(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 April 2010 (08.04.2010)

PCT

(10) International Publication Number
WO 2010/039927 A2

(51) International Patent Classification:
B62D 1/04 (2006.01) *B62D 1/11* (2006.01)
B62D 1/06 (2006.01)

(21) International Application Number:
PCT/US2009/059182

(22) International Filing Date:
1 October 2009 (01.10.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/102,284 2 October 2008 (02.10.2008) US

(71) Applicant *(for all designated States except US)*: **KEY SAFETY SYSTEMS, INC.** [US/US]; 7000 Nineteen Mile Rd., Sterling Heights, MI 48314 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **XU, Xiaoping** [US/US]; 3584 Chartwood Drive, Rochester, MI 48306 (US).

(74) Agent: **SEITZMAN, Markell**; 7000 Nineteen Mile Road, Sterling Heights, MI 48314 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM,

[Continued on next page]

(54) Title: STEERING WHEEL

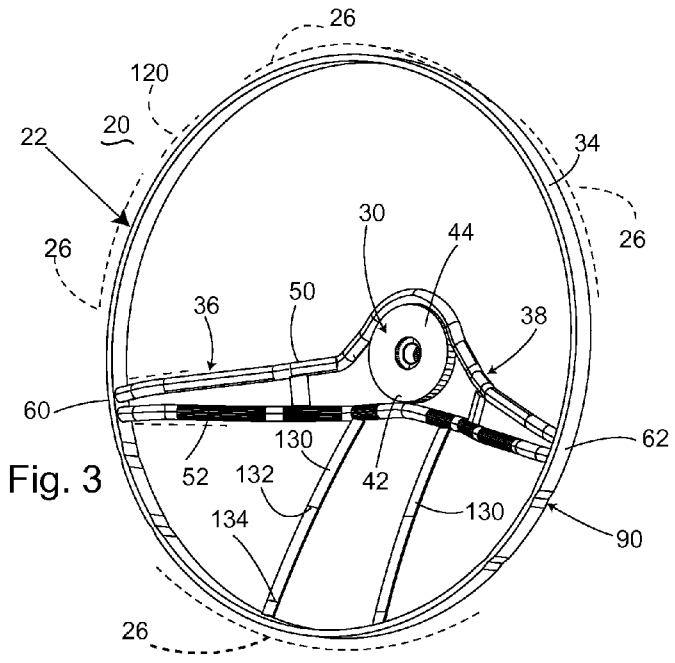


Fig. 3

(57) Abstract: A steering wheel (20) having: an armature (22) comprising: a central hub (30), a rim (34) positioned apart from the hub and at least one spoke (36; 38) connecting the hub and rim; the rim (34) including stress risers (92 - 98; 102 - 108; 92a 98a; 102a, 108a) to enable a top portion and/or a lower portion of the rim to compress more when a determinable force is applied against the rim in a radial direction compared to when the same force is applied to the lower portion of the rim at an angle to a plane in which the rim is located.

WO 2010/039927 A2

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

Steering Wheel

Background and Summary of the Invention

[0001] This application claims the benefit of U.S. Provisional Application 61/102,284, filed on October 2, 2008. The disclosure of the above application is incorporated herein by reference.

[0002] The present invention relates generally to steering wheels and more particularly to a steering wheel employing an armature having an oblong (including rectangular and oval) cross-section principally to control the deformation characteristics of the steering wheel rim.

[0003] Steering wheels are designed to absorb crash energy and protect the driver. During any driving cycle a driver is prone to change the angular position of the steering wheel relative to the driver's face, chest and abdomen and the design of the steering wheel must be sufficiently robust to absorb sufficient energy in any of the anticipated positions the steering wheel can be moved to.

[0004] Accordingly, the invention comprises: A steering wheel (20) having: an armature comprising: a central hub, a rim positioned apart from the hub and at least one spoke connecting the hub and rim; the rim includes first means to either a top portion and/or a lower portion of the rim to compress more when a determinable force is applied against the rim in a radial direction compared to when the same force is applied to the lower portion of the rim at an angle to a plane in which the rim is located.

[0005] In the typically normal steering wheel the rim is stiff and will deflect a less amount when a load is radially applied than when the load is applied at an angle to the plane of the steering wheel.

[0006] In the present invention the steering wheel is designed to work oppositely from above class of steering wheels. The

present steering wheel will deform more when the resultant force (crash force) acts generally perpendicular or radially on the lower (or upper) extreme of the steering wheel (the force is in the plane of the rim) than when the force acts on the steering wheel at an angle to the plane of the rim. Said another way, the steering is stiffer, that is, it deflects less, when the force is applied to the lower extremes of the steering wheel at an angle with a plane extending through the rim of the steering wheel. In view of this specification the steering wheel is required and achieved the force deflection curves reflected Figure 17.

Brief Description of the Drawings

[0007] Figures 1 and 2 diagrammatically show the position of a commercial steering wheel at or near two extremes of angular motion.

[0008] Figure 3 is an isometric view of a steering wheel armature that incorporates the present invention.

[0009] Figure 4 is a front plan view of the steering wheel armature of Figure 1.

[0010] Figure 4a shows a partial cross-sectional view of an armature support structure.

[0011] Figure 4b shows two opposing stress risers in the rim of the steering wheel.

[0012] Figure 5 shows a right-side plan view of the steering wheel armature.

[0013] Figure 6 shows a strip of steel used to form the rim of the armature.

[0014] Figure 6a is a cross-section of a strip of steel with a rectangular cross-section used to form the rim of the armature. Figure 6a also includes two phantom lines illustrating one or more rims with wider and longer dimensions.

[0015] Figure 6b shows a view of another rim having an oval cross-section.

[0016] Figures 7 and 7a show a butt weld.

[0017] Figures 8, 9 and 9a show an overlapped weld.

[0018] Figures 10 and 10a show an armature with an alternate pattern of stress risers.

[0019] Figures 11a – 11d show alternate patterns of stress risers.

[0020] Figure 12 is a plan view of the armature showing exemplary crash forces applied to the lower portion of the rim.

[0021] Figure 12a shows an alternate embodiment.

[0022] Figure 12b shows another embodiment of the invention.

[0023] Figure 13 diagrammatically illustrates how the lower portion of the rim deforms during a crash.

[0024] Figure 14 shows a deformed armature after being tested.

[0025] Figures 15 and 16 each show the rim being tested in a test fixture.

