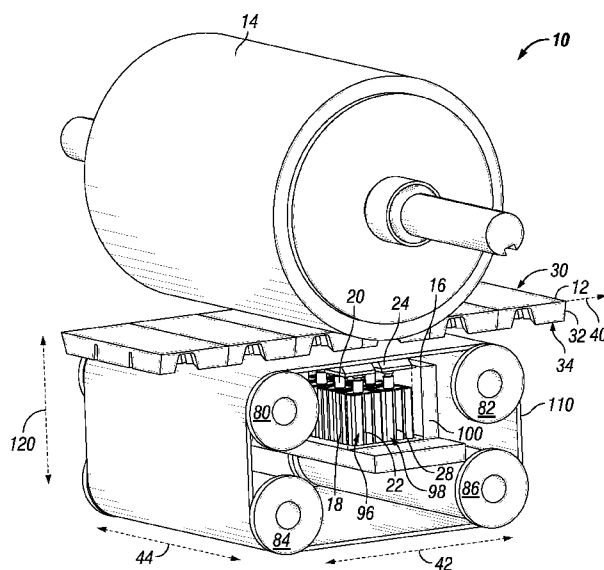


FIG. 5

(57) Abstract: A device (10) for supporting a tread (12) during a retread process is provided that has a plurality of plates (16) that support the tread when the tread is supported by the device. A plurality of actuation members (18) are also provided, and a first one of the plates (16) is acted upon by a first one (22) of the actuation members. A second one of the plates is acted upon by a second one (28) of the actuation members. The first and second actuation members move in directions towards and away from the tread. The first actuation member (22) actuates independently from the second actuation member (28).

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ADAPTIVE TREAD SUPPORT DEVICE FOR RETREAD FINISHING OF TIRES

FIELD OF THE INVENTION

[0001] The present invention relates generally to a device that supports tread that is being brushed in a retread finishing process. More particularly, the present application involves an adaptive tread support device that supports a tread surface of the tread passing through a brushing device so that the underside surface of the tread is evenly brushed.

BACKGROUND

[0002] The retreading of tires involves the molding of a new section of tread that has a tread surface and an underside surface opposite from the tread surface. In order to attach the underside surface to the tire carcass that is being reused, the underside surface must be brushed to prepare the surface for attachment. The tread section is provided in the form of a longitudinal strip, and an end of the strip is held while the strip is fed into a brush machine. Fig. 1 shows the underside surface 30 of a tread 12 that is engaged by and is being treated by a brush 14. A roller 70 supports the tread 12 as the tread 12 is being brushed. A tread outer surface 34 of the tread 12 opposite the underside surface 30 engages the roller 70, and the tread 12 engages surfaces on the brush 14 and roller 70 that are both convex in shape. Tread 12 can have various patterns and in some instances may have large open tread blocks. Upon going through the nip created by the brush 14 and roller 70 in the machine direction 40, the leading edge 72 of the tread block 32 is brushed and the tread block 32 tilts upwards. As the tread block 32 moves past the brush 14, the trailing edge 74 of the tread block 32 is pinched by the brush 14 and the roller 70 and the tread block 32 tilts downward. As the tread block 32 is bending at irregular angles through the pinch point of the brush 14 and roller 70, an irregular contact patch is created on the tread block 32 under the brushing force.

[0003] The rigidity difference in the tread 12 between the tread blocks 32 and the grooves 26 of the tread 12 will cause the tread 12 to deform differently under the brushing force and feeding force of the tread 12 past the brush 14. This rigidity difference will also cause

irregularities in the process due to the bending of the tread 12 along the roller. Through the various factors, the large open block tread 32 will experience irregular movement when being fed past the brush 14 which will cause irregularity in the brushing of the tread 12.

[0004] With reference to Fig. 2, the underside surface 30 of the tread 12 is shown after being brushed by the brush 14. Due to the irregular movement via the factors discussed above, the leading edges 72 of the tread blocks 32 will have over brushed areas that can include dig in notches 76 formed by the brush 14 on the underside surface 30. The trailing edges 74 of the tread blocks 32 will have various under brushed spots 78. These under brushed spots 78 must be manually reworked, which is ergonomically unfriendly, and results in additional labor and costs.

[0005] One way of supporting the tread 12 when it is being brushed is through a support device as shown in Fig. 3 that has nine rectangular plates 88 in one row in the longitudinal direction 42 that extend the entire width of the tread 12 in the lateral direction 44. The tread 12 first moves over a first roller 80 and a second roller 82 and then contacts the single row of nine rectangular plates 88. After passing over the nine rectangular plates 88, the tread 12 passes across the third roller 84 and the fourth roller 86, contacting all of the rollers 80, 82, 84 and 86. The brush 14 is positioned above the nine rectangular plates 88 and the tread 12 is located between the nine rectangular plates 88 and the brush 14 when the underside surface 30 is brushed. The nine rectangular plates 88 support the tread 12 during this process and seek to prevent it from moving around when being brushed so that the underside surface 30 is evenly brushed to attempt to prevent the formation of dig in notches 76 and under brushed spots 78.

[0006] Square bars 90 are associated with each one of the nine rectangular plates 88, and each one of the square bars 90 has a ball nose push that engages the underside of its respective associated rectangular plate 88. As shown in Fig. 4, a flexible tube 92 is below the square bars 90 and above a constraint element 94. Inflation of the flexible tube 92 does not cause the constraint element 94 to move but instead forces the square bars 90 upwards to in turn cause the rectangular plates to be moved upwards and against the tread 12 to provide support during the brushing process. Although capable of achieving better finished surface quality, the effective distance of the pressurized tube 92 is only 2-4 millimeters, thus requiring the provision of a complex adjustment mechanism to move the entire device up or down depending upon the thickness of the tread 12 being processed. Further, the single row of rectangular plates 88 provides limited tilting to the device to accommodate variations in the tread 12 when brushing,

and all of the rectangular plates 88 are acted upon by the same flexible tube 92 again limiting their adaptive function to support the tread 12. As such, there remains room for variation and improvement within the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, which makes reference to the appended Figs. in which:

[0008] Fig. 1 is a side view of tread passing through a roller and brush in accordance with the prior art.

[0009] Fig. 2 is a top view of the underside surface of the tread that has passed through the brush and roller arrangement of Fig. 1.

[0010] Fig. 3 is a perspective view, generally from the top, of a device for supporting tread that is being brushed in accordance with the prior art.

[0011] Fig. 4 is a side view, generally from the side, of the device of Fig. 3 with the frame see through in order to observe the components of the device.

[0012] Fig. 5 is a perspective view of the device in accordance with one exemplary embodiment with a brush treating tread located onto a belt of the device.

[0013] Fig. 6 is a perspective view of a pair of rows of plates and actuation members.

[0014] Fig. 7 is a perspective view of a pair of rows of plates and actuation members located within a frame.

[0015] Fig. 8 is a perspective view of an actuation member and a plate.

[0016] Fig. 9 is a side view in partial cross-section of a pair of actuation members and plates that support a tread.

[0017] Fig. 10 is a side view of the device in which portions of the frame have been removed for clarity.

[0018] Fig. 11 is a cross-sectional view of an actuation member and a plate in accordance with an alternative exemplary embodiment.

[0019] Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the invention.

DETAILED DESCRIPTION OF REPRESENTATIVE EMBODIMENTS

[0020] Reference will now be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, and not meant as a limitation of the invention. For example, features illustrated or described as part of one embodiment can be used with another embodiment to yield still a third embodiment. It is intended that the present invention include these and other modifications and variations.

