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(54) Title: CHAIR ASSEMBLY WITH UPHOLSTERY COVERING

(57) Abstract: A chair assembly includes a back shell member including a laterally-extending top portion, a laterally-extending bottom portion and a pair of longitudinally-extending side portions extending between the top portion and the bottom portion and cooperating therewith the defined open space therebetween, and a cover having a first surface adapted to support a seated user and a second surface opposite the first surface, wherein the cover is positioned over the back shell member to cover at least a portion of the open space, and wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance ration of at least 3:1.

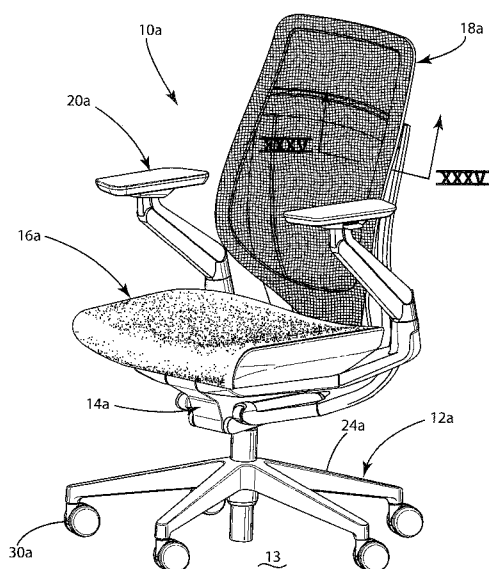


Fig. 31

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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**CHAIR ASSEMBLY WITH UPHOLSTERY COVERING**BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to a chair assembly, and in particular to an office chair assembly comprising a back assembly and a seat assembly each covered by mesh fabric upholstery coverings.

BRIEF SUMMARY OF THE INVENTION

**[0002]** One aspect of the present invention is to provide a chair back assembly comprising a back shell member including a laterally extending top portion, a laterally extending bottom portion and a pair of longitudinally extending side portions extending between the top portion and the bottom portion and cooperating therewith to define an open space therebetween, and a cover having a first surface adapted to support a seated user and a second surface opposite the first surface, wherein the cover is stretched over the back shell member to cover at least a portion of the open space, and wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance ratio of at least 3:1.

**[0003]** Another aspect of the present invention is to provide a chair component assembly comprising a support component adapted to support a portion of a seated user, a mesh fabric cover having a first surface and a second surface opposite the first surface, and a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along the longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to *the* support component.

**[0004]** Yet another aspect of the present invention is to provide a chair back assembly comprising a substantially rigid back frame assembly, a back shell member operably supported by the back frame assembly and comprising a laterally extending top portion, laterally extending bottom portion and a pair of longitudinally extending side portions extending between the top portion and the bottom portion and cooperating therewith to define an open space therebetween, wherein the pair of side portions are substantially

rigid in a lateral direction, and wherein the back shell member is substantially rigid in a lateral direction and substantially flexibly resilient in a fore-to-aft direction, and a cover having a first surface adapted to support a seated user and a second surface opposite the first surface, wherein the cover is stretched over the back shell member to cover at least a portion of the open space.

**[0005]** Still yet another aspect of the present invention is to provide a chair assembly comprising a base structure, a seat support structure pivotably coupled to the base structure for rotation about a first pivot point, wherein the seat support structure includes a seat support surface configured to support a seated user thereon, and a back structure pivotably coupled to the base structure for rotation about a second pivot point, wherein the back support structure includes an upwardly-extending portion adapted to move between an upright position and a reclined position. The chair assembly further comprises a back shell member including a back support surface that is generally forwardly-facing and configured to support a back of a seated user, and having an upper portion pivotably coupled to the upwardly-extending portion of the back support for rotation about a third pivot point and a lower portion, wherein the back shell member is covered by a mesh cover, and back link pivotably coupled to the lower portion of the back support surface for rotation about a fourth pivot point and pivotably coupled to the seat support structure for rotation about a fifth pivot point, wherein the back support surface is moved forward by the back link relative to the upright portion of the back support structure as the back support structure is moved from the upright position to the reclined position.

**[0006]** Another aspect of the present invention is to provide a chair assembly that comprises a base structure, a seat support structure operably coupled to the base structure, wherein the seat support structure includes a seat support surface configured to support a seated user thereon, and a back support structure operably coupled to the base structure, wherein the back support structure is adapted to move between an upright position and a reclined position. The chair assembly further comprises a back shell member including a back support member that is generally forwardly-facing and configured to support a back of a seated user, and pivotably coupled to the back support for rotation about a first back support pivot point, wherein the back shell member is covered by a mesh cover, and a back link pivotably coupled to the back support surface

for rotation about a second back support pivot point and operably coupled to the seat support structure, wherein a distance between the first back support pivot point and the second back support pivot point decreases as the back support structure moves from the upright position to the reclined position, and increases as the back support structure moves from the reclined position to the upright position.

**[0007]** Yet another aspect of the present invention is to provide a chair assembly comprising a base structure, a seat support structure pivotably coupled to the base structure for rotation about a first pivot point, wherein the seat support structure includes a seat support surface configured to support a seated user thereon, and the back support structure pivotably coupled to the base structure for rotation about a second pivot point, wherein the back support structure is adapted to move between an upright position and a reclined position. The chair assembly further comprises a back support assembly including a flexible back shell member that is generally forwardly-facing and configured to support a back of a seated user, and operably coupled to the back support, wherein the back shell member is covered by a mesh cover, and a back link operably coupled to the back support surface and operably coupled to the seat support structure, wherein the flexible back support assembly is flexed along a length thereof as the support structure is moved from the upright position to the reclined position.

**[0008]** These and other features and advantages of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims, and appended drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** Fig. 1 is a front perspective view of a chair assembly embodying the present invention;

**[0010]** Fig. 2 is a rear perspective view of the chair assembly;

**[0011]** Fig. 3 is a side elevational view of the chair assembly showing the chair assembly in a lowered position and in a raised position in dashed line, and a seat assembly in a retracted position and an extended position in dashed line;

**[0012]** Fig. 4 is a side elevational view of the chair assembly showing the chair assembly in an upright position and in a reclined position in dashed line;

**[0013]** Fig. 5 is an exploded view of the seat assembly;

- [0014] Fig. 6 is a top perspective of a upholstery cover assembly;
- [0015] Fig. 7 is a bottom perspective view of the cover assembly;
- [0016] Fig. 8 is a bottom perspective view of the cover assembly and the seat assembly;
- [0017] Fig. 9 is a cross-sectional view of the cover assembly;
- [0018] Fig. 10 is a front perspective view of a back assembly;
- [0019] Fig. 11 is a side elevational view of the back assembly;
- [0020] Fig. 12A is an exploded front perspective view of the back assembly;
- [0021] Fig. 12B is an exploded rear perspective view of the back assembly;
- [0022] Fig. 13 is an enlarged perspective view of an area XIII, Fig. 12A;
- [0023] Fig. 14 is an enlarged perspective view of an area XIV, Fig. 2;
- [0024] Fig. 15 is a cross-sectional view of an upper back pivot assembly taken along the line XV-XV, Fig. 10;
- [0025] Fig. 16A is an exploded rear perspective view of the upper back pivot assembly;
- [0026] Fig. 16B is an exploded front perspective view of the upper back pivot assembly;
- [0027] Fig. 17 is an enlarged perspective view of the area XVII, Fig. 12B;
- [0028] Fig. 18A is an enlarged perspective view of a comfort member and a lumbar assembly;
- [0029] Fig. 18B is a rear perspective view of the comfort member and the lumbar assembly;
- [0030] Fig. 19A is a front perspective view of a pawl member;
- [0031] Fig. 19B is a rear perspective view of the pawl member;
- [0032] Fig. 20 is a partial cross-sectional perspective view along the line X-X, Fig. 18B;
- [0033] Fig. 21 is a cross-sectional side view of the back assembly and an upholstery assembly along the line XXI-XXI, Fig. 10;
- [0034] Figs. 22A - 22D are stepped assembly views of the back assembly and the upholstery assembly;
- [0035] Fig. 23 is an enlarged perspective view of an area XXIII, Fig. 18B;
- [0036] Figs. 24A – 24H are a series of back elevational views of a boat cleat and the sequential steps of a drawstring secured thereto;
- [0037] Fig. 25 is an exploded view of an alternative embodiment of the back assembly;
- [0038] Fig. 26 is a cross-sectional side view of a top portion of the alternative embodiment of the back assembly;