[0026] Figure 17 shows force-deflection graphical relationships.

[0027] Figures 18 and 19 show the steering wheel relative to a driver.

Detailed Description of the Drawings

[0028] Reference is made to Figures 3, 4 and 5, which illustrate an armature 22 of a steering wheel 20 of the present invention. The armature 22 defines the internal skeleton of the steering wheel and may also

be referred to as a frame. As used herein, skeleton, armature and frame are used interchangeably. The armature 22, such as illustrated in Figures 3. 4 and 4a, is covered with a plastic, resin or similar material 26 such as polyurethane and may also include a leather wrap (not shown) about the plastic covering material. Even though the armature is covered by a plastic or resin material 26, the energy absorbing characteristics of the overall steering wheel are controlled primarily by the characteristics of the armature.

[0029] Armatures typically include a rim and hub region and one or more spokes and this is true of the present invention. The prior art will also show this hub region is referred to by many names a hub, a hub plate, a central area, etc. Here the hub region is referred to as a hub plate or hub 30. A plurality of spokes 36 and 38 connect the hub 30 to the rim 34. In the preferred embodiment of the invention the rim 34 is constructed of a metal bar having an oblong cross-section including a rectangular cross-section (also see Figures 6 and 6a) and an oval cross-section (shown in Figure 6b). In Figures 3 and 4 the two main spokes 36 and 38 are made of metal rods 50 and 52 configured to be bent to conform to the shape of the hub. The spokes can be made in many different ways. Both of the rods 50 and 52 extend from a first section 60 (on the right-hand side of the Figure 1) of the rim 34 and extend to the hub and continue across to a generally opposite second section 62 of rim 34. Rod 52 is bent near its middle and is attached to a lower portion 42 of the hub plate, while the upper rod 50 is bent to conform to the upper curvature of the upper portion of the hub plate 44 and is connected thereto. Each rod 50 and 52 is preferably attached to the rim 34 and hub plate by welding. Regions 60 and 62 of the steering wheel are positioned slightly off from the 3 and 9 o'clock regions of the rim and are separated by 140 - 180 degrees. The steering wheel may optionally include any number of spokes or spoke-like members as shown below. In Figure 4 the covering material 26 covers the rim 34 as well as the spokes 36, 38 and support structure 130, discussed below.

[0030] In the preferred embodiment of the invention the rim 34 is formed of an oblong strip 72 of cold-formed steel. In the preferred embodiment the oblong shape is a flat bar of rectangular construction. In another embodiment the oblong shape is achieved using a bar having an oval cross-section. The strip 72 is rolled or otherwise formed giving the rim its desired hoop or hook-like 70 shape which is typically circular or slightly oval. The strip of steel 72 as illustrated in Figure 6 has ends 74 and 76. To form the looped configuration, the rim ends 74 and 76 are connected together. Figures 7 and 7a show ends 74 and 76 connected in a butt weld, shown by numeral 78. In Figure 8 ends 74 and 76 are overlapped and welded together, the weld also shown by numeral 78. The localized, asymmetric thickness of the rim in the region of the weld is masked by the plastic covering material. As can be appreciated the weld can be made using other techniques as well. For example in Figures 9 and 9a approximately one-half of each end is narrowed (Figure 9) and subsequently moved together and welded (Figure 9a). The ends 74 and 76 can be ground-down or stamped to achieve the narrowed profile. This profile can be formed in either the wide side 82 or narrow side 83 of the flat bar 72.

[0031] In the preferred embodiment of the invention, the lower portion 39 of the armature is configured to compress when loaded during a crash. A weld such as 78 will locally increase the stiffness of the rim. Consequently, for this embodiment, it is preferable not to locate the weld in the lower region of the rim. One such position for the placement of the weld 78 is at the top of the rim, provided the top of the rim is also not designed to compress. Another location for the weld is generally above regions 60 and 62 while another possible location of the weld is in one of the regions 60 or 62, such as between the rods 50 and 52 at the rim.

[0032] The hub or hub plate 30 is adapted to connect to a steering column (not shown) in a conventional manner such as through a splined connection 30a (referred by some as the hub) shown in Figure 5. Axis 80 represents the axis of the steering column and extends

perpendicular to the plane 81; plane 81 is parallel to rim 34. The rim 34, which as mentioned above is formed into a hoop or hoop-like configuration, is arranged such that the larger diameter or dimension of (the cross-section) the rim, identified by 82, is situated essentially parallel to axis 81 and the narrow dimension of the rim identified by numeral 83 is situated essentially perpendicular to the plane of the rim 34, see Figure 5. Rims for steering wheels are often circularly shaped but can also be of an oval shape. Also, an axis through the geometric center of the rim need not extend through the center of the hub. Generally, the rim axis and axis 80 are parallel to each other but not always collinear.

[0033] The steering wheel 20 and more particularly armature 22 may additionally include, as an option, a plurality of rim support structures 130 extending from the spokes 36 and 38 to the rim 34. Two such structures 130 are shown, however, one, two, three or more can be used with the present invention. The support structures 130 have an oblong (rectangular or oval) cross-section (a rectangular cross-section is shown in Figure 4a), and each support structure 130 is prestressed with a concave shape or bend as shown in Figure 5. These structures 130 are configured to bend when end-loaded, see arrow or vector E_L. To facilitate the bending of the structures 130 they also may include prefabricated bends (stress risers) 132 which further control how these structures bend or deform under load. The use of structures 130 does not significantly change the ultimate deformed shape of the lower portion 39 of the rim. Depending upon the relative strength (deformation characteristics) of each structure 130 the amount the lower portion of the rim will deform as a function of each unit of crash load will vary. In the illustrated embodiment the structures 130 are made from steel. Arrow E_L of Figure 5 shows the structure 130 being end loaded. The phantom line in Figure 5 also shows the position taken by each structure 130 after being loaded.

[0034] The steering wheel of the present invention will be primarily used in the environment shown by Figures 1 and 2 (or 18 and 19);

consequently, the lower portion of the steering wheel and armature, with the armature in the zero-position of Figure 3, will most often be impacted by the driver during a crash. In this scenario it is much less likely the upper portions of the steering wheel will be impacted by the driver. To more fully control the deflection (stiffness) characteristics of the lower portion of the rim under load, and meet the requirements mentioned above, rim 34 includes a first set of stress increasing features (also referred to as stress enhancers or stress risers). These stress features are generally referred to by numeral 90. The embodiment shown in Figures 3 or 4 includes a first set of stress risers 92, 94, 96, 98. The steering wheel may also include a second set of stress risers 102 – 108. The embodiment of Figure 10 includes only the first set of stress risers 92 – 98; the details of these stress risers are also discussed below; while the embodiment of Figure 10a includes only stress risers 92 and 96.