[0021] It is to be understood that the ranges mentioned herein include all ranges located within the prescribed range. As such, all ranges mentioned herein include all sub-ranges included in the mentioned ranges. For instance, a range from 100-200 also includes ranges from 110-150, 170-190, and 153-162. Further, all limits mentioned herein include all other limits included in the mentioned limits. For instance, a limit of up to 7 also includes a limit of up to 5, up to 3, and up to 4.5.

[0022] The present invention provides for a device 10 that can be used to support a tread 12 when the tread 12 is being treated by a brush 14, for instance when an underside surface 30 of the tread 12 is being brushed in a retreading process. The device 10 includes a plurality of plates 16 that are actuated by a plurality of actuation members 18 such that the plates 16 can be independently actuated by the actuation members 18. The plates 16 can be actuated different amounts and may be actuated at different times such that some of the plates 16 are actuated while other plates 16 are not actuated. The plates 16 can be arranged into a first row 96 and a second row 98 across which the tread 12 can pass, and the orientation into two rows 96, 98 allows for a degree of adaptability to be achieved by the device 10. The rows 96, 98 can have a width in the lateral direction 44 that is greater than the width of the tread 12 in the lateral direction 44 to ensure the entire width of the tread 12 is supported. A belt 110 may be included and can separate the plates 16 from the tread 12 such that the tread 12 engages the belt 110 but does not engage the plates 16. The brush 14 forces the tread 12 down onto the belt 110 which in turn imparts force onto the plates 16. The freedom of pivoting of the plates 16 allow for improved support of the plates 16 relative to the tread 12 to result in improved brushing of the underside surface 30.

[0023] Fig. 5 shows one exemplary embodiment of the device 10 as a tread 12 is being brushed by the brush 14 and is being transported in the machine direction 40 as it is supported by the plates 16. The tread 12 engages the belt 110 but does not engage any of the plates 16 as the plates 16 may never come into contact with the tread 12. However, in other arrangements it may be the case that one or more of the plates 16 do in fact come into contact with the tread 12. The plates 16 and actuation members 18 may be surrounded by the belt 110 that extends in a loop that runs in the machine direction 40, which is the longitudinal direction 42, and that may also run in the vertical direction 120. Four rollers 80, 82, 84 and 86 support the belt 110 and are positioned about the plates 16 and actuation members 18 such that two 80, 84 are rearward in the longitudinal direction 42, and so that two 82, 86 are forward in the longitudinal direction 42. Two of the rollers 80, 82 may be at the same elevation as the plates 16 in the vertical direction 120, and two of the rollers 84, 86 may be below the plates 16 in the vertical direction 120.

[0024] A support is present that fixes the location of the actuation members 18 relative to the rollers, and a frame 100 may be carried by the support. The mounting of the support is not illustrated in Fig. 5 for purposes of clarity in the figure. The actuation members 18 may remain stationary in the longitudinal direction 42 and lateral direction 44 during brushing operations. The roller 14 presses the underside surface 30 so that the tread 12 is forced against the belt 110 which in turn forces the belt 110 against the plates 16. The orientation of the plates 16 changes based on the amount and direction of force applied against the plates 16 so that the tread 12 is in turn supported in a manner that reduces or eliminates dig in notches 76 and under brushed spots 78. The tread 12 may be pulled through the nip created by the plates 16 and brush 14 through the turning of the brush 14, the longitudinal movement of the belt 110, or through some other grasping and pulling of the tread 12.

[0025] Fig. 6 shows the plates 16 arranged into a first row 96 of nine plates 16, and a second row 98 also of nine plates 16. The rows 96, 98 are arranged next to one another in the longitudinal direction 42 so that the tread 12 will first move over the first row 96 and then subsequently over the second row 98 as the tread 12 moves in the machine direction 40. The plates 16 of the rows 96, 98 are symmetrically arranged with respect to one another and have the same size and orientation, but this may not be the case in other embodiments. The first row 96 extends the same length as the second row 98 in the lateral direction 44, and the first row 96 likewise extends the same length as second row 98 in the longitudinal direction 42. The

actuation members 18 are each associated with a single one of the plates 16 so that all of the plates 16 are independent of one another. However, it is to be understood that other embodiments exist in which multiple plates 16 are actuated or associated with a common or single actuation member 18.

[0026] The plates 16 of the first row 96 are shown in see through in order to illustrate portions of the actuation members 18 that are associated with each one of the plates 16 in the first row 96. One of the plates 16 of the first row 96 is designated as a first plate 20 that is actuated by one of the actuation members 18 designated as a first actuation member 22. The first actuation member 22 can be an air cylinder and may have a first rod 58 that moves up and down in the vertical direction 120 so that it can press the first plate 20 against the tread 12 as the tread 12 is supported. The first rod 58 has a first ball nose 60 at its distal end. The first ball nose 60 allows the first plate 20 to have a freedom of movement on the first rod 58. Another one of the plates 16 is the second plate 24 that is in the second row 98 and is located immediately adjacent the first plate 20. The second plate is actuated by a second actuation member 28 that can be an air cylinder that is configured in the same manner as the first actuation member 22. The first plate 20 and second plate 24 may be spaced from one another in the longitudinal direction 42 so that they do not touch one another. However, the positioning of the two plates 20, 24 next to one another may constrain their movement in that they will engage one another so that they will in fact touch, and so that they will be secured into a desired position in the rows 96, 98.

[0027] The first row 96 and second row 98 are also shown with reference to Fig. 7 in which the plates 16 of the first row 96 are again transparent in order to show detail of the device 10 below the plates 16 of the first row 96. A frame 100 surrounds the first and second rows 96, 98 in order to constrain the movement of the plates 16. In this regard, the second plate 24 may engage the frame 100 on two of its sides so that its movement is constrained, and the second plate 24 may engage the first plate 20 on one side and may engage another plate 16 of the second row 98 on another side so that its location within the rows 96, 98 are known. The frame 100 may extend around the entire perimeter of the plates 16 so that all of the plates 16 are bordered on one or two sides by the frame 100. If a third row or additionally more rows of plate 16 were provided, some of these plates 16 would not directly engage the frame 100 but would still be within a perimeter of the frame 100 and surrounded by the frame 100. In yet other embodiments, the frame 100 is not present or if it is present does not completely surround the perimeter of the

plates 16. In these instances, the plates 16 can be configured with the actuation members 18 so that they are constrained in some manner so that they do not move off of the actuation members 18. The various plates 16 can have convex sides that face and engage the frame 100 to allow for pivoting of the plates 16.

[0028] Fig. 8 is a perspective view of one of the actuation members 18, in this case the first actuation member 22, and one of the plates 16, this one being the first plate 20. The first plate 16 is pivotally mounted onto the first rod 58 of the first actuation member 22. The first plate 16 has an upper surface 38 that in its center has an origin 126. The upper surface 38 can be a flat surface. A three dimensional axis system extends from the origin 126 in order to explain the pivoting movement of the first plate 20 relative to the first actuation member 22 and likewise relative to the ground. The first plate 20 has a front side surface 48 and an oppositely disposed back side surface 50. The first plate 20 also has a left side surface 52 and a right side surface 56 that are likewise opposite one another. The various side surfaces 48, 50, 52 and 56 extend down from the upper surface 38 and completely border the upper surface 38.