- [0039] Fig. 27 is a cross-sectional view of a side portion of the alternative embodiment of the back assembly;
- [0040] Fig. 28 is a front elevational view of a stay member;
- [0041] Fig. 29 is a front elevational view of the stay member in an inside-out orientation; and
- [0042] Fig. 30 is a partial front elevational view of the stay member sewn to a cover member.
- [0043] Fig. 31 is a front perspective view of an alternative embodiment of the chair assembly, including a back assembly comprising a mesh fabric cover;
- [0044] Fig. 32 is a back perspective view of an alternative embodiment of the chair assembly, including a back assembly comprising a mesh fabric cover;
- [0045] Fig. 33 is an exploded front perspective view of a back assembly of the alternative chair assembly;
- [0046] Fig. 34 is an exploded rear perspective view of a back assembly of the alternative chair assembly;
- [0047] Fig. 35A is a cross-sectional view of the back assembly of the alternative chair assembly taken through the line XXXV – XXXV, Fig. 31;
- [0048] Fig. 36 is a perspective view of a control input assembly supporting a seat support plate thereon;
- [0049] Fig. 37 is a perspective view of the control input assembly with certain elements removed to show the interior thereof;
- [0050] Fig. 38 is an exploded view of the control input assembly;
- [0051] Fig. 39 is a side elevational view of the control input assembly;
- [0052] Fig. 40A is a front perspective view of a back support structure;
- [0053] Fig. 40B is an exploded perspective view of the back support structure;
- [0054] Fig. 41 is a side elevational view of the chair assembly illustrating multiple pivot points thereof;
- [0055] Fig. 42 is a side perspective view of the control assembly showing multiple pivot points associated therewith;
- [0056] Fig. 43 is a cross-sectional view of the chair showing the back in an upright position with the lumbar adjustment set at a neutral setting;

- [0057] Fig. 44 is a cross-sectional view of the chair showing the back in an upright position with the lumbar portion adjusted to a flat configuration;
- [0058] Fig. 45 is a cross-sectional view of the chair showing the back reclined with the lumbar adjusted to a neutral position;
- [0059] Fig. 46 is a cross-sectional view of the chair in a reclined position with the lumbar adjusted to a flat configuration;
- [0060] Fig. 47 is a cross-sectional view of the chair showing the back reclined with the lumbar portion of the shell set at a maximum curvature;
- [0061] Fig. 48 is a perspective view of the back assembly;
- [0062] Fig. 49 is a front perspective view of the alternative embodiment of the chair assembly;
- [0063] Fig. 50 is a front elevational view of the alternative embodiment of the chair assembly;
- [0064] Fig. 51 is a first side elevational view of the alternative embodiment of the chair assembly;
- [0065] Fig. 52 is a second side elevational view of the alternative embodiment of the chair assembly;
- [0066] Fig. 53 is an rear elevational view of the alternative embodiment of the chair assembly;
- [0067] Fig. 54 is a top plan view of the alternative embodiment of the chair assembly; and
- [0068] Fig. 55 is a bottom plan view of the alternative embodiment of the chair assembly.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

- [0069] For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizontal," and derivatives thereof shall relate to the invention as oriented in Figs. 1 and 2. However, it is to be understood that the invention may assume various alternative orientations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are exemplary embodiments of the inventive concepts defined in the



appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

**[0070]** The reference numeral 10 (Figs. 1 and 2) generally designates a chair assembly embodying the present invention. In the illustrated example, the chair assembly 10 includes a castered base assembly 12 abutting a supporting floor surface 13, a control or support assembly 14 supported by the castered base assembly 12, a seat assembly 16 and back assembly 18 each operably coupled with the control assembly 14, and a pair of arm assemblies 20. The control assembly 14 (Fig. 3) is operably coupled to the base assembly 12 such that the seat assembly 16, the back assembly 18 and the arm assemblies 20 may be vertically adjusted between a fully lowered position A and a fully raised position B, and pivoted about a vertical axis 21 in a direction 22. The seat assembly 16 is operably coupled to the control assembly 14 such that the seat assembly 16 (Fig. 4) is longitudinally adjustable with respect to the control assembly 14 between a fully retracted position C and a fully extended position D. The seat assembly 16 and the back assembly 18 are operably coupled with the control assembly 14 and with one another such that the back assembly 18 is movable between a fully upright position E and a fully reclined position F, and further such that the seat assembly 16 is movable between a fully upright position G and a fully reclined position H corresponding to the fully upright position E and the fully reclined position F of the back assembly 18, respectively.

**[0071]** The base assembly 12 includes a plurality of pedestal arms 24 radially extending and spaced about a hollow central column 26 that receives a pneumatic cylinder 28 therein. Each pedestal arm 24 is supported above the floor surface 13 by an associated caster assembly 30. Although the base assembly 12 is illustrated as including a multiple-arm pedestal assembly, it is noted that other suitable supporting structures maybe utilized, including but not limited to fixed columns, multiple leg arrangements, vehicle seat support assemblies, and the like.

**[0072]** The seat assembly 16 (Fig. 5) includes a relatively rigid seat support plate 32 having a forward edge 34, a rearward edge 36, and a pair of C-shaped guide rails 38 defining the side edges of the seat support plate 32 and extending between the forward edge 34 and the rearward edge 36. The seat assembly 16 further includes a flexibly resilient outer seat shell 40 having a pair of upwardly turned side portions 42 each

terminating in a side edge 43, a forward edge 45, and an upwardly turned rear portion 44 that terminates in a rear edge 47 and includes a flap portion 49, wherein the side portions 42 and rear portion 44 cooperate to form a three-dimensional upwardly disposed generally concave shape. In the illustrated example, the seat shell 40 is comprised of a relatively flexible material such as a thermoplastic elastomer (TPE) and is molded as a single integral piece. In assembly, described in further detail below, the outer seat shell 40 is secured and sandwiched between the seat support plate 32 and a plastic, flexibly resilient seat pan 46 which is secured to the seat support plate 32 by a plurality of mechanical fasteners. The seat pan 46 includes a forward edge 48, a rearward edge 50, side edges 52 extending between the forward edge 48 and the rearward edge 50, a top surface 54 and a bottom surface 56 that cooperate to form an upwardly disposed generally concave shape. In the illustrated example, the seat pan 46 includes a plurality of longitudinally extending slots 58 extending forwardly from the rearward edge 50. The slots 58 cooperate to define a plurality of fingers 60 therebetween, each finger 60 being individually flexibly resilient. The seat pan 46 further includes a plurality of laterally oriented, elongated apertures 62 located proximate the forward edge 48. The apertures 62 cooperate to increase the overall flexibility of the seat pan 46 in the area thereof, and specifically allow a forward portion 64 of the seat pan 46 to flex in a vertical direction 66 with respect to a rearward portion 68 of the seat pan 46, as discussed further below. The seat assembly 16 further includes a foam cushion member 70 that rests upon the top surface 54 of the seat pan 46 and is cradled within the outer seat shell 40, a fabric seat cover 72, and an upper surface 76 of the cushion members 70. In the illustrated example, the cover 72 includes a forward edge 73, a rearward edge 75 and a pair of side edges 77 extending therebetween. A spring support assembly 78 (Figs. 5 and 6) is secured to the seat 16 and is adapted to flexibly support the forward portion 64 of the seat pan 46 for flexure in the vertical direction 66. In the illustrated example, the spring support assembly 78 includes a support housing 80 comprising a foam and having side portions 82 defining an upwardly concave arcuate shape. The spring support assembly 78 further includes a relatively rigid attachment member 84 that extends laterally between the side portions 82 of the support housing 80 and is located between the support housing 80 and the forward portion 64 of the seat pan 46. A plurality of mechanical fasteners 86 secure the support housing 80 and the

attachment member 84 to the forward portion 64 of the seat pan 46. The spring support assembly 78 further includes a pair of cantilever springs 88 each having a distal end 90 received through a corresponding aperture 92 of the attachment member 84, and a proximate end 94 secured to the seat support plate 32 such that the distal end 90 of each cantilever spring 88 may flex in the vertical direction 66. A pair of linear bearings 96 are fixedly attached to the attachment member 84 and aligned with the apertures 92 thereof, such that the linear bearing 96 slidably receives the distal ends 90 of a corresponding cantilever springs 88. In operation, the cantilever springs 88 cooperate to allow the forward portion 64 of the seat pan 46, and more generally the entire forward portion of seat assembly 16 to flex in the vertical direction 66 when a seated user rotates forward on the seat assembly 16 and exerts a downward force on the forward edge thereof.

**[0073]** As best illustrated in Figs. 6 and 7, the flexible resilient seat shell 40 and the fabric seat cover 72 cooperate to form an upholstery cover assembly or cover 100. Specifically, the side edges 43 of the seat shell 40 and the side edges 77 of the seat cover 72, the forward edge 45 of the seat shell 40 and the forward edge 73 of the seat cover 72, and the rear edge 47 of the seat shell 40 and the rear edge 75 of the seat cover 72 are respectively attached to one another to form the cover 100 and to define an interior space 102 therein.

**[0074]** The flap portion 49 of the seat shell 40 includes a pair of corner edges 104 each extending along a corner 106 of the seat shell 40 located between the rear portion 44 and respective side portions 42, such that the flap portion 49 is movable between an open position I and a closed position J. In the illustrated example, each corner edge 104 of the flap portion 49 includes a plurality of tabs 108 spaced along the corner edge 104 and each including an aperture 110 extending therethrough. The tabs 108 of the corner edge 104 are interspaced with a plurality of tabs 112 spaced along a corner edge 114 of each side portion 42. Each of the tabs 112 includes an aperture 116 that extends therethrough.

**[0075]** The seat shell 40 also includes a plurality of integrally-molded coupling tabs 118 spaced about an inner edge 121 of the seat shell 40 and each having a Z-shaped, cross-section configuration.