[0035] In Figures 3 and 4, one of the stress risers in the second set of stress risers 102 -108 is located opposite a corresponding one of the stress risers of the first set. These stress risers are created by stamping or otherwise forming a shallow V-shaped trough or notch in the inside and/or outside surfaces of the rim 34. In Figures 3, 10 and 11a the angle of the shallow stress risers is about 120°. The deeper each stress riser extends into the rim the less force is needed to deform the rim. A shallow depth stress riser requires a greater level of force to deform the rim, that is, for a given thickness of rim. Figure 11a shows the paired use of opposing stress risers. To achieve the desired stiffness of the rim and steering wheel, the first riser 92 can be situated on the exterior of the rim below region 60 of the rim and at least another stress increasing feature 96 is also situated on the exterior of the rim below region 62 of the rim. In the preferred embodiment features 92 and 96 are placed symmetrically relative to regions 60 and 62 on the exterior of the rim. Additional stress risers 94 and 98 placed on the interior of the rim are closer to the bottom 39 of the rim. Stress risers 92 and 94 and 96 and 98 are separated by a distance which

identifies a torsion or moment arm, Am, (see Figure 4) which assists in the controlled bending of the lower portion of the rim 34. Figure 10 shows an embodiment of the invention having only the above-mentioned four stress risers 92 – 98 and as mentioned the embodiment of Figure 10a shows two stress risers. The stiffness of the rim can be increased by increasing the width and/or thickness of the rim as shown by the phantom lines in Figure 6a. The required stress riser depth will vary with the dimension of the cross-section of the rim.

[0036] Reference is briefly made to Figures 11a – 11d which illustrate alternate locations of the stress risers. As mentioned above, Figure 11a shows the use of shallow-grooved notches with stress risers in opposition. Figure 11b shows only one set of stress risers 92a– 98a as U-shaped notches; Figure 11c shows a sharpened groove of about 90°. Figure 11d shows a U-shaped notch with sharp corners. Each of the stress risers in Figures 11b-11d can be used in the configuration of Figure 11a and visa-versa. Also, the stress risers of any category shown in the above figures can me intermixed. The positioning of two stress risers such as 92 and 102 are also shown in Figure 4b.

[0037] Reference is made to Figures 12 and 13 which are used to explain how the lower portions of the rim deform when loaded in the present invention. Figure 14 is a sketch of a deformed rim after being tested. As can be seen the layout of the various stress risers permits the lower portion of the rim to take on a rectangularly shaped configuration when loaded as described. Figures 15 and 16 show test fixtures usable with the invention. The test fixture of Figure 16 was used to load the rim of Figure 12 (prior to it being deformed), as mentioned the deformed steering wheel is shown in Figure 14. During a crash the abdomen and chest of the driver may load the lower portion 39 of the steering wheel 20 in a manner similar to the results achieved using the test fixtures. These crash loads are generally shown by arrows or vectors F in Figures 12 and 13. These loading forces are transferred to the steering wheel 20 and to lower portions of rim 34.

Vectors or arrows FT and FN represent the tangential component of force along the rim and the normal or perpendicular component of force acting on the rim. Each normal force FN creates a torque T on the moment arm Am on either side of the rim 34, causing the moment arm Am to rotate about stress riser 92 in a clockwise direction and about stress riser 96 in a counter clockwise direction, urging the moment arm Am outwardly toward the final position shown in Figures 12 and 13. As the moment arm Am moves outwardly the rim tends to collapse about stress risers 94 and 98. Arrowsor vector T1 show the torque acting about these stress risers 94 and 98 to bend the lower part 39 of rim 34 to yield the configuration of the rim 34 shown in dotted line in Figure 13. As the lower portions of the rim move to the position shown in Figure 13, the structures 130 are placed in compression, see force EL of Figure 5, causing both structures, if used, to buckle upwards and move closer to the plane of the rim 34.

[0038] Reference is briefly made to Figure 12a which shows another embodiment of the invention. Depending upon the physical characteristics of the rim 34 the rim may be relatively easy to deform. In Figure 12a reinforcing members 34a and 34b have been added to the rim 34. The reinforcing members 34a and 34b can be made from the same material as the rim 34 and fabricated with less curvature to enable members 34a and 34b to be secured to an outer surface of the rim34. The members 34a and 34b may begin at regions 60 and 62 and extend upward toward the top of the rim 34 with a separation of the top of the members of about 120 +/- 10 °. The rim's stiffness will increase as the length of each member 34a and/or 34b increases. Also, the thickness of the members 34a and 34b can also be increased relative to the thickness of the rim 34. By using members 34a and 34b having thickness that is the same or differs from that of the rim 34 is an easy way to change the polar moment of inertia of the armature.

[0039] Figures 15 and 16 show two test fixtures 300 and 350 useful in testing the mechanical properties or characteristics of the armature 22. Each test fixture includes a base 302 and mounting plate 304 to which

the armature 22 and/or steering wheel 20 can be attached. In Figure 15 the mounting plate is at 65° to the horizontal and in Figure 16 90° to the horizontal, which are analogous to the two extreme positions of use of the steering wheel 20. Each test fixture also includes a hydraulically powered ram 306 which pushes plate 308. The lower portions 39 of the steering wheel are compressively loaded as shown in these figures. Force vector F in Figure 15 is representative of the force vectors F shown loading the armature in Figure 12. Figure 17 represents test data (force F versus deflection D of the lower-center region of the armature) for an armature 22 under the conditions shown in Figures 15 and 16. In the tests shown in Figure 17 the deflection of the lower portion of the steering wheel 39 from its nominal condition is within the range of 20mm to 45mm with the forces in the range of 1960N to 2600N; this steering wheel will meet the specifications mentioned above. As can be seen the lower portion of the steering wheel with the present invention is less stiff (yields a greater deflection of the rim) in the condition when a force is applied radially, or in the plane of the rim (as applied with the test fixture of Figure 16 or the operative environment of Figure 18, than when a force is applied at an angle to rim as applied by the test fixture of Figure 15 and in the operative environment of Figure 19.