[0029] In the normal, at rest condition with no brushing operations being performed, the first plate 20 is arranged generally so that the front side surface 48 is oriented forward of the other side surfaces 50, 52, 56 in the longitudinal direction 42, which may also be described as a longitudinal axis 42 extending through the origin 126. The back side surface 50 is the most rearward surface of the other side surfaces 48, 52, 56 in the longitudinal direction 42. The left and right side surfaces 52, 56 are the most outboard side surfaces in the lateral direction 44, which may be described as a lateral axis 44 that extends through the origin 126. A vertical axis 120 extends through the origin 126 in the vertical direction 120. The first plate 20 is shown pivoted in Fig. 8 such that the various side surfaces 48, 50, 52, 56 are not oriented exactly along their various axes 42, 44 as previously described but are instead at angles thereto. As illustrated, the first plate 20 is pivoted with respect to the origin 126 so that it is rotated around the longitudinal axis 42 and the lateral axis 44. Additionally, the first plate 20 may be rotationally mounted onto the first rod 58 so that it is capable of rotating about the vertical axis 120 and this orientation is likewise illustrated in Fig. 8. The amount of rotation of the first plate 20 about the origin 126 can be limited due to the presence of the first rod 58, presence of other plates 16, presence of the frame 100, or through the configuration of the connection between the first rod 58 and the first plate 20.

[0030] The front side surface 48, back side surface 50, left side surface 52, and right side surface 56 are convex surfaces and do not extend completely up and down in the vertical direction 120. In some instances, only part of the surfaces 48, 50, 52 and 56 are convex while other portions of the surfaces 48, 50, 52, 56 are flat and do extend in the vertical direction 120 with surface normal that are perpendicular to the vertical axis 120. By having the surfaces 48, 50, 52 and 56 convex, additional space is afforded between the various plates 16 and frame 100 so that the plates 16 have additional room to pivot during brushing operations. The convex surfaces may allow the plates 16 to tilt freely in any direction for a small angle around the ball nose 60 joint, and yet maintain contact so that a gap is not present. This continued contact may cause the assembly to better withstand forces in the longitudinal direction 42 that could otherwise bend the first rod 58. Although described as being the first plate 20, it is to be understood that all of the plates 16 can be arranged in a manner similar to the first plate 20 as discussed. Further, although being described as convex in shape, the surfaces 48, 50, 52, 56 could be chamfered or have other shapes in accordance with various exemplary embodiments.

[0031] Fig. 9 is a partial cross-sectional view of the first row 96 and second row 98 with the belt 110 and tread 12 disposed onto the plates 16. The first actuation member 18 with first plate 20 is illustrated, as is the second actuation member 28 with the second plate 24. The first actuation member 22 is an air cylinder in which the first rod 58 travels through the bore of the first actuation member 22, and in which a spring 122 biases the first rod 58 downward and away from the tread 12. Air pressure provided through port 124 will act on the first rod 58 and urge it upwards and against the bias force of the spring 122 in order to overcome the spring force and push the first rod 58 in the vertical direction toward the tread 12. The second actuation member 28 can be arranged in a similar manner in which air pressure provided through port 130 causes the second rod 64 to be pushed upwards against the downward biasing force of the spring 128 to cause the second rod 64 to move towards the tread 12. If air pressure is removed from the ports 124, 130 the springs 122, 128 cause the rods 58, 64 to be retracted back into their respective bores and cause the plates 20, 24 to be moved in the vertical direction 120 away from the tread 12.

[0032] The first rod 58 has a first ball nose 60 at its upper terminal end. The first ball nose 60 may engage an underside 62 of the first plate 20. A socket connection can be located at the underside 62 to receive the first ball nose 60 to allow the first plate 20 to pivot with respect to

the first rod 58 as previously discussed. A tread block 32 is shown on the belt 110 and immediately above the first plate 20. The angle and force from this tread block 32 causes the first plate 20 to pivot about the first ball nose 60 into the illustrated position which in turn supports the tread block 32 during the brushing operations. The belt 110 pushes against the upper surface 38 and the tread block 32 does not come into any contact with the first plate 20.

[0033] The second rod 64 of the second actuation member 28 has a second ball nose 66 at its upper, terminal distal end. The second ball nose 66 can engage an underside 68 of the second plate 24, or may be received within a socket connection that is in turn rigidly attached to the underside 68. The socket connection allows the second plate 24 to pivot relative to the second ball nose 66 as previously described with respect to the first plate 20. A tread block 32 of the tread 12 is located partially over the second plate 24. This tread block 32 engages the belt 110 which in turn has a bottom side 118 that engages the upper surface 46 of the second plate 24. The amount and direction of force from the tread block 32 dictates the pivoting angle of the second plate 24 relative to the second ball nose 66.

[0034] The first plate 20 and the second plate 24 are oriented at different angles during brushing operations in order to accommodate tread blocks 32 that press at different angles when force from the brush 14 is applied. The amount of air pressure acting on the actuation members 22, 28 can be varied during the brushing operations in response to the amount of force applied by the brush 14, or the amount of air pressure from the actuation members 22, 28 may be the same during the entire brushing sequence. Increasing the air pressure of the actuation members 22, 28 will cause the plates 20, 24 to be forced upwards against belt 110 and hence against the tread blocks 32. This force may function to stabilize the tread 12 as it is being brushed in order to minimize or prevent the tread 12 from jumping around during the brushing process and to achieve a more desired brushing result.

[0035] The first plate 20 and the second plate 24 may engage one another at all times so that a gap is not formed in the longitudinal direction 42 when the plates 20, 24 pivot relative to one another. The touching ends of the plates 20, 24 are convex in shape in order to allow them to move relative to one another and remain in contact with one another. The curvature of the ends of the plates 20, 24 that touch can be centered about the pivot point of the ball noses 60, 66 so that the point of the ends of the plates 20, 24 farthest from the ball noses 60, 66 are at the same distance in the vertical direction 120 as the ball noses 60, 66 when the plates 20, 24 are in

the flat orientation. Any shape or configuration of the touching ends of the plates 20, 24 can be employed to allow them to pivot about the lateral direction 44 and the longitudinal direction 42.

[0036] Fig. 10 is a side view of the device 10 as it supports the tread 12 when being brushed by the brush 14 to prepare the tread 12 for tire retreading. A portion of the frame 100 is removed in order to observe two of the actuation members 18 and plates 16 that are the first and second actuation members 22, 28 and the first and second plates 20, 24. The plates 20, 24 can assume angles that are the same as or different from one another depending upon the direction of forces imparted by the brush 14 as transferred through the tread blocks 32 into the belt 110 and then onto the plates 20, 24. The belt 110 is arranged around four rollers 80, 82, 84, 86 but it is to be understood that more than or fewer than four rollers can be used in other exemplary embodiments in order to support the belt 110. The belt 110 has a bottom side 118 that engages the upper surfaces 36 of the plates 16 of the device 10. The bottom side 118 may be arranged in such a manner that it does not engage the tread 12. The belt 110 also has a top side 116 that does not engage the upper surfaces 36 of the plates 16 but that does engage the tread 12 at the tread outer surface 34. In some embodiments, the belt 110 can be made out of different materials to take advantage of the fact that the belt 110 has surfaces that contact some elements but not others. For example, the top side 116 of the belt 110 can be made out of a first material 112 that is a high friction material such as rubber. The coefficient of friction of the first material 112 is high because it sits against and moves with the tread 12 while it passes through the brush 14. The bottom side 118 of the belt 110 can be made of a second material 114 that is of less friction than the first material 112. The second material 114 can be of lesser friction because it engages the plates 16 and will want to pass across these surfaces. The second material may be nylon in some instances.