**[0076]** In assembly, the upholstery cover assembly 100 (Fig. 8) is constructed from the seat shell 40 and seat cover 72 as described above. The seat pan 46, the cushion member 70 and the spring support assembly 78 are then arranged with respect to one another and positioned within the interior space 102 of the upholstery cover assembly 100 by positioning the flap 49 in the open position I, after which the flap 49 is moved to the closed position J. A pair of quick-connect fasteners 120 each include a plurality of snap couplers 122 spaced along the length of an L-shaped body portion 124. In assembly, the snap couplers 122 are extended through the apertures 110, 116 of the tabs 108, 112, and are snapably received within corresponding apertures 126 of the seat pan 46, thereby securing the corner edges 104, 114 to the seat pan 46 and the flap portion 49 in the closed position J.

**[0077]** Further in assembly, the coupling tabs 118 (Fig. 9) are positioned within corresponding apertures 130 of the seat pan 46, such that the cover assembly 100 is temporarily secured to the seat pan 46, thereby allowing further manipulation of the over seat assembly 16 during assembly while maintaining connection and alignment of the cover assembly 100 with the seat pan 46. As used herein, “temporarily securing” is defined as a securing not expected to maintain the securement of the cover assembly 100 to the seat pan 46 by itself during normal use of the chair assembly 10 throughout the normal useful life of the chair assembly 10. The support plate 32 is then secured to an underside of the seat pan 46 by a plurality of screws 132, thereby sandwiching the coupling tabs 118 between the support plate 32 and the seat pan 46, and permanently securing the cover assembly 100 to the seat pan 46. As used herein, “permanently securing” is defined as a securing expected to maintain the securement of the cover assembly 100 to the seat pan 46 during normal use of the chair assembly throughout the normal useful life of the chair assembly.

**[0078]** The back assembly 18 (Figs. 10-12B) includes a back frame assembly 150 and a back support assembly 151 supported thereby. The back frame assembly 150 is generally comprised of a substantially rigid material such as metal, and includes a laterally extending top frame portion 152, a laterally extending bottom frame portion 154, and a pair of curved side frame portion 156 extending between the top frame portion 152 and the bottom frame portion 154 and cooperating therewith to define an opening 158

having a relatively large upper dimension 160 and a relatively narrow lower dimension 162.

**[0079]** The back assembly 18 further includes a flexibly resilient, plastic back shell 164 having an upper portion 166, a lower portion 168, a pair of side edges 170 extending between the upper portion 166 and a lower portion 168, a forwardly facing surface 172 and a rearwardly facing surface 174, wherein the width of the upper portion 166 is generally greater than the width of the lower portion 168, and the lower portion 168 is downwardly tapered to generally follow the rear elevational configuration of the frame assembly 150. A lower reinforcement member 176 attaches to hooks 177 (Fig. 12A) of lower portion 168 of back shell 164. Reinforcement member 176 includes a plurality of protrusions 179 that engage reinforcement ribs 180 to prevent side-to-side movement of lower reinforcement member 176 relative to back shell 164. As discussed below, reinforcement member 176 pivotably interconnects a back control link 600 (Fig. 42) to the lower portion 168 of the back shell 164 at pivot points or axis 602.

**[0080]** The back shell 164 also includes a plurality of integrally molded, forwardly and upwardly extending hooks 177 (Fig. 13) spaced about the periphery of the upper portion 166 thereof. An intermediate or lumbar portion 182 is located vertically between the upper portion 166 and the lower portion 168 of the back shell 164, and includes a plurality of laterally extending slots 184 that cooperate to form a plurality of laterally extending ribs 186 located therebetween. The slots 184 cooperate to provide additional flexure to the back shell 164 in the location thereof. Pairings of lateral ribs 186 are coupled by vertically extending ribs 188 integrally formed therewith and located at an approximate lateral midpoint thereof. The vertical ribs 188 function to tie the lateral ribs 186 together and reduce vertical spreading therebetween as the back shell 164 is flexed at the intermediate portion 182 thereof when the back assembly 18 is moved from the upright position E to the reclined position F. The back shell 164 further includes a plurality of laterally-spaced reinforcement ribs 190 extending longitudinally along the vertical length of the back shell 164 between the lower portion 168 and the intermediate portion 182. It is noted that the depth of each of the ribs 190 increases the further along each of the ribs 190 from the intermediate portion 182, such that the overall rigidity of the back shell 164 increases along the length of the ribs 190 from the intermediate portion 182 toward the lower portion 168.

**[0081]** The back shell 164 further includes a pair of rearwardly extending, integrally molded pivot bosses 192 forming part an upper back pivot assembly 194. The back pivot assembly 194 (Figs. 14-16B) includes the pivot bosses 192 of the back shell 164, a pair of shroud members 196 that encompass respective pivot bosses 192, a race member 198, and a mechanical fastening assembly 200. Each pivot boss 192 includes a pair of side walls 202 and a rearwardly-facing concave seating surface 204 having a vertically elongated pivot slot 206 extending therethrough. Each shroud member 196 is shaped so as to closely house the corresponding pivot boss 192, and includes a plurality of side walls 210 corresponding to side walls 202, and a rearwardly-facing concave bearing surface 212 that includes a vertically elongated slot pivot slot 214 extending therethrough, and which is adapted to align with the slot 206 of a corresponding pivot boss 192. The race member 198 includes a center portion 216 extending laterally along and abutting the top frame portion 152 of the back frame assembly 150, and a pair of arcuately-shaped bearing surfaces 218 located at the ends thereof. Specifically, the center portion 216 includes a first portion 220, and a second portion 222, wherein the first portion 220 abuts a front surface of the top frame portion 152 and second portion 222 abuts a top surface of the top frame portion 152. Each bearing surface 218 includes an aperture 224 extending therethrough and which aligns with a corresponding boss member 226 integral with the back frame assembly 150.

**[0082]** In assembly, the shroud members 196 are positioned about the corresponding pivot bosses 192 of the back shell 164 and operably positioned between the back shell 164 and race member 198 such that the bearing surface 212 is sandwiched between the seating surface 204 of a corresponding pivot boss 192 and a bearing surface 218. The mechanical fastening assemblies 200 each include a bolt 230 that secures a rounded abutment surface 232 of the bearing washer 234 in sliding engagement with an inner surface 236 of the corresponding pivot boss 192, and threadably engages the corresponding boss member 226 of the back shell 164. In operation, the upper back pivot assembly 194 allows the back support assembly 151 to pivot with respect to the back frame assembly in a direction 240 (Fig. 11) about a pivot axis 242 (Fig. 10).

**[0083]** The back support assembly 151 further includes a flexibly resilient comfort member 244 attached to the back shell 164 and slidably supporting a lumbar assembly 246. The comfort member 244 includes an upper portion 248, a lower portion 250, a pair

of side portions 252, a forward surface 254 and a rearward surface 256, wherein the upper portion 248, the lower portion 250 and the side portions cooperate to form an aperture 258 that receives the lumbar assembly 246 therein. As best illustrated in Figs. 12B and 17, the comfort member 244 includes a plurality of box-shaped couplers 260 spaced about the periphery of the upper portion 248 and extending rearwardly from the rearward surface 256. Each box-shaped coupler 260 includes a pair of side walls 262 and a top wall 264 that cooperate to form an interior space 266. A bar 268 extends between the side walls 262 and is spaced from the rearward surface 256. In assembly, the comfort member 244 is secured to the back shell 164 by aligning and vertically inserting the hooks 180 of the back shell 164 into the interior space 266 of each of the box-shaped couplers 260 until the hooks 180 engage a corresponding bar 268. It is noted that the forward surface 172 of the back shell 164 and the rearward surface 256 of the comfort member 244 are free from holes or apertures proximate the hooks 180 and box-shaped couplers 260, thereby providing a smooth forward surface 254 and increasing the comfort to a seated user.

**[0084]** The comfort member 244 (Figs. 18A and 18B) includes an integrally molded, longitudinally extending sleeve 270 extending rearwardly from the rearward surface 256 and having a rectangularly-shaped cross-sectional configuration. The lumbar assembly 246 includes a forwardly laterally concave and forwardly vertically convex, flexibly resilient body portion 272, and an integral support portion 274 extending upwardly from the body portion 272. In the illustrated example, the body portion 272 is shaped such that the body portion vertically tapers along the height thereof so as to generally follow the contours and shape of the aperture 258 of the comfort member 244. The support portion 274 is slidably received within the sleeve 270 of the comfort member 244 such that the lumbar assembly 246 is vertically adjustable with respect to the remainder of the back support assembly 151 between a fully lowered position L and a fully raised position M. A pawl member 276 selectively engages a plurality of apertures 288 spaced along the length of support portion 274, thereby releasably securing the lumbar assembly 246 at selected vertical positions between the fully lowered position I and the fully raised position J. The pawl member 276 (Figs. 19A and 19B) includes a housing portion 278 having engagement tabs 280 located at the ends thereof and rearwardly offset from an

outer surface 282 of the housing portion 280. A flexibly resilient finger 284 is centrally disposed within the housing portion 280 and includes a rearwardly-extending pawl 286.