[0040] Reference is briefly made to Figure 12b which shows another embodiment of the invention. As mentioned above the use of the individual stress risers or set of stress risers provides a means for making the rim less stiff when a radially direct force loads the rim as opposed to when the force is directed at an angle to the plane of the rim. In certain situations, it is also desirable to permit the top portions of the steering wheel (those portions above the spokes) to compress in the manner the lower portions of the steering wheel compress under a similar load This situation may occur if an accident occurs when the steering wheel has been turned about 180 degrees, reversing the normal orientation of the top and lower portions of the steering wheel. In Figure 12b the upper portions of the rim

include the stress risers 92a – 98a and 102a – 108a which can be used in the same manner as stress risers 92-1 98 and 102 – 108.

[0041] Many changes and modifications in the above-described embodiment of the invention can, of course, be carried out without departing from the scope thereof. Accordingly, that scope is intended to be limited only by the scope of the appended claims.

Claims

1. A steering wheel (20) having:
an armature (22) comprising
a central hub (30),
a rim (34) positioned apart from the hub and
at least one spoke (36;38) connecting the hub and rim;
the rim (34) includes first means (92 – 98; 102 – 108) for enabling one or both of a top portion and lower portion of the rim to compress more when a determinable force is applied against the rim in a radial direction than when the same force is applied to the lower portion of the rim at an angle to a plane in which the rim is located.

2. The steering wheel (20) according to Claim 1 wherein the rim and spoke are covered by a covering material ((26).

3. The steering wheel (20) according to Claim 1 including deformable lower rim support structure (130, 132) extending from the hub to the centrally located lower portions of the rim.

4. The steering wheel according to Claim 1 wherein the rim is hoop shaped.

5. The steering wheel according to Claim 4 wherein the cross-section of the rim is substantially oblong with a major axis and a minor axis perpendicular to the major axis.

6. The steering wheel according to Claim 5 wherein the major axis of the rim, in cross-section, is substantially parallel to an axis extending through the hub of the steering wheel.

7. The steering wheel according to Claim 1 wherein the rim is oblong in cross-section having a major axis and a minor axis.

8. The steering wheel according to Claim 7 wherein the rim has a rectangular shape in cross-section.

9. The steering wheel according to Claim 1 wherein one or both of the top portion and lower portion of the rim has a first and a second stress riser (92, 96; 92a, 96a) located proximate an intersection of the rim with one of two extending spokes (36, 38).

10. The steering wheel according to Claim 9 including a second set of stress risers (94, 98, 94a, 98a) located closer to a bottom center of the rim or closer to the top portion of the rim.

11. The steering wheel according to Claim 10 wherein the rim is configured to bow outwardly proximate the each stress riser in the first set of stress risers and to bow inwardly about each stress riser in the second set of stress risers.

12. The steering wheel according the Claim 1 wherein the rim is configured to take on a flattened shaped configuration after being loaded by the force.

13. The steering wheel according to Claim 11 wherein the first means includes a plurality of stress risers situated in pairs, each pair including a first stress riser on an exterior flat side of the rim and a second stress riser on in interior side of the rim.

14. The steering wheel according to Claim 13 including four such sets of stress risers.

14. The steering wheel according to Claim 13 including at least one deformable support member (130) extending from a spoke to the rim, the spoke extending from a center hub to the rim.

15. The steering wheel according to Claim 14 including a second support member.

16. The steering wheel according to Claim 13 wherein the cross-sectional shape of the rim and each support member is oblong.

17. A steering wheel (20) having an armature (22) with a rim (34), the rim compressible when force is applied thereto, wherein the rim is configured to yield a first determinable amount when a determinable force is applied perpendicularly to a side surface of a top portion or lower portion of the rim and wherein the rim is also configured to yield to a lesser extent when the same force is applied to the rim.

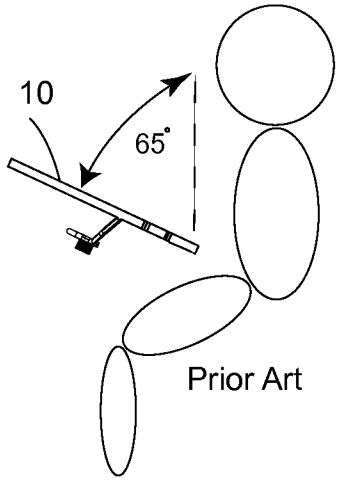


Fig - 1

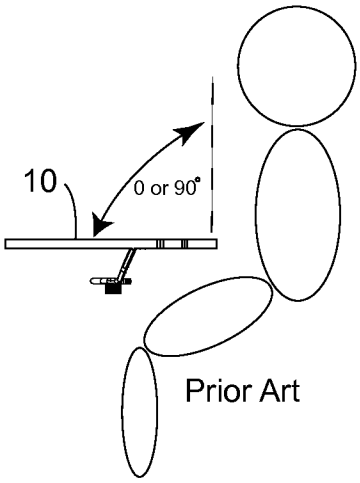


Fig - 2

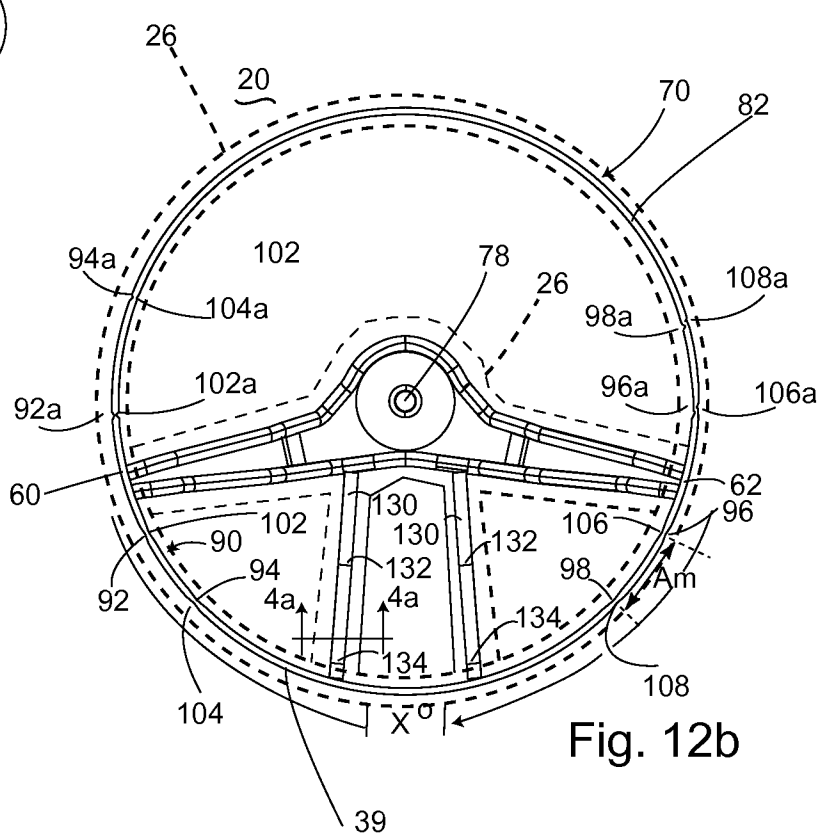
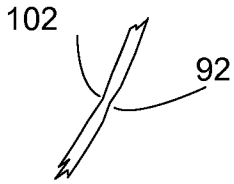