[0037] The plates 16 and actuation members 18 can be configured in numerous alternate manners from those described and shown in other embodiments of the device 10. One such alternate manner is shown with reference to Fig. 11 in which the plate 16 in addition to having an upper surface 36 is also attached to a spring 140. The plate 16 has an unactuated position 132 in which the plate 16 is farthest from the tread 12 in the vertical direction 120. The actuation member 18 has a port 136 through which air can be introduced to enter into a chamber 138 of the actuation member 18. The introduction of air into the chamber 138 causes the chamber 138 to be pressurized to such an extent that the air pressure forces the plate 16 upwards in the vertical

direction 120 and out of the unactuated position 132. The plate 16 may be forced into the fully actuated position 134 that is shown in dashed lines in Fig. 11. An amount of air pressure in between the two positions 132, 134 can also be established in order to cause the plate 16 to be at some point between the positions 132, 134. The plate 16 may be forced against the belt 110 in order to squeeze the tread 12 between the brush 14 and belt 110 to hold the tread 12 more securely during brushing operations. Air can be evacuated from the chamber 138 and the absence or reduction of this air pressure will allow the spring 140 of the actuation member 18 to return towards or to its biased position. The biased position of the spring 140 if no air pressure is present is in the unactuated position 132. The plate 16 will likewise be drawn back into the unactuated position 132 as the plate 16 is integrally formed with or otherwise attached to the spring 140.

[0038] The belt 110 and the associated plates 16 and actuation members 18 function to restrict the space available to the tread 12 on the side of the tread 12 opposite to the brush 14. This space restriction prevents or minimizes movement of the tread 12 during brushing to result in less or no dig in notches 76 and under brush spots 78 on the underside surface 30. The actuation members 18 may push the plates 16 upwards as the tread 12 is traveling across, above the plates 16 in the machine direction 40. If different sized tread 12 or brushes 14 are used, the actuation members 18 can provide an adjustment that allows the belt 110 and the plates 16 to be positioned closer to or farther from the tread 12. In this regard, the travel of the rods 58, 64 can be from 30-40 millimeters so that various sizes of tread 12 and brushes 14 can be accommodated. In other embodiments, the travel length of the rods 58, 64 in the vertical direction 120 may be from 10-20 millimeters, from 20-30 millimeters, from 40-50 millimeters, or up to 100 millimeters. An adjustment mechanism, other than the stroke lengths of the actuators 18 themselves, need not be present in the device 10 to account for different tread 12 thicknesses and different sized brushes 14. The pushing force of all of the actuation members may be from 300-400 Newtons. The plates 16 can pivot about the longitudinal axis 42, the lateral axis 44, and combinations thereof, and the plates 16 can all pivot independently from one another and may be actuated, biased by their own individual actuation member 18 that is independently actuated from the others 18. The freedom to be tilted in the disclosed directions may allow the tread blocks 36 to have maximum contact with the supported belt 110 to achieve a more even and better surface texture from the brushing. Although the plates 16 are shown with

square upper surfaces 36, the plates 16 may have rectangular, triangular, or circular shaped upper surfaces 36, or may have upper surfaces 36 that are of any shape in accordance with other exemplary embodiments.

[0039] While the present invention has been described in connection with certain preferred embodiments, it is to be understood that the subject matter encompassed by way of the present invention is not to be limited to those specific embodiments. On the contrary, it is intended for the subject matter of the invention to include all alternatives, modifications and equivalents as can be included within the spirit and scope of the following claims.

CLAIMS

What is claimed is:

1. A device for supporting a tread during a retread process, comprising:

a plurality of plates that support the tread when the tread is supported by the device; and

a plurality of actuation members, wherein a first one of the plates is acted upon by a first one of the actuation members, wherein a second one of the plates is acted upon by a second one of the actuation members, wherein the first actuation member and the second action members move in directions towards and away from the tread, wherein the first actuation member actuates independently from the second actuation member.
2. The device as set forth in claim 1, wherein all of the plates of the plurality of plates are acted upon by individual actuation members of the plurality of actuation members, wherein each of the plurality of actuation members actuate independently from one another.
3. The device as set forth in claims 1 or 2, wherein the plurality of plates each have a square upper surface.
4. The device as set forth in claim 3, wherein the plurality of plates each have convex shaped front, back, left, and right side surfaces.
5. The device as set forth in any one of claims 1-4, wherein the first actuation member has a first rod with a first ball nose that engages an underside of the first plate, wherein the first plate pivots about the first rod in a lateral direction of the device, in a longitudinal direction of the device, and in combinations of the lateral and longitudinal directions of the device;

wherein the second actuation member has a second rod with a second ball nose that engages an underside of the second plate, wherein the second plate pivots about the second rod in the lateral direction of the device, in the longitudinal direction of the device, and in combinations of the lateral and longitudinal directions of the device.

6. The device as set forth in any one of claims 1-5, wherein the plurality of plates are arranged into a first row and a second row, wherein the tread moves in the machine direction which is a longitudinal direction of the device and first engages the first row and then subsequently engages the second row.

7. The device as set forth in any one of claims 1-6, further comprising a frame that borders the plurality of plates on a front side, back side, left hand side, and right hand side of the plurality of plates, wherein the frame limits movement of some of the plates of the plurality of plates upon engagement with the frame.

8. The device as set forth in claim 7, wherein all of the plates of the plurality of plates border the frame and are limited in movement upon engagement with the frame.

9. The device as set forth in any one of claims 1-8, further comprising a belt that travels in a machine direction of the tread and is located between the tread and the plurality of plates, wherein the tread engages the belt, wherein the tread does not engage the plurality of plates.

10. The device as set forth in claim 9, wherein the belt has a first material that is located at a top side of the belt that engages a brush, wherein the belt has a second material that

is located at a bottom side of the belt that engages the plurality of plates, wherein the first material of the belt has a higher frictional resistance than the second material of the belt.

11. The device as set forth in any one of claims 1-10, wherein the plurality of actuation members are air cylinders.

12. The device as set forth in claim 11, wherein the air cylinders have a stroke that is from 30-40 millimeters, and wherein the air cylinders have from 300-400 Newtons of pushing force.

13. The device as set forth in any one of claims 1-10, wherein the plurality of actuation members are air springs.

14. The device as set forth in any one of the preceding claims, further comprising a brush that engages an underside surface of the tread, wherein the tread is located between the plurality of plates and the brush.