**[0085]** In assembly, the pawl member 276 (Fig. 20) is positioned within an aperture 288 located within the upper portion 248 of the comfort member 244 such that the outer surface 282 of the housing portion 278 of the pawl member 276 is coplanar with the forward surface 254 of the comfort member 244, and such that the engagement tabs 280 of the housing portion 278 abut the rearward surface 256 of the comfort member 244. The support portion 274 of the lumbar assembly 246 is then positioned within the sleeve 270 of the comfort member 244 such that the sleeve 270 is slidable therein and the pawl 286 is selectively engageable with the apertures 278, thereby allowing the user to optimize the position of the lumbar assembly 246 with respect to the overall back support assembly 151. Specifically, the body portion 272 of the lumbar assembly 246 includes a pair of outwardly extending integral handle portions 290 each having a C-shaped cross-sectional configuration that wraps about and guides along the respective side edge 252 of the back shell 164.

**[0086]** In operation, a user adjusts the relative vertical position of the lumbar assembly 246 with respect to the back shell 244 by grasping one or both of the handle portions 290 and sliding the handle assembly 290 along the back shell 244 in a vertical direction. A stop tab 292 is integrally formed within a distal end 294 and is offset therefrom so as to engage an end wall of the sleeve 270 of the comfort member 244, thereby limiting the vertical downward travel of the support portion 274 of the lumbar assembly 246 with respect to the sleeve 270 of the comfort member 244.

**[0087]** The back assembly 151 further includes a cushion member 296 having an upper portion 297 and a lower portion 298, wherein the lower portion 298 tapers along the vertical length thereof to correspond to the overall shape and taper of the back shell 164 and the comfort member 244.

**[0088]** The back assembly 151 further includes an upholstery cover assembly 300 (Figs. 12A and 12B) that houses the back shell 244, the lumbar support assembly 246 and the cushion member 296 therein. In the illustrated example, the cover assembly 300 (Fig. 21) comprises a fabric material and includes a front side 302 and a rear side 304 that are sewn together along the respective side edges thereof to form a first pocket 306 having a first interior or inner space 308 that receives the back shell 244 and the cushion member



296 therein, and a flap portion 310 that is sewn to the rear side 304 and cooperates therewith to form a second pocket 312 having a second interior or inner space 308 that receives the lumbar support assembly 246 therein.

**[0089]** In assembly, the first pocket 306 (Fig. 22A) is formed by attaching the respective side edges of the front side 302 and the rear side 304 to one another such as by sewing or other means suitable for the material for which the cover assembly 300 is comprised, and to define the first interior space 308. An edge of the flap portion 310 is then secured to the rear side 304 proximate a midsection 312 thereof. In the illustrated example, the combination of the back shell 164 and the cushion member 296 are then inserted into the interior space 308 of the first pocket 306 via an aperture 314 located of the rear side 304 (Fig. 22B). The upholstery cover assembly 300 is stretched about the cushion member 296 and the comfort member 244, and is secured to the comfort member 244 by a plurality of apertures 320 that receive upwardly extending hook members 324 (Fig. 23) therethrough. Alternatively, the cover assembly 300 may be configured such that apertures 320 are positioned to also receive T-shaped attachment members 322 therethrough. In the illustrated example, the attachment members 322 and the hook members 324 are integrally formed with the comfort member 244. Each attachment member 322 is provided with a T-shaped cross-section or boat-cleat configuration having a first portion 328 extending perpendicularly rearward from within a recess 329 of the rear surface 256 of the comfort member 244, and a pair of second portions 330 located at a distal end of the first portion 328 and extending outwardly therefrom in opposite relation to one another. One of the second portions 330 cooperates with the first portion 328 to form an angled engagement surface 332. The recess 329 defines an edge 334 about the perimeter thereof.

**[0090]** The cover assembly 300 is further secured to the comfort member 244 by a drawstring 336 that extends through a drawstring tunnel 338 of the cover assembly 300, and is secured to the attachment members 322. Specifically, and as best illustrated in Figs. 24A – 24H, each free end of the drawstring 336 is secured to an associated attachment member 322 in a knot-free manner and without the use of a mechanical fastener that is separate from the comfort member 244. In assembly, the drawstring 336 and drawstring tunnel 338 guide about a plurality of guide hooks 339 (Fig. 18B) located about a periphery of and integrally formed with the back shell 344. The drawstring 336 is

wrapped about the associated attachment member 322 such that the tension in the drawstring 336 about the attachment member 322 forces the drawstring 366 against the engagement surface 332 that angles towards the recess 329, thereby forcing a portion of the drawstring 336 into the recess 329 and into engagement with at least a portion of the edge 334 of the recess 329 resulting in an increased frictional engagement between the drawstring 336 and the comfort member 244.

**[0091]** The lumbar assembly 246 is then aligned with the assembly of the cover assembly 300, the cushion member 296 and the comfort member 244 such that the body portion 272 of the lumbar assembly 246 is located near the midsection 312 of the cover assembly 300, and the support portion 274 of the lumbar assembly 246 is coupled with the comfort member 244 as described above. The flap portion 310 is then folded over the lumbar assembly 246, thereby creating a second pocket 348 having an interior space 350. A distally located edge 352 of the flap portion 310 is attached to the comfort member 244 by a plurality of apertures 354 with the flap portion 310 that receive the hooks 324 therethrough. The distal edge 352 may also be sewn to the rear side 304 of the cover assembly 300. In the illustrated example, the side edges 356 of the flap portion 310 are not attached to the remainder of the cover assembly 300, such that the side edges 356 cooperate with the remainder of the cover assembly 300 to form slots 360 through with the handle portions 290 of the lumbar assembly 246. The second pocket 348 is configured such that the lumbar assembly 246 is vertically adjustable therein. The assembly of the cover assembly 300, the cushion member 296, the comfort member 244 and the lumbar assembly 246 are then attached to the back shell 164.

**[0092]** The reference numeral 18a generally designates an alternative embodiment of the back assembly. Since back assembly 18a is similar to the previously described back assembly 18, similar parts appearing in Figs. 12A and 12B and Figs. 25 - 30 are represented respectively by the same corresponding reference numeral, except for the suffix "a" in the numerals of the latter. The back assembly 18a includes a back frame assembly 150a, a back shell 164a, and an upholstery cover assembly 300a. In the illustrated example, the back shell 164a includes a substantially flexible outer peripheral portion 400 and a substantially less flexible rear portion 402 to which the peripheral portion 400 is attached. The rear portion 402 includes a plurality of laterally extending, vertically spaced slots 405 that cooperate to define slats 404 therebetween. As best

illustrated in Figs. 26 and 27, the peripheral portion 400 and the rear portion 402 cooperate to form an outwardly facing opening 408 extending about a periphery of the back shell 164a. The rear portion 402 includes a plurality of ribs 410 spaced about the groove 408 and are utilized to secure the cover assembly 300a to the back shell 164a as described below.

**[0093]** The cover assembly 300a includes a fabric cover 412 and a stay-member 414 extending about a peripheral edge 416 fabric cover 412. The fabric cover 412 includes a front surface 418 and a rear surface 420 and preferably comprises a material flexible in at least one of a longitudinal direction and a lateral direction. As best illustrated in Fig. 28, the stay member 414 is ring-shaped and includes a plurality of widened portions 422 each having a rectangularly-shaped cross-sectional configuration interspaced with a plurality of narrowed corner portions 424 each having a circularly-shaped cross-sectional configuration. Each of the widened portions 422 include a plurality of apertures 426 spaced along the length thereof and adapted to engage with the ribs 410 of the back shell 164a, as described below. The stay member 414 is comprised of a relatively flexible plastic such that the stay member 414 may be turned inside-out, as illustrated in Fig. 29.

**[0094]** In assembly, the stay member 414 is secured to the rear surface 420 of the cover 412 such that the cover 412 is fixed for rotation with the widened portions 422, and such that the cover 412 is not fixed for rotation with the narrowed corner portions 424 along a line tangential to a longitudinal axis of the narrowed corner portions 424. In the present example, the stay member 414 (Fig. 30) is sewn about the peripheral edge 416 of the cover 412 by a stitch pattern that extends through the widened portions 422 and about the narrowed corner portions 424. The cover assembly 300a of the cover 412 and the stay member 414 are aligned with the back shell 164a, and the peripheral edge 416 of the cover 412 is wrapped about the back shell 164a such that the stay member 414 is turned inside-out. The stay member 414 is the inserted into the groove 408, such that the tension of the fabric cover 412 being stretched about the back shell 164a causes the stay member 414 to remain positively engaged within the groove 408. The ribs 410 of the back shell 164 engage the corresponding apertures 426 of the stay member 414, thereby further securing the stay member 414 within the groove 408. It is noted that the stitch pattern attaching the cover 412 to the stay member 414 allows the narrowed corner portions 424 of the stay member 414 to rotate freely with respect to the cover

412, thereby reducing the occurrence of aesthetic anomalies near the corners of the cover 412, such as bunching or over-stretch of a given fabric pattern.

**[0095]** The reference numeral 10b (Figs. 31 and 32) generally designates another embodiment of the present invention. Since chair assembly 10b is similar to the previously described chair assembly 10, similar parts appearing in Figs. 1–30 and Figs. 31–34 respectfully are representative of the same, corresponding reference numeral, except for the suffix “b” in the numerals of the latter. The chair assembly 10b is similar in construction and assembly to the chair assembly 10 as previously described, with the most notable exception being the configuration of the back assembly 18b.