Fig. 12b

Fig - 4b



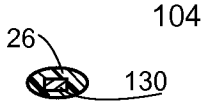


Fig - 4a

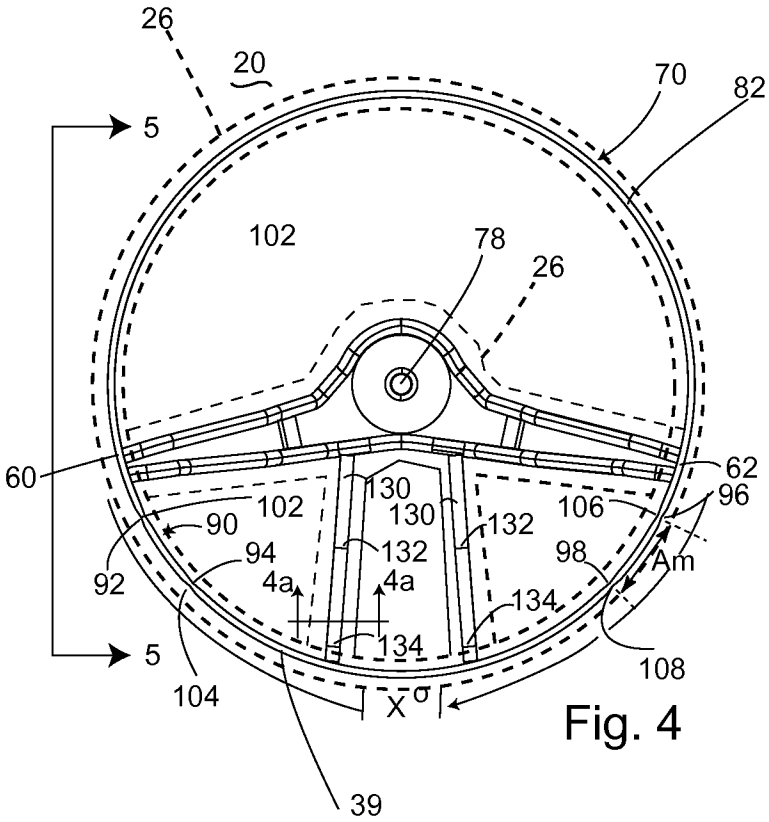


Fig. 4

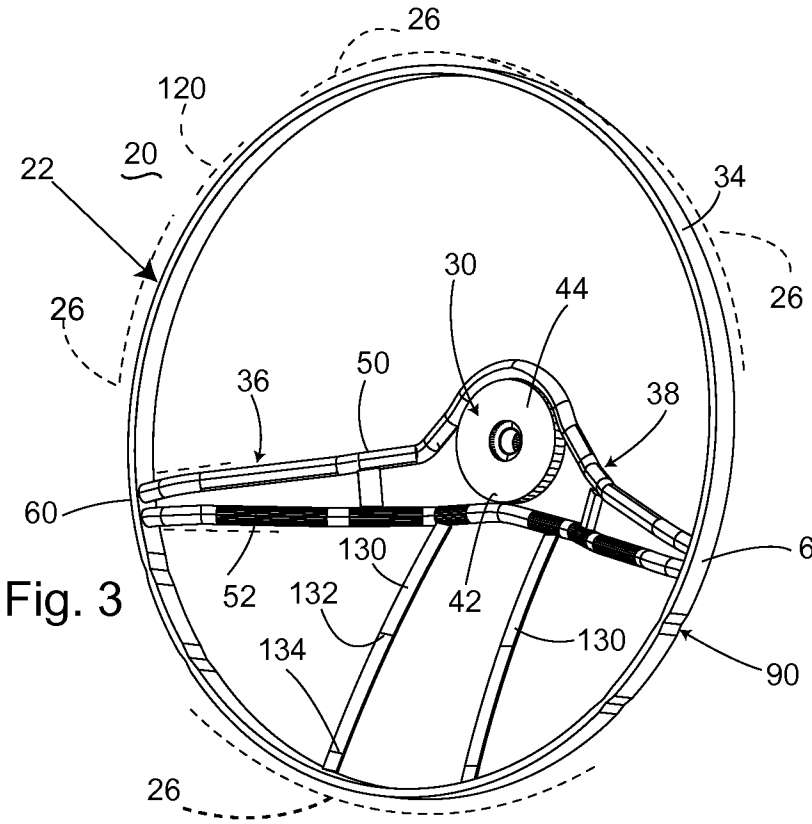


Fig. 3

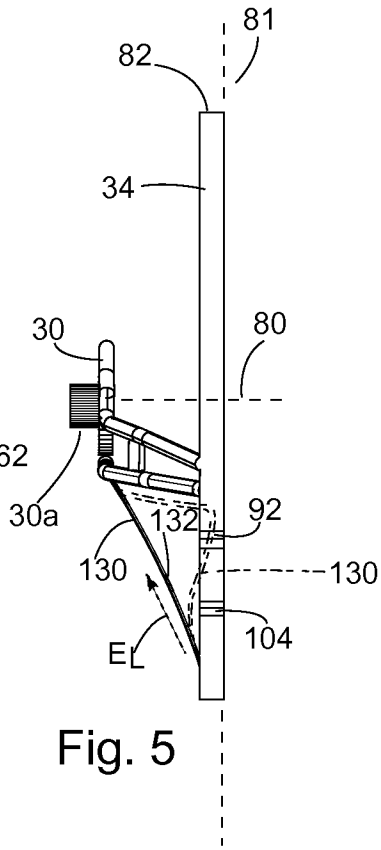


Fig. 5

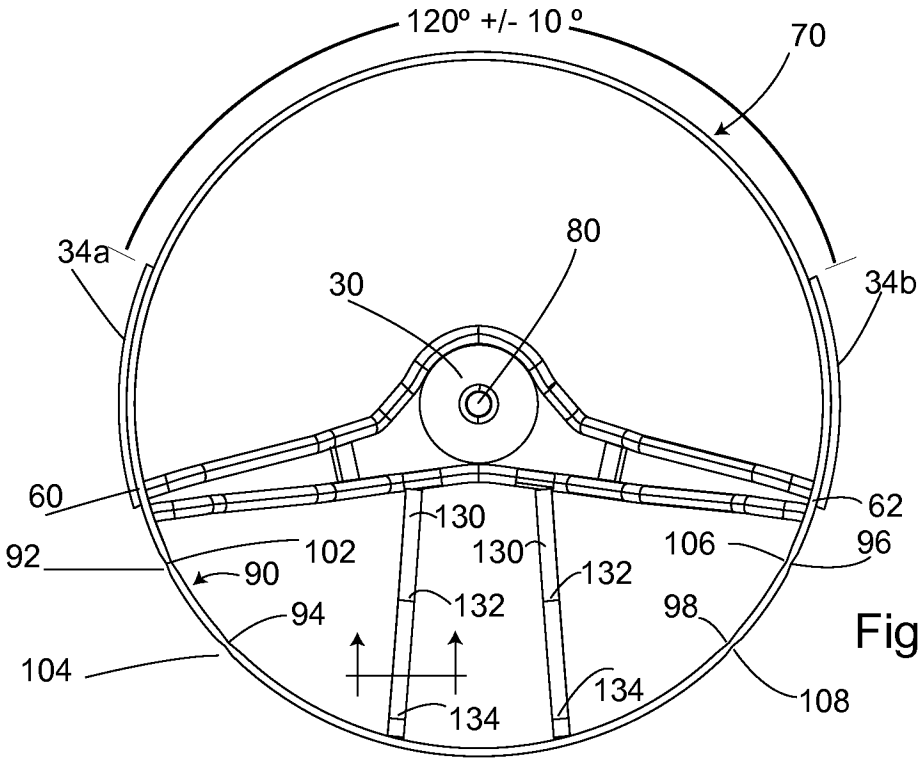


Fig. 12a

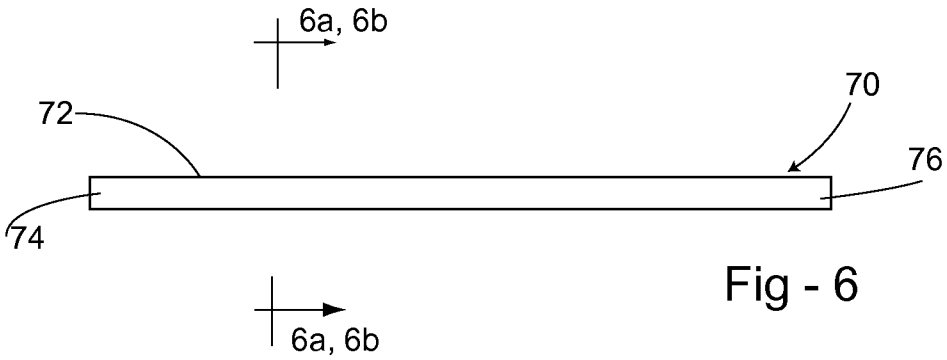