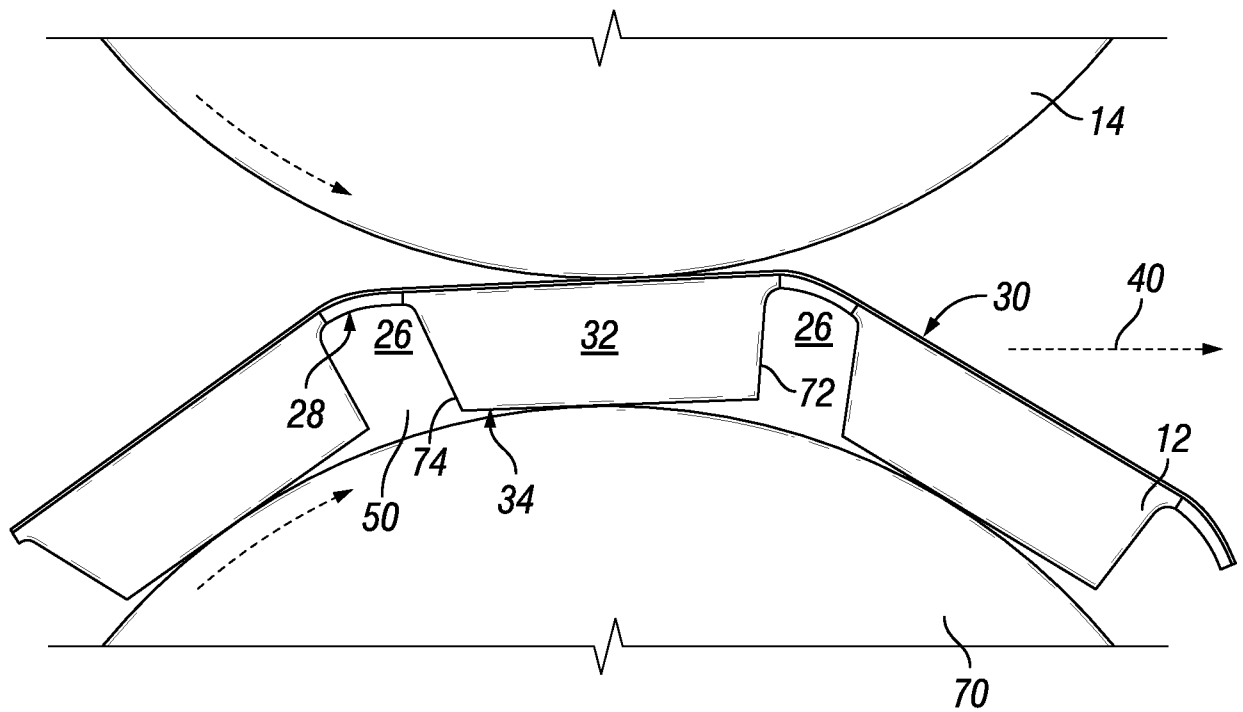


FIG. 1
(Prior Art)

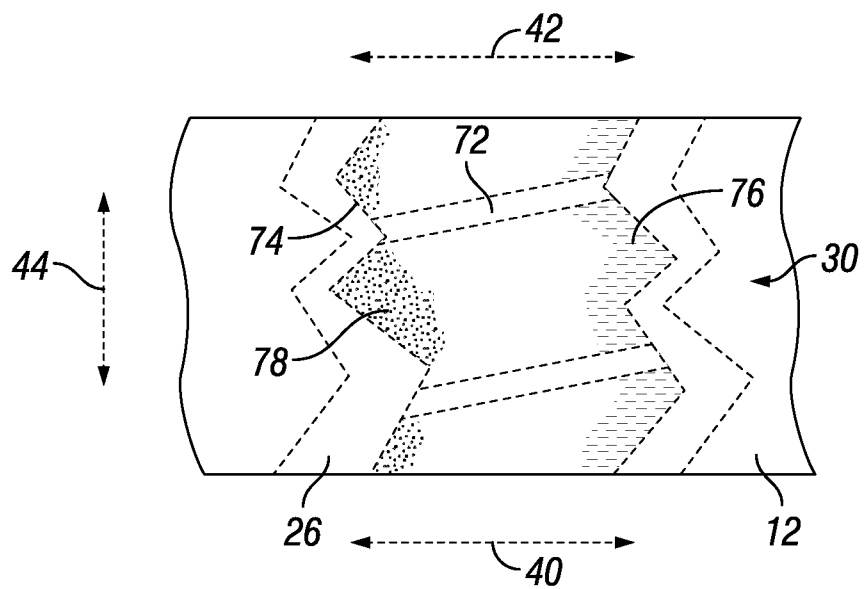


FIG. 2
(Prior Art)

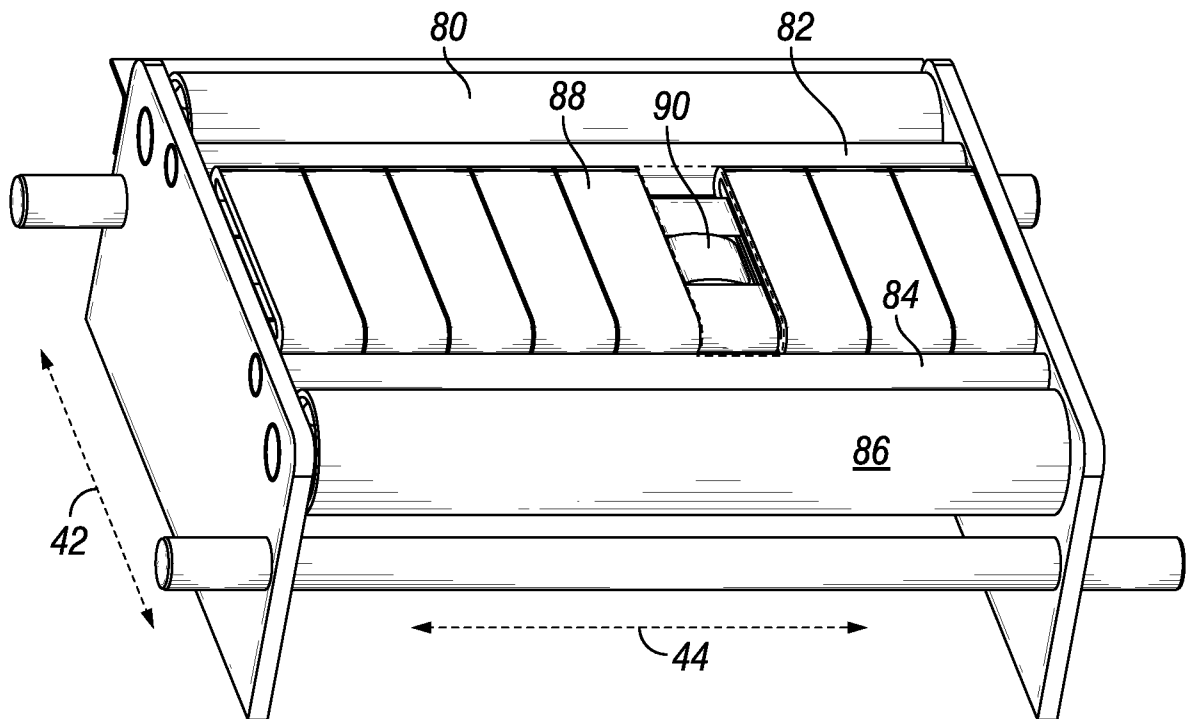


FIG. 3
(Prior Art)