**[0096]** As best illustrated in Figs. 31–34, the back assembly 18b includes back frame assembly 150b, a back shell member 500, a cross member 502, and a mesh fabric upholstery cover 504. The back shell member 500 includes a laterally extending top portion 508, a laterally extending bottom portion 510, and a pair of longitudinally extending side portions 512 that extend between the top portion 508 and the bottom portion 510 and cooperate therewith to define an open space 514 therebetween. In the illustrated example, the back shell member 500 comprises a molded plastic, and is configured such that the side portions 512 and overall back shell member 500 are substantially rigid in a lateral direction 516 and relatively flexible in fore-and-aft direction 518. The back shell member 500 further includes a lateral portion 520 that extends between the side portions 512 at a position spaced between the top portion 508 and the bottom portion 510. The lateral portion 520 includes integrally molded pivot bosses 192b. In the illustrated example, the back shell member 500 is molded as a single, integral piece.

**[0097]** The cross member 502 extends laterally across and is secured to the back frame assembly 150b. In the illustrated example, the cross member 502 includes arcuately-shaped bearing surfaces 218b that cooperate with the pivot bosses 192b in a similar manner to as previously described bearing surfaces 218 and pivot bosses 192 of chair assembly 10, such that the lumbar area of the back shell member 500 is flexed in the fore-and-aft direction 518 as the back frame assembly 150b is moved between the upright and reclined positions in a similar manner to as described herein with respect to the back shell 164.

**[0098]** The cover 504 comprises a thermoelastic knit or woven fabric material that is substantially less compliant in a lateral direction 524 than in a longitudinal direction 526. Preferably, the cover 504 has a longitudinal direction compliance to lateral direction compliance of at least 3:1, and more preferably of at least 10:1. In assembly, the ring or stay member 414b (Fig. 35) is attached to a rear surface 528 of the cover 504, opposite the front surface 530 and proximate the outer edge 532. The ring 414b and the outer edge 532 of the cover 504 are then wrapped about the back shell member 500 and inserted into a channel 534 that opens peripherally outward and extends longitudinally along the top portion 508, the bottom portion 510 and the side portions 512 of the back shell member 500. In the illustrated example, the ring member 414b includes a plurality of peripherally-spaced tabs 550 and reliefs 552, while the channel 534 includes a plurality of peripherally-spaced reliefs 554 and tabs 556 that interspaced and engage one another, respectively, thereby cooperating to provide the back support assembly 151b with a rounded-edge aesthetic appearance. It is noted that in the illustrated example, an inwardly extending peripheral lip portion 535 of the cover 504 extends 180° to the main user-supporting portion 537 of the cover 504. The lip portion 535 preferably extends between 90° and 180° of the user-supporting portion 537.

**[0099]** The seat assembly 16 and the back assembly 18 are operably coupled to and controlled by the control assembly 14 (Fig. 36) and a control input assembly 604. The control assembly 14 (Figs. 37-39) includes a housing or base structure or ground structure 606 that includes a front wall 608, a rear wall 610, a pair of side walls 612 and a bottom wall 614 integrally formed with one another and that cooperate to form an upwardly opening interior space 616. The bottom wall 614 includes an aperture 618 centrally disposed therein for receiving the cylinder assembly 28 (Fig. 3) therethrough. The base structure 606 further defines an upper and forward pivot point 620, a lower and forward pivot point 622, and an upper and rearward pivot point 624, wherein the control assembly 14 further includes a seat support structure 626 that supports the seat assembly 16. In the illustrated example, the seat support structure 626 has a generally U-shaped plan form configuration that includes a pair of forwardly extending arm portions 628 each including a forwardly located pivot aperture 630 pivotably secured to the base structure 606 by a pivot shaft 632 for pivoting movement about the upper and forward pivot point 620. The seat support structure 626 further includes a rear portion

634 extending laterally between the arm portions 628 and cooperating therewith to form an interior space 636 within which the base structure 606 is received. The rear portion 634 includes a pair of rearwardly extending arm mounting portions 638 to which the arm assemblies 20. The seat support structure 626 further includes a control input assembly mounting portion 640 to which the control input assembly 604 is mounted. The seat support structure 626 further includes a pair of bushing assemblies 642 that cooperate to define a pivot point 644.

**[00100]** The control assembly 14 further includes a back support structure 646 having a generally U-shaped plan view configuration and including a pair of forwardly extending arm portions 648 each including a pivot aperture 650 and pivotably coupled to the base structure 606 by a pivot shaft 652 such that the back support structure 646 pivots about the lower and forward pivot point 672. The back support structure 646 includes a rear portion 654 that cooperates with the arm portions 648 to define an interior space 656 which receives the base structure 606 therein. The back support structure 646 further includes a pair of pivot apertures 658 located along the length thereof and cooperating to define a pivot point 660. It is noted that in certain instances, at least a portion of the back frame assembly 150 may be included as part of the back support structure 646.

**[00101]** The control assembly 14 further includes a plurality of control links 642 each having a first end 644 pivotably coupled to the seat support structure 626 by a pair of pivot pins 668 for pivoting about the pivot point 644, and a second end 670 pivotably coupled to corresponding pivot apertures 658 of the back support structure 646 by a pair of pivot pins 672 for pivoting about the pivot point 660. In operation, the control links 642 control the motion, and specifically the recline rate of the seat support structure 626 with respect to the back support structure 646 as the chair assembly is moved to the recline position, as described below.

**[00102]** As best illustrated in Figs. 40A and 40B, a bottom frame portion 154 of the back frame assembly 150 is configured to connect to the back support structure 646 via a quick connect arrangement 674. Each arm portion 648 of the back support structure 646 includes a mounting aperture 676 located at a proximate end 678 thereof. In the illustrated example, the quick connect arrangement 674 includes a configuration of the bottom frame portion 154 of the back frame assembly 150 to include a pair of forwardly-extending coupler portions 680 that cooperate to define a channel 682 therebetween

that receives the rear portion 654 and the proximate ends 678 of the arm portions 648 therein. Each coupler portion 680 includes a downwardly extending boss 684 that aligns with and is received within a corresponding aperture 676. Mechanical fasteners, such as screws 686 are then threaded into the bosses 684, thereby allowing a quick connection of the back frame assembly 150 to the control assembly 14.

**[00103]** As best illustrated in Fig. 41, the base structure 606, the seat support structure 626, the back support structure 646 and the control links 662 cooperate to form a 4-bar linkage assembly that supports the seat assembly 16, the back assembly 18, and the arm assemblies 20. For ease of reference, the associated pivot assemblies associated with the 4-bar linkage assembly of the control assembly 14 are referred to as follows: the upper and forward pivot point 620 between the base structure 606 and the base support structure 626 as the first pivot point 620; the lower and forward pivot point 622 between the base structure 606 and the back support structure 646 as the second pivot point 622; the pivot point 644 between the first end 664 of the control link 662 and the seat support structure 626 as the third pivot point 644; and, the pivot point 660 between the second end 670 of the control link 662 and the back support structure 646 as the fourth pivot point 660. Further, Figure 41 illustrates the component of the chair assembly 10 shown in a reclined position in dashed lines, wherein the reference numerals of the chair in the reclined position are designated with a “ ‘ ”.

**[00104]** In operation, the 4-bar linkage assembly of the control assembly 14 cooperates to recline the seat assembly 16 from the upright position G to the reclined position H as the back assembly 18 is moved from the upright position E to the reclined position F. Specifically, the control link 662 is configured and coupled to the seat support structure 626 and the back support structure 646 to cause the seat support structure 626 to rotate about the first pivot point 620 as the back support structure 646 is pivoted about the second pivot point 622. Preferably, the seat support structure 646 is rotated about the first pivot point 620 at between about  $1/3$  and about  $2/3$  the rate of rotation of the back support structure 646 about the second pivot point 620, more preferably the seat support structure rotates about the first pivot point 612 at about half the rate of rotation of the back support structure 646 about the second pivot point 620, and most preferable the seat assembly 16 reclines to an angle  $\beta$  of about  $9^\circ$  from the fully upright position G

to the fully reclined position H, while the back assembly 18 reclines to an angle  $\alpha$  of about 18° from the fully upright position E to the fully reclined position F.

**[00105]** As best illustrated in Fig. 41, the first pivot point 612 is located above and forward of the second pivot point 620 when the chair assembly 10 is at the fully upright position, and when the chair assembly 10 is at the fully reclined position as the base structure 606 remains fixed with respect to the supporting floor surface 13 as the chair assembly 10 is reclined. The third pivot point 644 remains behind and below the relative vertical height of the first pivot point 612 throughout the reclining movement of the chair assembly 10. It is further noted that the distance between the first pivot point 612 and the second pivot point 620 is greater than the distance between the third pivot point 644 and fourth pivot point 660 throughout the reclining movement of the chair assembly 10. As best illustrated in Fig. 42, a longitudinally extending center line axis 688 of the control link 662 forms an acute angle  $\alpha$  with the seat support structure 626 when the chair assembly 10 is in the fully upright position and an acute angle  $\alpha'$  when the chair assembly 10 is in the fully reclined position. It is noted that the center line axis 688 of the control link 662 does not rotate past an orthogonal alignment with the seat support structure 626 as the chair assembly 10 is moved between the fully upright and fully reclined positions thereof.