Fig - 6

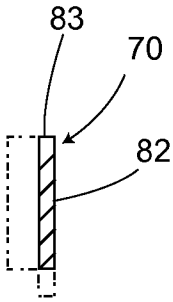


Fig - 6a

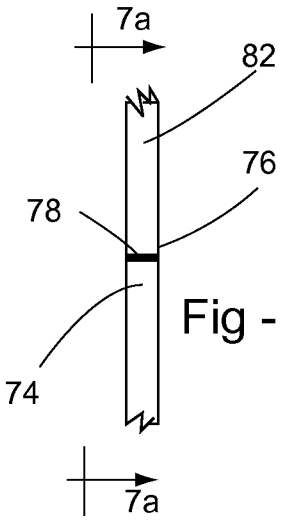


Fig - 7



Fig - 7a



Fig 6b

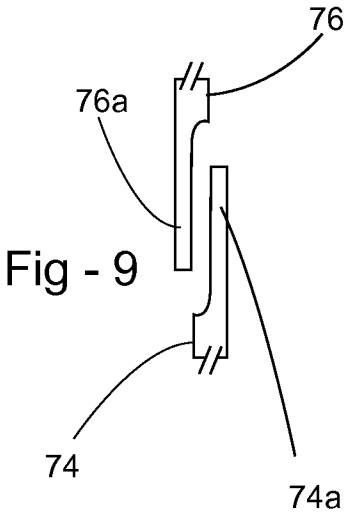


Fig - 9

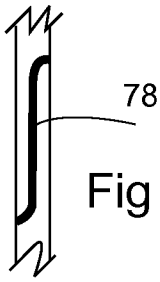


Fig - 9a

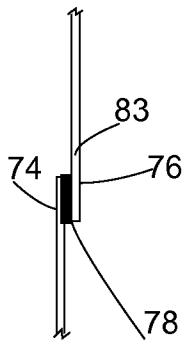
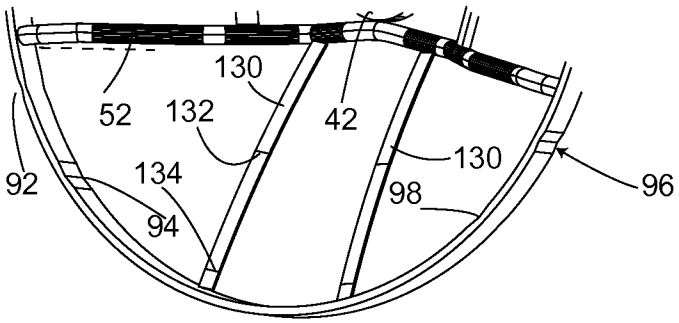