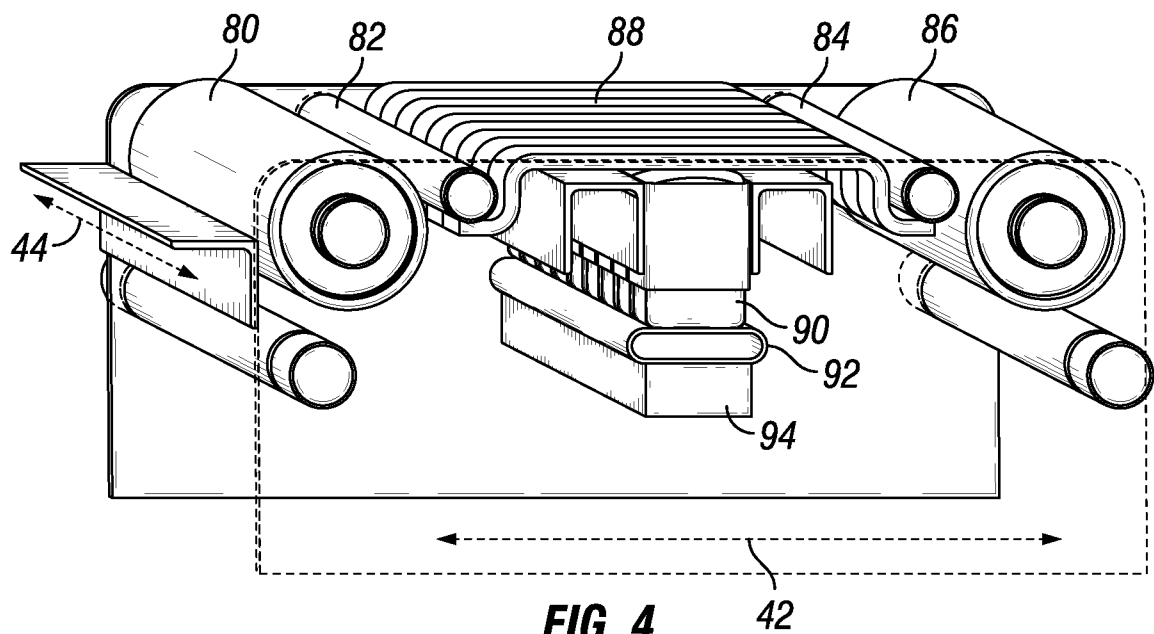


FIG. 4
(Prior Art)