**[00106]** With further reference to Fig. 43, the back control link 600 includes a forward end 687 that is pivotably connected to seat support structure 626 at a fifth pivot point 689. A rearward end 690 of back control link 600 is connected to lower portion 168 of back shell 164 at a sixth pivot point 692. Sixth pivot point 692 is optional, and back control link 600 and back shell 164 may be rigidly fixed to one another. Also, pivot point 692 may include a stop feature that limits rotation of back control link 600 relative to back shell 164 in a first and/or second rotational direction. For example, with reference to Fig. 43, pivot 692 may include a stop feature that permits clockwise rotation of lower portion 168 of back shell 164 relative to control link 600. This permits the lumbar to become flatter if a rearward/horizontal force tending to reduce dimension D1 is applied to the lumbar portion of back shell 164. However, the stop feature may be configured to prevent rotation of lower portion 168 of back shell 164 in a counter clockwise direction (Fig. 43) relative to control link 600. This causes link 600 and lower portion 168 of back shell 164



to rotate at the same angular rate as a user reclines in the chair by pushing against an upper portion of back assembly 18.

**[00107]** A cam link 694 is also pivotably connected to seat support structure 626 for rotation about pivot point or axis 689. Cam link 694 has a curved lower cam surface 696 that slidably engages an upwardly facing cam surface 698 formed in back support structure 646. A pair of torsion springs 700 (Fig. 48) rotatably bias the back control link 600 and the cam link 694 in a manner that tends to increase the angle  $\emptyset$  (Fig. 43). The torsion springs 700 generate a force tending to rotate control link 600 in a counter-clockwise direction (Fig. 43), and simultaneously rotate cam link 694 in a clockwise direction (Fig. 43). Thus, torsion springs 700 tend to increase the angle  $\emptyset$  between back control link 600 and cam link 694. A stop 702 on seat support structure 626 limits counter clockwise rotation of back control link 600 to the position shown in Fig. 43. This force may also bias control link 600 in a counter clockwise direction into the stop feature.

**[00108]** As discussed above, the back shell 164 is flexible, particularly in comparison to the rigid back frame structure 150. As also discussed above, the back frame structure 150 is rigidly connected to the back support structure 646, and therefore pivots with the back support structure 646. The forces generated by torsion springs 700 push upwardly against lower portion 168 of back shell 164. The slots 184 in back shell structure 164 create additional flexibility at lumbar support portion 182 of back shell 164. The force generated by torsion springs 700 also tend to cause the lumbar portion 182 of the back shell 164 to bend forwardly such that the lumbar portion 182 has a higher curvature than the regions adjacent lumbar portion 182.

**[00109]** As discussed above, the position of lumbar assembly 246 is vertically adjustable. Vertical adjustment of the lumbar assembly 246 also adjusts the way in which the back shell 164 flexes/curves during recline of the chair back. In Fig. 43, the lumbar assembly 182 is adjusted to an intermediate or neutral position, such that the curvature of lumbar portion 182 of back shell 164 is also intermediate or neutral. With further reference to Fig. 44, if the vertical position of the lumbar assembly 246 is adjusted, the angle  $\emptyset$  is reduced, and the curvature of lumbar region 182 is reduced. As shown in Fig. 44, this also causes angle  $\emptyset^1$  to become greater, and the overall shape of the back shell 164 to become relatively flat.

**[00110]** With further reference to Fig. 45, if the height of lumbar assembly 246 is set at an intermediate level (i.e., the same as Fig. 43), and a user leans back, the 4-bar linkage defined by links and structures 606, 626, 646, 662, and pivot points 620, 622, 644, 660 will shift (as described above) from the configuration of Fig. 43 to the configuration of Fig. 45. This, in turn, causes an increase in the distance between pivot point 688 and cam surface 698. This causes an increase in the angle  $\emptyset$  from about 49.5° (Fig. 43) to about 59.9° (Fig. 45). As the spring rotates towards an open position, some of the energy stored in the spring is transferred into the back shell 164, thereby causing the degree of curvature of lumbar portion 168 of back shell 164 to become greater. In this way, back control link 600, cam link 694, and a torsion springs 700 provide for greater curvature of lumbar portion 182 to reduce curvature of a user's back as the user leans back in the chair.

**[00111]** Also, as the chair tilts from the position of Fig. 43 to the position of Fig. 45, the distance D between the lumbar portion 182 and the seat 16 increases from 174mm to 234mm. A dimension D<sup>1</sup> between the lumbar portion 182 of back shell 164 and back frame structure 150 also increases as the back tilts from the position of Fig. 43 to the position of Fig. 45. Thus, although the distance D increases somewhat, the increase in the dimension D<sup>1</sup> reduces the increase in dimension D because the lumbar portion 182 of back shell 164 is shifted forward relative to the back frame 150 during recline.

**[00112]** Referring again to Fig. 43, a spine 704 of a seated user 706 tends to curve forwardly in the lumbar region 708 by a first amount when a user is seated in an upright position. As a user leans back from the position of Fig. 43 to the position of Fig. 45, the curvature of the lumbar region 708 tends to increase, and the user's spine 704 will also rotate somewhat about hip joint 710 relative to a user's femur 712. The increase in the dimension D and the increase in curvature of lumbar region or portion 182 of back shell 112 simultaneously ensure that a user's hip joint 710 and femur 712 do not slide on the seat 16, and also accommodate curvature of the lumbar region 708 of a user's spine 704.

**[00113]** As discussed above, Fig. 44 shows the back of the chair in an upright position with the lumbar region 182 of shell 164 adjusted to a flat position. If the chair back is tilted from the position of Fig. 44 to the position of Fig. 46, the back control link 700 and the cam link 694 both rotate in a clockwise direction. However, the cam link 694 rotates at a somewhat higher rate, and the angle  $\emptyset$  therefore changes from 31.4° to 35.9°. The

distance D changes from 202mm to 265mm, and the angle  $\phi^1$  changes from 24.2° to 24.1°.

**[00114]** With further reference to Fig. 47, if the chair back is reclined, and the lumbar adjustment is set high, the angle  $\phi$  is 93.6°, and the distance D is 202mm.

**[00115]** Thus, the back shell 164 curves as the seat back is tilted rearwardly. However, the increase in curvature in the lumbar region 182 from the upright to the reclined position is significantly greater if the curvature is initially adjusted to a higher level. This accounts for the fact that the curvature of a user's back does not increase as much when a user reclines if the user's back is initially in a relatively flat condition when seated upright. Restated, if a user's back is relatively straight when in an upright position, the user's back will remain relatively flat even when reclined, even though the degree of curvature will increase somewhat from the upright position to the reclined position. Conversely, if a user's back is curved significantly when in the upright position, the curvature of the lumbar region will increase by a greater degree as the user reclines relative to the increase in curvature if a user's back is initially relatively flat.

**[00116]** A pair of spring assemblies 714 (Figs. 37-39) bias the back assembly 18 from the reclined position F towards the upright position E. As best illustrated in Fig. 39, each spring assembly 714 includes a cylindrically-shaped housing 716 having a first end 718 and a second end 720. Each spring assembly 714 further includes a compression coil spring 722, a first coupler 724 and a second coupler 726. In the illustrated example, the first coupler is secured to the first end 718 of the housing 716, while the second coupler 726 is secured to a rod member 728 that extends through the coil spring 722. A washer 730 is secured to a distal end of the rod member 728 and abuts an end of the coil spring 722, while the opposite end of the coil spring 722 abuts the second end 720 of the housing 716. The first coupler 724 is pivotably secured to the back support structure 446 by a pivot pin 732 for pivoting movement about a pivot point 734, wherein the pivot pin 732 is received within pivot apertures 736 of the back support structure 646, while the second coupler 726 is pivotably coupled to a moment arm shift assembly 738 by a shaft 740 for pivoting about a pivot point 742. The moment arm shift assembly 738 is adapted to move the biasing or spring assembly 714 from a low tension setting to a high tension setting wherein the force exerted by the biasing assembly 714 on the back assembly 18 is increased relative to the low-tension setting.

**[00117]** In the foregoing description, it will be readily appreciated by those skilled in the art that modifications may be made to the invention without departing when the concept is disclosed. Such modifications are to be considered as included in the following claims, unless these claims by their language expressly state otherwise.

The invention claimed is:

1. A chair back assembly, comprising:  
a back shell member including a laterally extending top portion, a laterally extending bottom portion and a pair of longitudinally extending side portions extending between the top portion and the bottom portion and cooperating therewith to define an open space therebetween; and  
a cover having a first surface adapted to support a seated user and a second surface opposite the first surface, wherein the cover is positioned over the back shell member to cover at least a portion of the open space, and wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance ratio of at least 3:1.
2. The chair back assembly of claim 1, wherein the ratio is at least 10:1.
3. The chair back assembly of either of claims 1 and 2, wherein the back shell member is flexible along the length thereof in a fore-to-aft direction.
4. The chair back assembly of any one of the preceding claims, wherein the cover comprises a mesh fabric.
5. The chair back assembly of any one of the preceding claims, further including:  
a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along a longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to the back shell member.