Fig - 8

Fig - 10



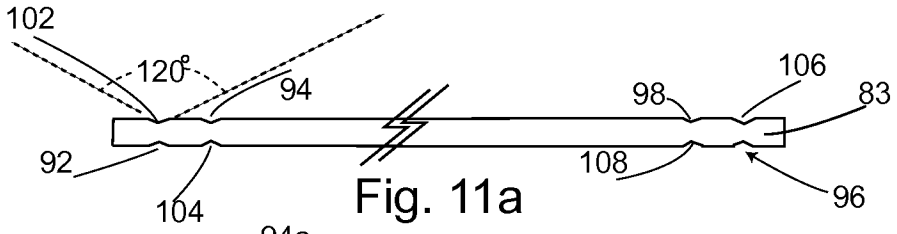


Fig. 11a

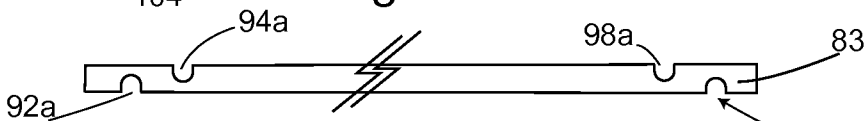


Fig. 11b

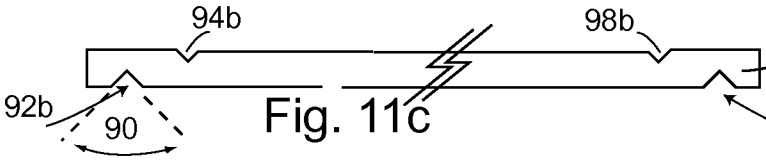


Fig. 11c

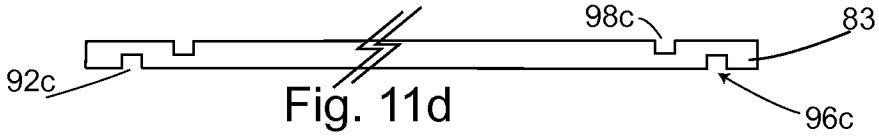


Fig. 11d

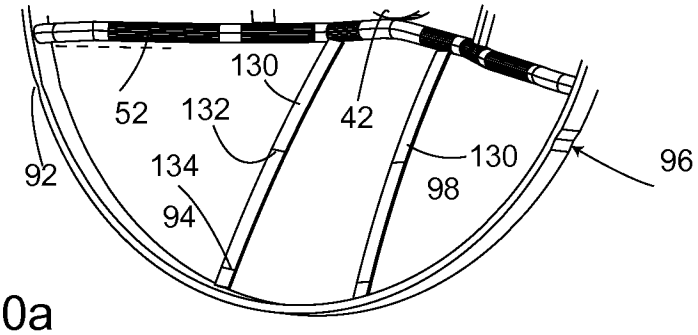


Fig - 10a

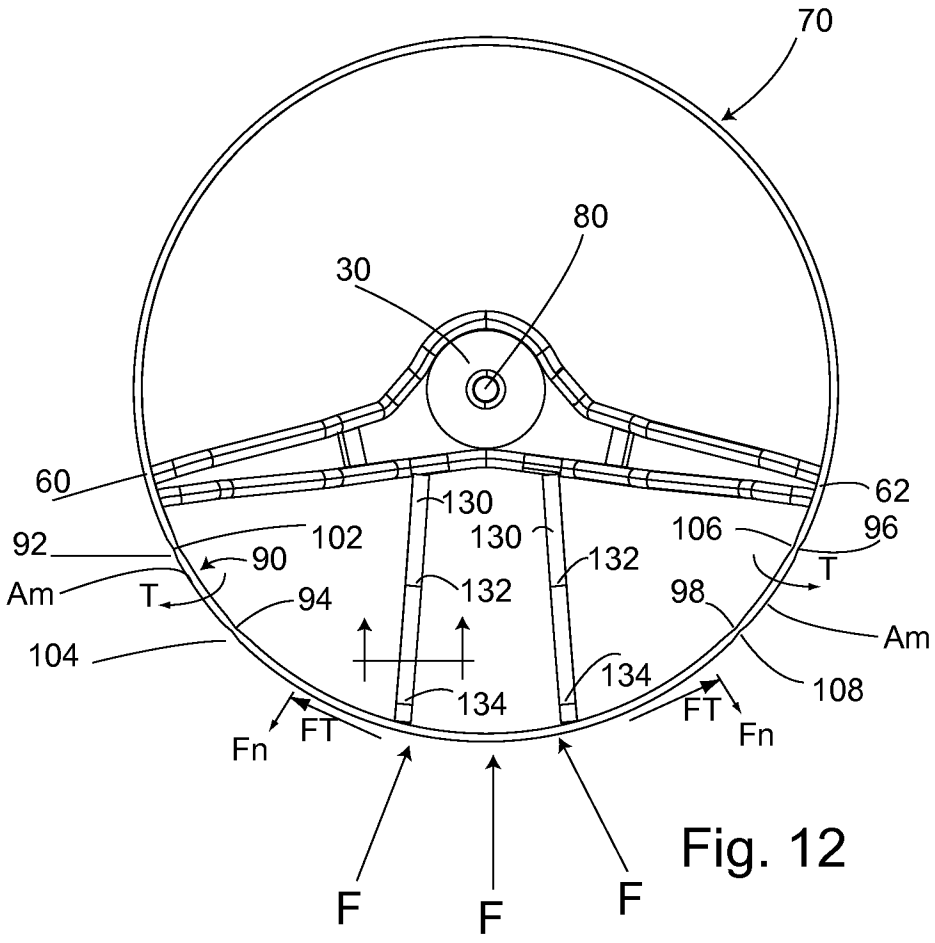


Fig. 12

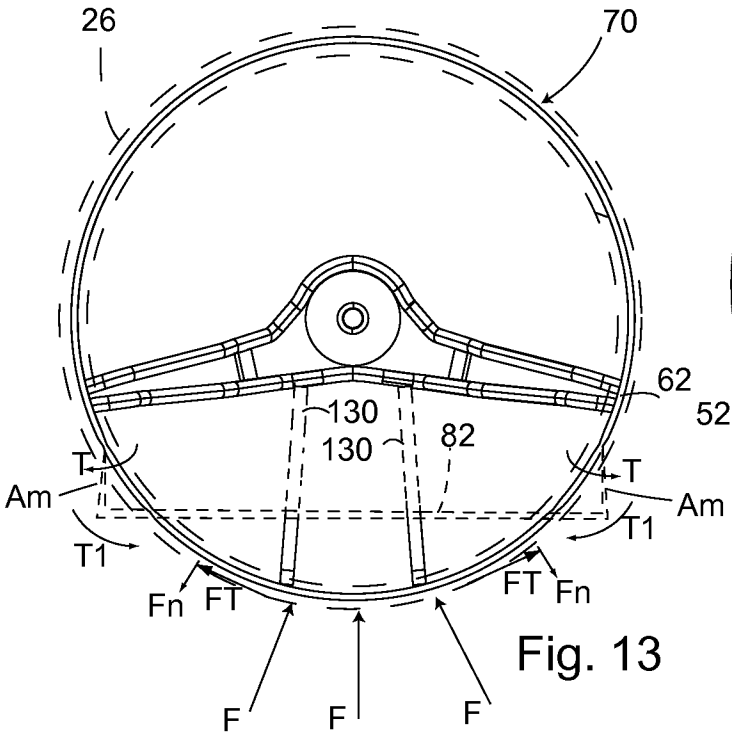