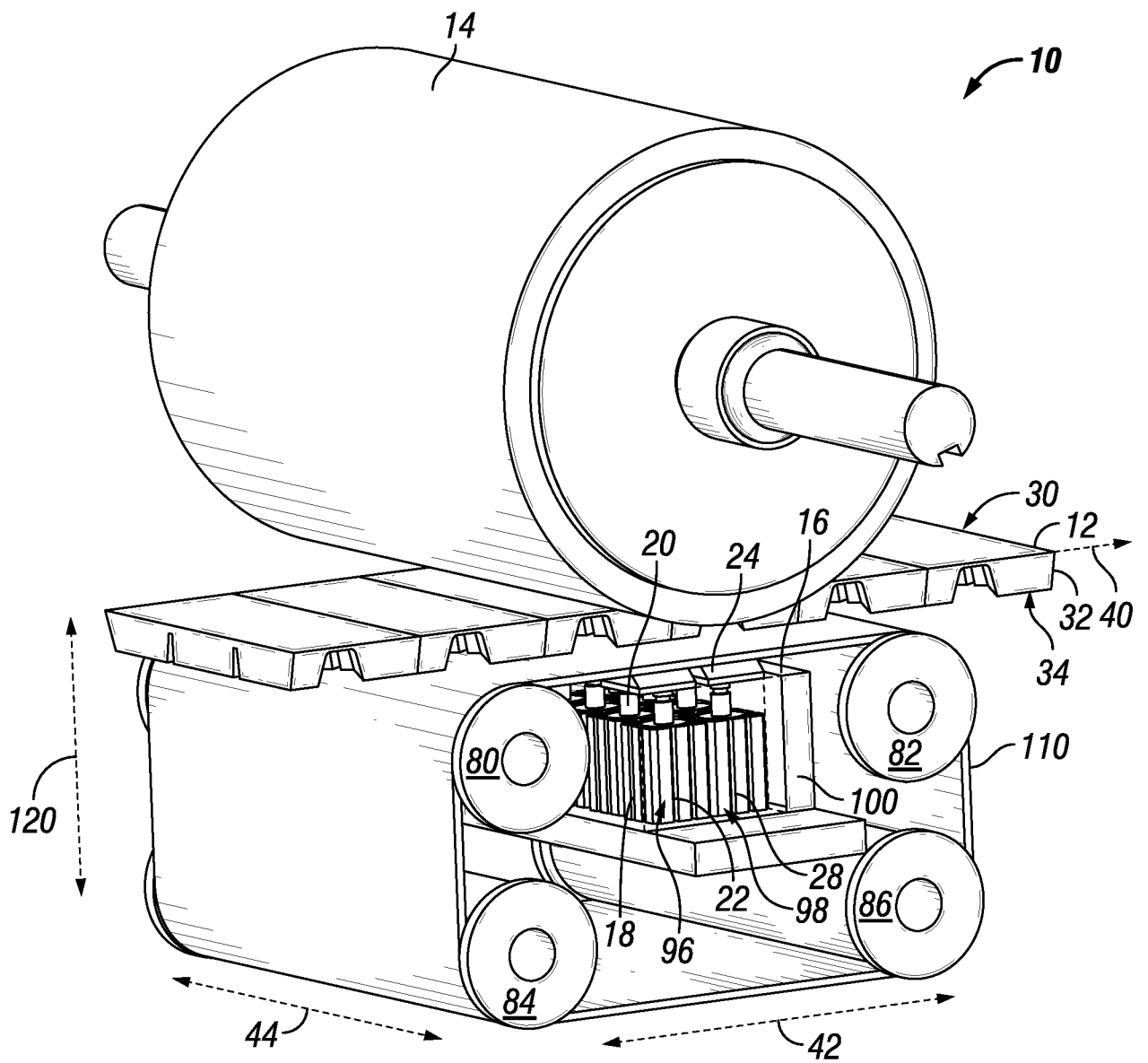


FIG. 5

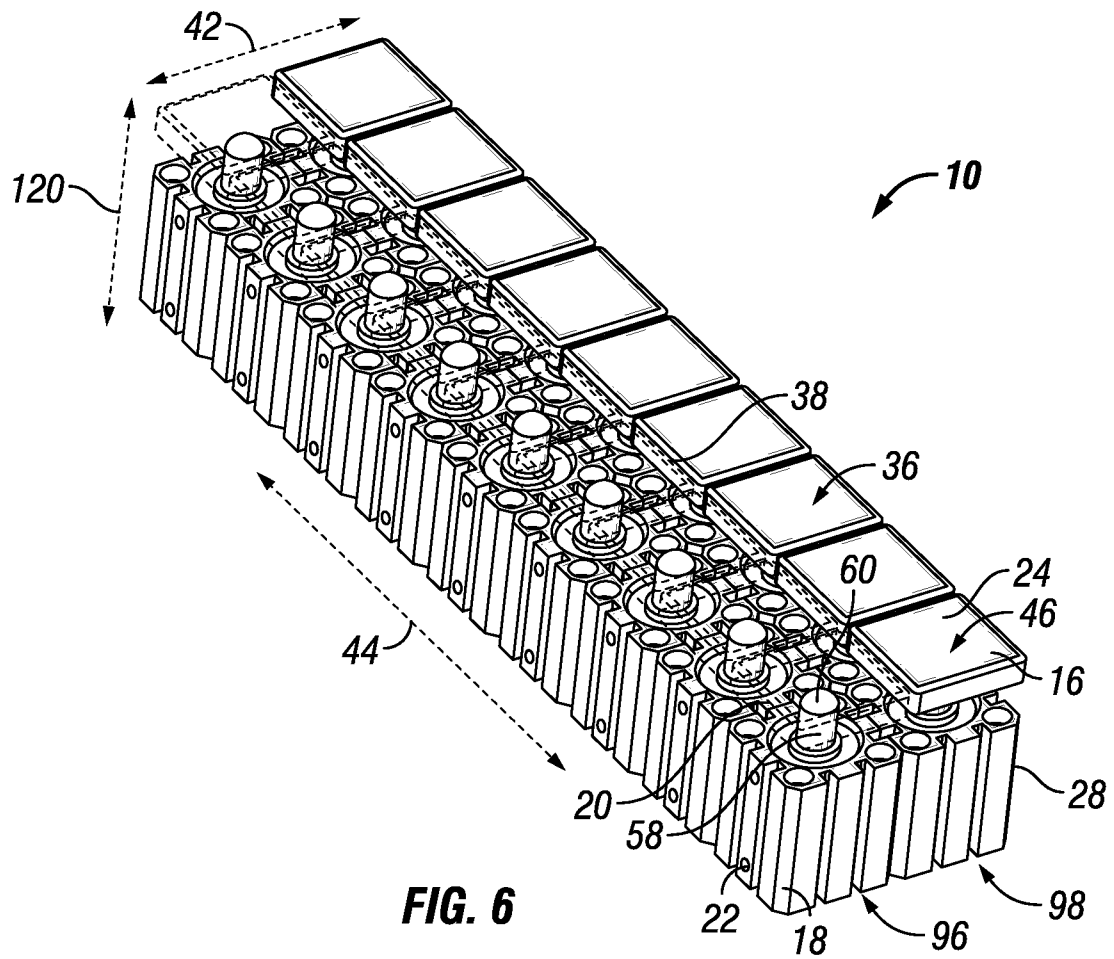


FIG. 6

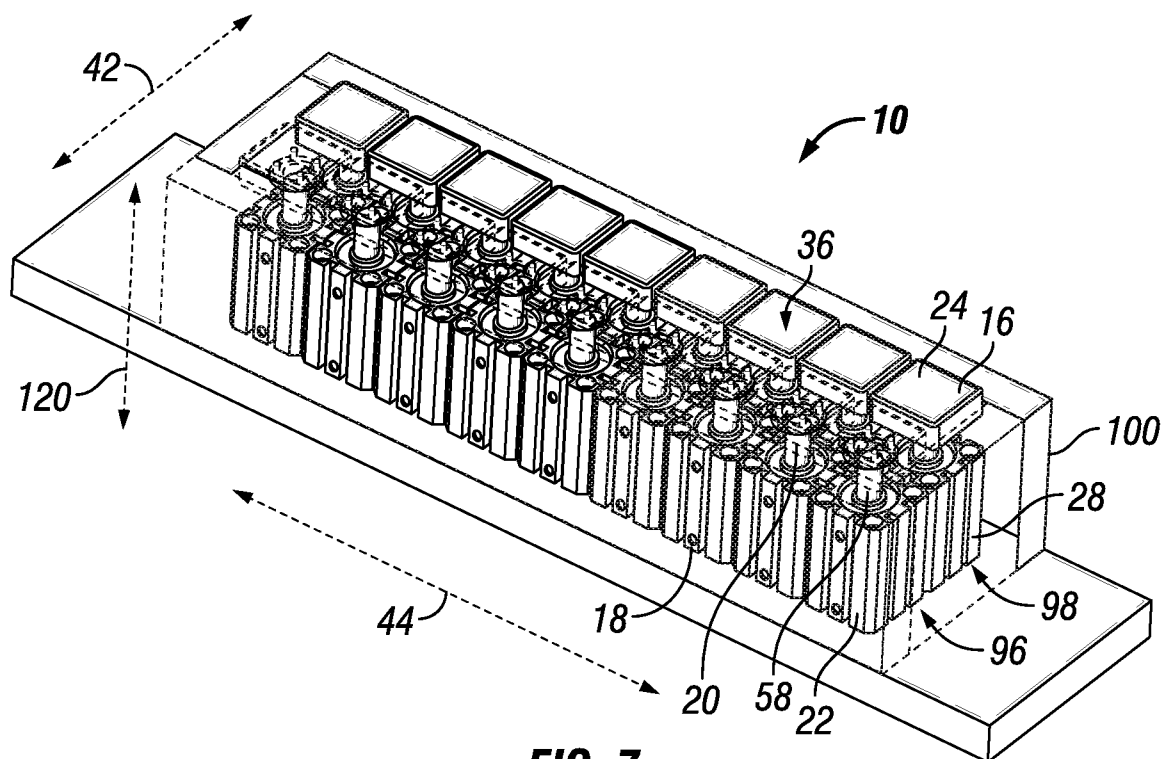


FIG. 7

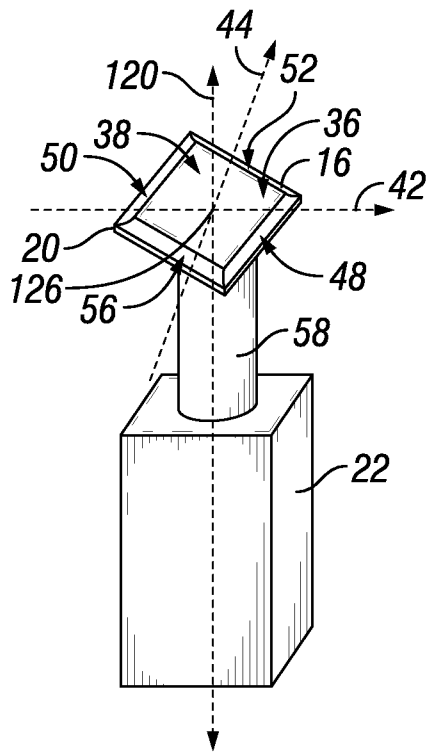


FIG. 8

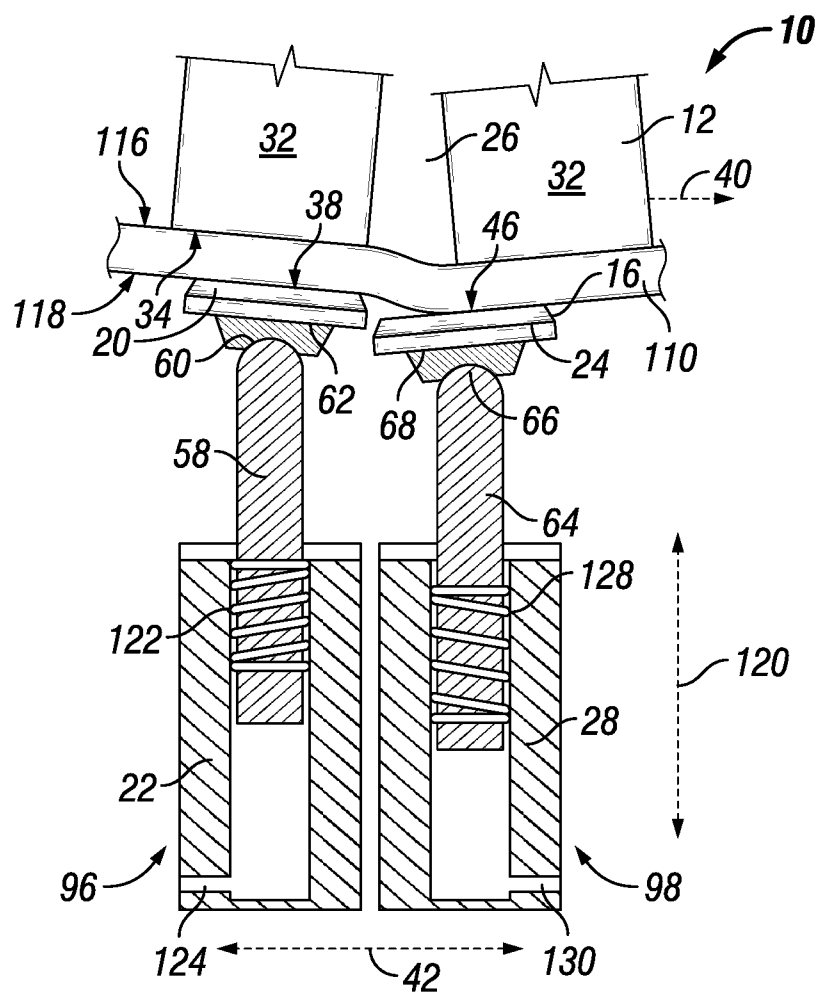
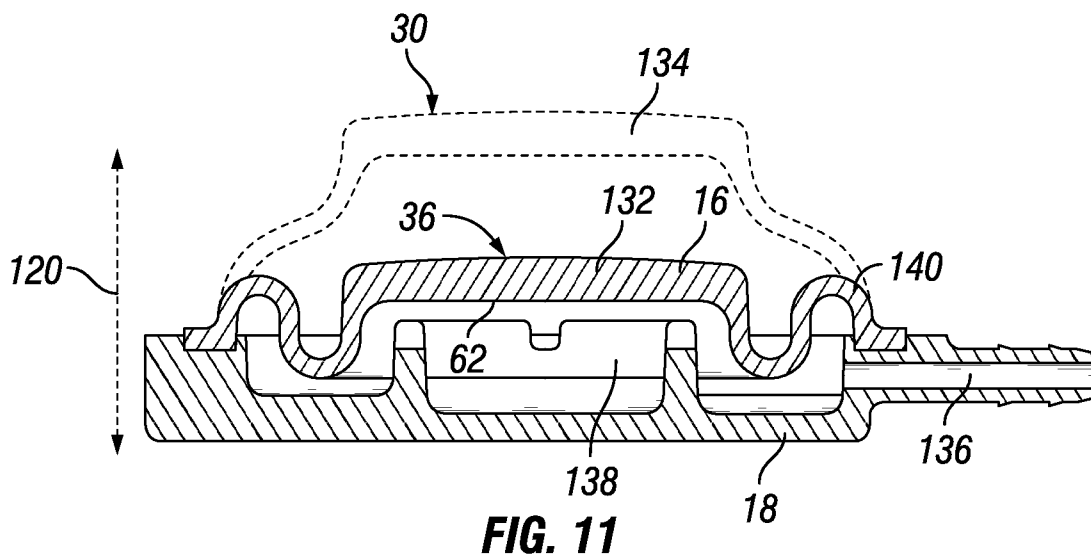
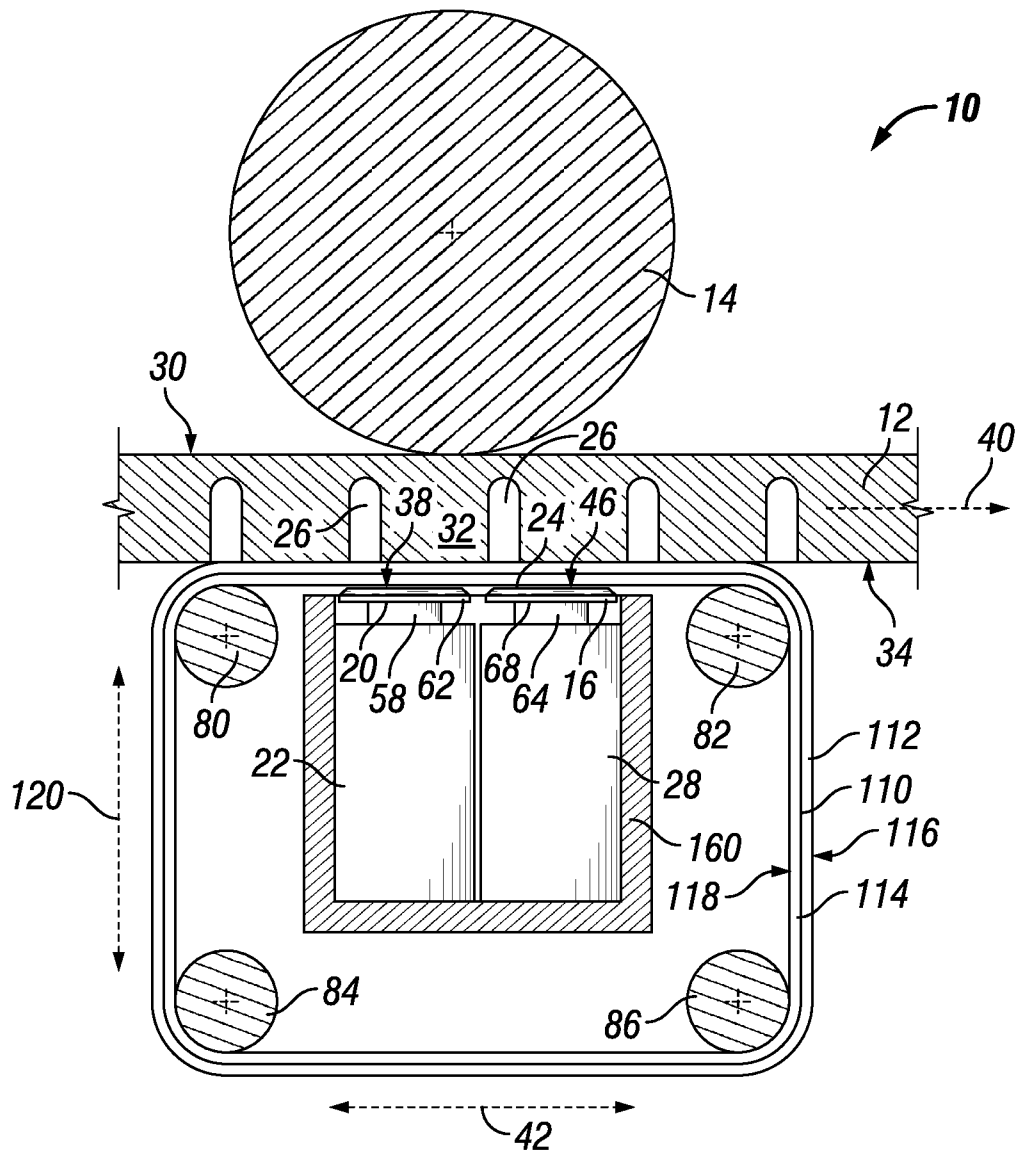


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/060606

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29D30/54
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B29D

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)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 4 845 897 A (HOLST SVEND [DK] ET AL) 11 July 1989 (1989-07-11) column 2, line 58 - column 3, line 17 column 3, line 45 - column 4, line 60; figures 1,2,4	1-4,7-9, 14 5,6, 10-13
X	----- US 1 521 582 A (STEVENS WILLIAM C) 30 December 1924 (1924-12-30) page 1, line 66 - page 2, line 50; figures 1-5	1,2,10, 14
A	----- US 4 679 354 A (HOLST SVEND [DK] ET AL) 14 July 1987 (1987-07-14) column 1, line 10 - column 5, line 28; figures 1-3 ----- -/--	1-14

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

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

31 January 2018

Date of mailing of the international search report

08/02/2018

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Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/060606

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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