6. The chair back assembly of claim 5, wherein the back shell member includes a channel extending along at least one of the top portion, the bottom portion and the side portions, and wherein the ring member is received within the channel.
7. The chair back assembly of claim 6, wherein the channel extends along the top portion, the bottom portion and the side portions.
8. The chair back assembly of any one of claims 5-7, wherein the at least one of the side portions of the ring includes a relatively widened portion with respect to the at least one of the corner portions, and wherein the at least one of the corner portions includes a relatively narrowed portion with respect to the at least one of the side portions of the ring.
9. The chair back assembly of any one of claims 5-8, wherein the at least one of the side portions of the ring comprises a substantially rectangular cross-sectional configuration.
10. The chair back assembly of any one of claims 5-9, wherein the at least one of the corner portions comprises a substantially circular cross-sectional configuration.
11. The chair back assembly of any one of claims 5-10, wherein the at least one of the side portions of the ring and the at least one of the corner portions are sewn to the cover.
12. The chair back assembly of any one of the preceding claims, further comprising:  
a substantially rigid back frame assembly operably supporting the back shell member and movable between an upright position and a reclined position.
13. The chair back assembly of any one of the preceding claims, wherein the back shell member is pivotably supported by the back frame assembly.

14. The chair back assembly of either of claims 12 and 13, wherein the back shell member flexes in a fore-and-aft direction as the back frame is pivoted between the upright and reclined positions.

15. The chair back assembly of any one of claims 12-14, wherein a lumbar area of the back shell member moves in a fore-and-aft direction as the back frame assembly is moved between the upright and reclined positions.

16. The chair back assembly of any one of the preceding claims, wherein the cover is stretched over the back shell member.

17. A chair component assembly, comprising:

a support component adapted to support a portion of a seated user;

a mesh fabric cover having a first surface and a second surface opposite the first surface; and

a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along a longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to the support component.

18. The chair component assembly of claim 17, wherein the support component comprises a back shell frame comprising a laterally extending top portion, a laterally extending bottom portion and a pair of longitudinally extending side portion extending between the top portion and the bottom portion and cooperating therewith to define an open space therebetween.

19. The chair component assembly of either of claims 17 and 18, wherein the cover includes a first surface adapted to support a seated user and a second surface opposite

the first surface, wherein the cover is positioned over the back shell member to cover at least a portion of the open space, and wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance ratio of at least 3:1.

20. The chair back assembly of claim 19, wherein the ratio is at least 10:1.

21. The chair back assembly of any one of claims 17-20, wherein the cover is stretched over the back shell.

22. The chair back assembly of claim 18, wherein the back shell member is flexible along the length thereof in a fore-to-aft direction.

23. The chair back assembly either one of claims 18 and 22, wherein the back shell member includes a channel extending along at least one of the top portion, the bottom portion and the side portions, and wherein the ring member is received within the channel.

24. The chair back assembly of claim 23, wherein the channel extends along the top portion, the bottom portion and the side portions.

25. The chair back assembly of any one of claims 17-24, wherein the at least one of the side portions of the ring includes a relatively widened portion with respect to the at least one of the corner portions, and wherein the at least one of the corner portions includes a relatively narrowed portion with respect to the at least one of the side portions of the ring.

26. The chair back assembly of any one of claims 17-25, wherein the at least one of the side portions of the ring comprises a substantially rectangular cross-sectional configuration.



27. The chair back assembly of any one of claims 17-26, wherein the at least one of the corner portions comprises a substantially circular cross-sectional configuration.

28. The chair back assembly of any one of claims 17-27, wherein the at least one of the side portions of the ring and the at least one of the corner portions are sewn to the cover.

29. The chair back assembly of any one of claims 17-28, further comprising:  
a substantially rigid back frame assembly operably supporting the back shell member and movable between an upright position and a reclined position.

30. The chair back assembly of claim 29, wherein the back shell member is pivotably supported by the back frame assembly.

31. The chair back assembly of either of claims 29 and 30, wherein the back shell member flexes in a fore-and-aft direction as the back frame is pivoted between the upright and reclined positions.

32. The chair back assembly of any one of claims 29-31, wherein a lumbar area of the back shell member moves in a fore-and-aft direction as the back frame assembly is moved between the upright and reclined positions.

33. A chair back assembly, comprising:  
a substantially rigid back frame assembly;  
a back shell member operably supported by the back frame assembly and comprising a laterally extending top portion, a laterally extending bottom portion and a pair of longitudinally extending side portion extending between the top portion and the bottom portion and cooperating therewith to define an open space therebetween, wherein the pair of side portions are substantially rigid in a lateral direction, and wherein the back shell member is substantially rigid in a lateral direction and substantially flexibly resilient in a fore-to-aft direction; and

a cover having a first surface adapted to support a seated user and a second surface opposite the first surface, wherein the cover is positioned over the back shell member to cover at least a portion of the open space.

34. The chair back assembly of claim 29, wherein the cover comprises an elastomeric material having a longitudinal direction compliance to a lateral direction compliance ratio of at least 3:1.

35. The chair back assembly of either one of claims 33 and 34, wherein the ratio is at least 10:1.

36. The chair back assembly of any one of claims 33-35, wherein the cover comprises a mesh fabric.

37. The chair back assembly of any one of claims 33-36, further including:  
a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along a longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to the back shell member.

38. The chair back assembly of claim 37, wherein the back shell member includes a channel extending along at least one of the top portion, the bottom portion and the side portions, and wherein the ring member is received within the channel.

39. The chair back assembly of claim 38, wherein the channel extends along the top portion, the bottom portion and the side portions.

40. The chair back assembly of any one of claims 37-39, wherein the at least one of the side portions of the ring includes a relatively widened portion with respect to the at least one of the corner portions, and wherein the at least one of the corner portions includes a relatively narrowed portion with respect to the at least one of the side portions of the ring.

41. The chair back assembly of any one of claims 37-40, wherein the at least one of the side portions of the ring comprises a substantially rectangular cross-sectional configuration.

42. The chair back assembly of any one of claims 37-41, wherein the at least one of the corner portions comprises a substantially circular cross-sectional configuration.

43. The chair back assembly of any one of claims 37-42, wherein the at least one of the side portions of the ring and the at least one of the corner portions are sewn to the cover.

44. The chair back assembly of any one of claims 33-43, wherein the back shell member is pivotably supported by the back frame assembly.

45. The chair back assembly of any one of claims 33-43, wherein the back frame assembly is movable between an upright position and a reclined position.

46. The chair back assembly of claim 45, wherein the back shell member flexes in a fore-and-aft direction as the back frame is pivoted between the upright and reclined positions.

47. The chair back assembly of either of claims 45 and 46, wherein a lumbar area of the back shell member moves in a fore-and-aft direction as the back frame assembly is moved between the upright and reclined positions.

48. The chair back assembly of any one of claims 33-47, wherein the cover is stretched over the back shell member.

49. A chair assembly, comprising:

a base structure;

a seat support structure pivotably coupled to the base structure for rotation about a first pivot point, wherein the seat support structure includes a seat support surface configured to support a seated user thereon;

a back support structure pivotably coupled to the base structure for rotation about a second pivot point, wherein the back support structure includes an upwardly extending portion adapted to move between an upright position and a reclined position;

a back shell member including a back support surface that is generally forwardly facing and configured to support a back of a seated user, and having an upper portion pivotably coupled to the upwardly extending portion of the back support for rotation about a third pivot point and a lower portion, wherein the back shell member is covered by a mesh cover; and

a back link pivotably coupled to the lower portion of the back support surface for rotation about a fourth pivot point and pivotably coupled to the seat support structure for rotation about a fifth pivot point, wherein the back support surface is moved forward by the back link relative to the upright portion of the back support structure as the back support structure is moved from the upright position to the reclined position.

50. The chair assembly of claim 49, wherein the back shell member is flexible along the length thereof in a fore-to-aft direction.

51. The chair assembly of either of claims 49 and 50, wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance ratio of at least 3:1.

52. The chair assembly of any one of claims 49-51, wherein the ratio is at least 10:1.

53. The chair assembly of any one of claims 49-52, further including:

a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along a longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to the back shell member.

54. The chair assembly of claim 53, wherein the back shell member includes a channel extending along at least one of the top portion, the bottom portion and the side portions, and wherein the ring member is received within the channel.

55. The chair assembly of claim 54, wherein the channel extends along the top portion, the bottom portion and the side portions.

56. The chair assembly of any one of claims 53-55, wherein the cover is stretched over the back shell member.

57. The chair assembly of any one of claims 53-56, wherein at least a portion of the back support surface and the back support structure define a distance therebetween that changes during movement of the back support structure from the upright position to the reclined position.

58. The chair assembly of claim 57, wherein the upwardly extending portion of the back support structure is substantially rigid, and wherein the portion of the back support surface that defines the distance is significantly less rigid than the back support structure.

59. The chair support of any one of claims 49-58, wherein the back shell member includes a forwardly curved lower lumbar portion defining a curvature, and wherein the curvature is increased as the back support structure is moved from the upright position to the reclined position.

60. The chair support of claim 59, wherein the operable connection between the back support structure and the back support assembly comprises a pivotal connection of the back shell member to the upwardly extending portion of the back support structure.