Fig. 13

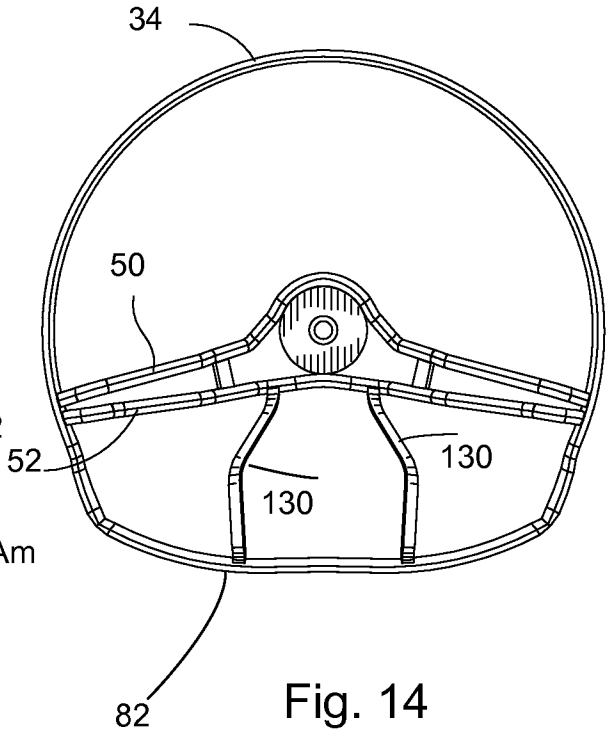


Fig. 14

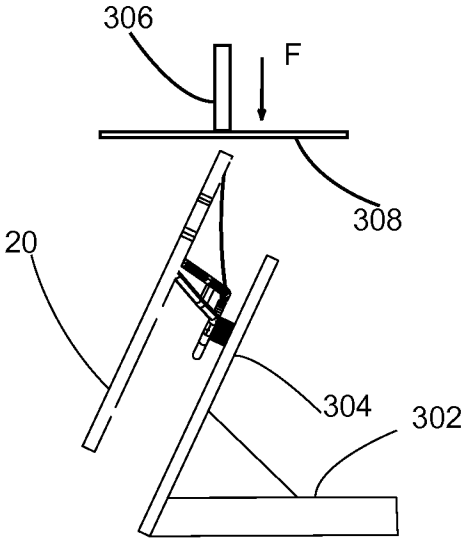


Fig - 15

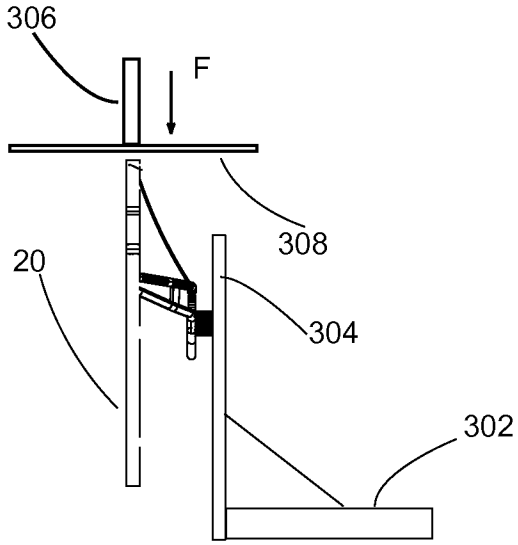


Fig - 16

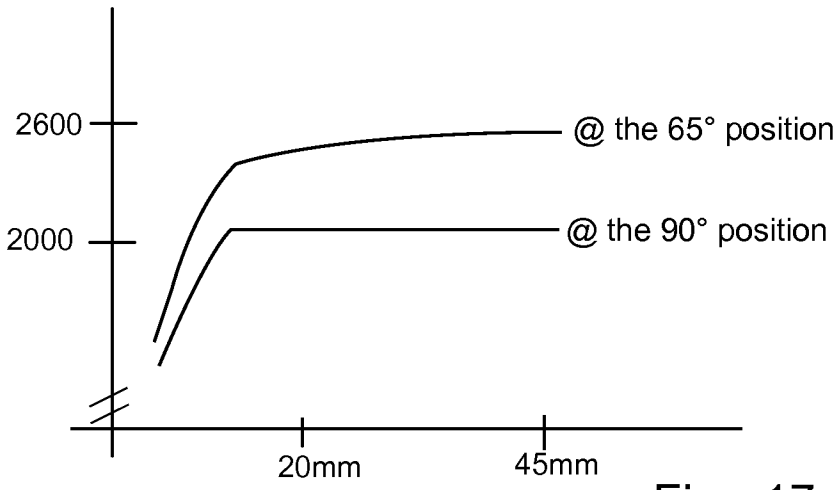
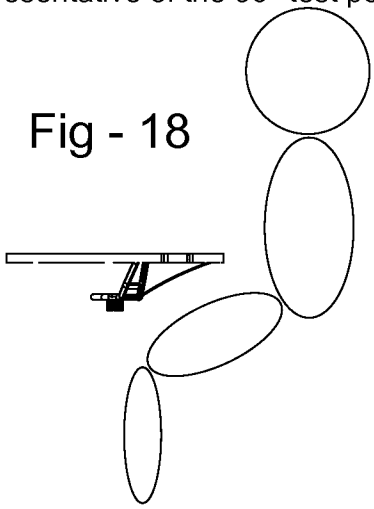


Fig - 17

Representative of the 90° test position

Fig - 18



Representative of the 65° test position

Fig - 19