61. A chair assembly, comprising:

a base structure;

a seat support structure operably coupled to the base structure, wherein the seat support structure includes a seat support surface configured to support a seated user thereon;

a back support structure operably coupled to the base structure, wherein the back support structure is adapted to move between an upright position and a reclined position;

a back shell member including a back support surface that is generally forwardly facing and configured to support a back of a seated user, and pivotably coupled to the back support for rotation about a first back support pivot point, wherein the back shell member is covered by a mesh cover; and

a back link pivotably coupled to the back support surface for rotation about a second back support pivot point and operably coupled to the seat support structure, wherein a distance between the first back support pivot point and the second back support pivot point decreases as the back support structure moves from the upright position to the reclined position, and increases as the back support structure moves from the reclined position to the upright position.

62. The chair assembly of claim 61, wherein the back shell member is flexible along the length thereof in a fore-to-aft direction.

63. The chair assembly of either one of claims 61 and 62, wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance of at least 3:1.

64. The chair assembly of claim 61, wherein the ratio is at least 10:1.

65. The chair assembly of any one of claims 61-64, further including:

a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along a longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to the back shell member.

66. The chair assembly of claim 65, wherein the back shell member includes a channel extending along at least one of the top portion, the bottom portion and the side portions, and wherein the ring member is received within the channel.

67. The chair assembly of claim 66, wherein the channel extends along the top portion, the bottom portion and the side portions.

68. The chair assembly of any one of claims 61-67, wherein the cover is stretched over the back shell member.

69. The chair assembly of any one of claims 61-68, wherein the back link is pivotably coupled to the seat support structure about a seat support pivot point, and wherein the second back support pivot point does not move with respect to the seat support pivot point as the back support structure is moved from the upright position to the reclined position.

70. The chair assembly of any one of claims 61-69, wherein the back support surface is moved forward by the back link relative to at least a portion of the back support structure as the back support structure is moved from the upright position to the reclined position

71. The chair assembly of any one of claims 61-70, further comprising:  
a control link having a first end operably coupled to the seat support structure, and a second end operably coupled to the back support structure, wherein the control link reclines the seat support structure at a slower rate of recline than a rate of recline of the back support structure as the back support structure is moved from the upright position to the reclined position.
72. A chair assembly, comprising:  
a base structure;  
a seat support structure pivotably coupled to the base structure for rotation about a first pivot point, wherein the seat support structure includes a seat support surface configured to support a seated user thereon;  
a back support structure pivotably coupled to the base structure for rotation about a second pivot point, wherein the back support structure is adapted to move between an upright position and a reclined position;  
a back support assembly including a flexible back shell member that is generally forwardly facing and configured to support a back of a seated user, and operably coupled to the back support, wherein the back shell member is covered by a mesh cover; and  
a back link operably coupled to the lower portion of the back support surface and operably coupled to the seat support structure, wherein the flexible back support assembly is flexed along a length thereof as the back support structure is moved from the upright position to the reclined position.
73. The chair assembly of claim 72, wherein the back shell member is flexible along the length thereof in a fore-to-aft direction.
74. The chair assembly of either one of claims 72 and 73, wherein the cover comprises an elastomeric material having a longitudinal direction compliance to lateral direction compliance ratio of at least 3:1.
75. The chair assembly of claim 74, wherein the ratio is at least 10:1.



76. The chair assembly of any one of claims 72-75, further including:

a ring member having a plurality of side portions and a plurality of corner portions interspaced with the side portions, wherein at least one of the side portions is secured to the first surface of the cover such that the at least one of the side portions is fixed for rotation with the cover along a longitudinal axis of the at least one of the side portions, and wherein at least one of the corner portions is secured to the first surface of the cover such that the at least one of the corner portions is free for rotation with the cover along a line tangential to the at least one of the corner portions, and wherein the ring member is secured to the back shell member.

77. The chair assembly of claim 76, wherein the back shell member includes a channel extending along at least one of the top portion, the bottom portion and the side portions, and wherein the ring member is received within the channel.

78. The chair assembly of claim 77, wherein the channel extends along the top portion, the bottom portion and the side portions.

79. The chair assembly of any one of claims 72-78, wherein the cover is stretched over the back shell member.

80. The chair assembly of any one of claims 72-79, wherein the back support assembly is moved forward by the back link relative to at least a portion of the back support structure as the back support structure is moved from the upright position to the reclined position.

81. The chair support of any one of claims 72-80, wherein the back shell member includes a forwardly curved lower lumbar portion defining a curvature, and wherein the curvature is reduced as the back support structure is moved from the upright position to the reclined position.

82. The chair support of claim 81, wherein the operable connection between the back support structure and the back support assembly comprises a pivotal connection of the back shell member to the back support structure.

83. The chair assembly of any one of claims 72-82, wherein the seat support structure includes a forward portion and a rearward portion, and the back support structure includes a forward portion and a rearward portion, and wherein the first pivot point is located at the forward portion of the seat support structure, and the second pivot point is located at the forward portion of the back support structure.

84. The chair assembly of any one of claims 72-83, wherein the back support structure is generally L-shaped, and wherein the back support structure includes a lower portion that extends forwards from an upwardly extending portion.

85. The chair assembly of claims 72-84, wherein a rate of recline of the seat support structure as the back support structure is moved from the upright position to the reclined position less than the rate of recline of the back support structure as the back support structure is moved from the upright position to the reclined position.

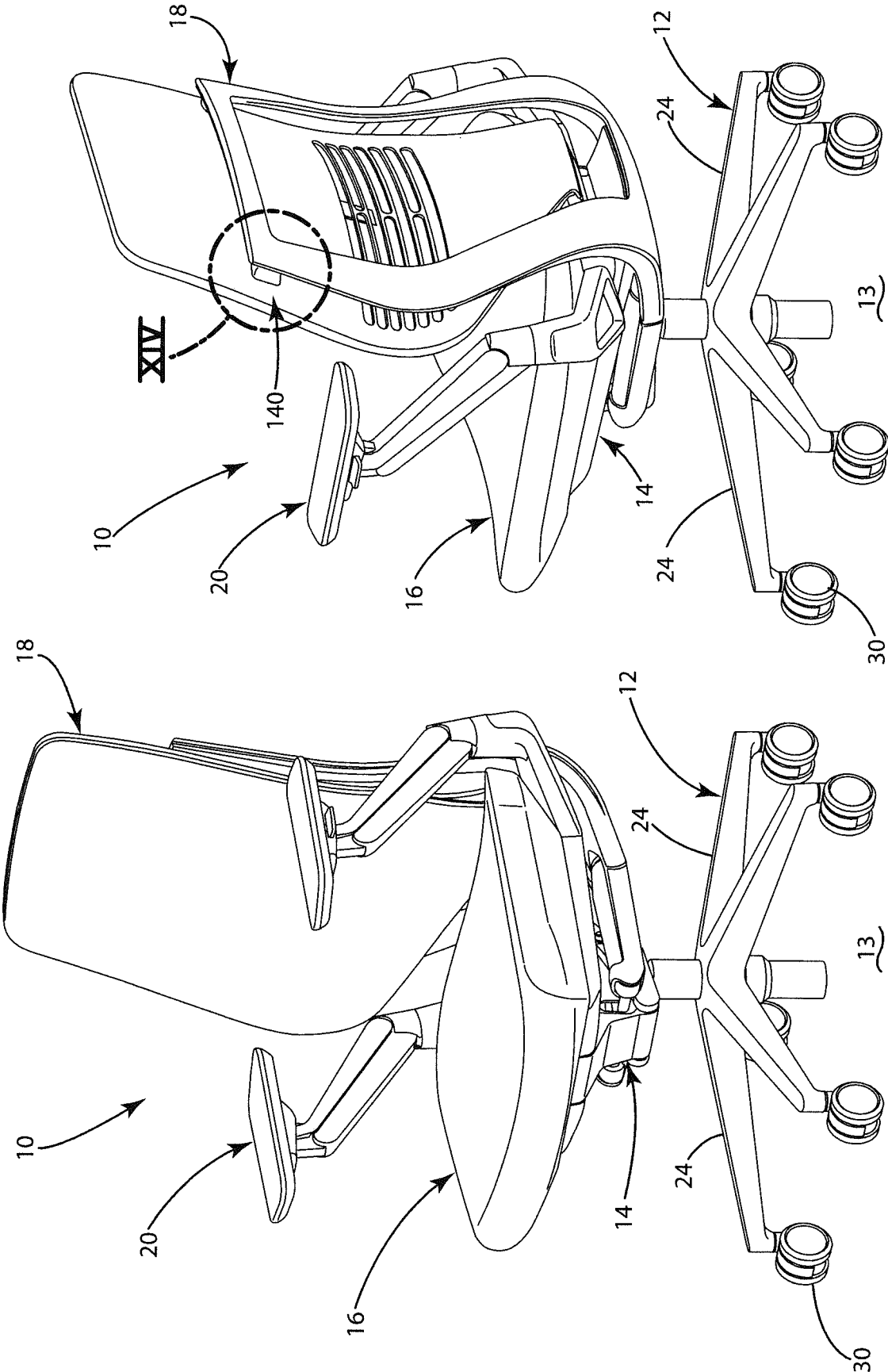


Fig. 2

Fig. 1

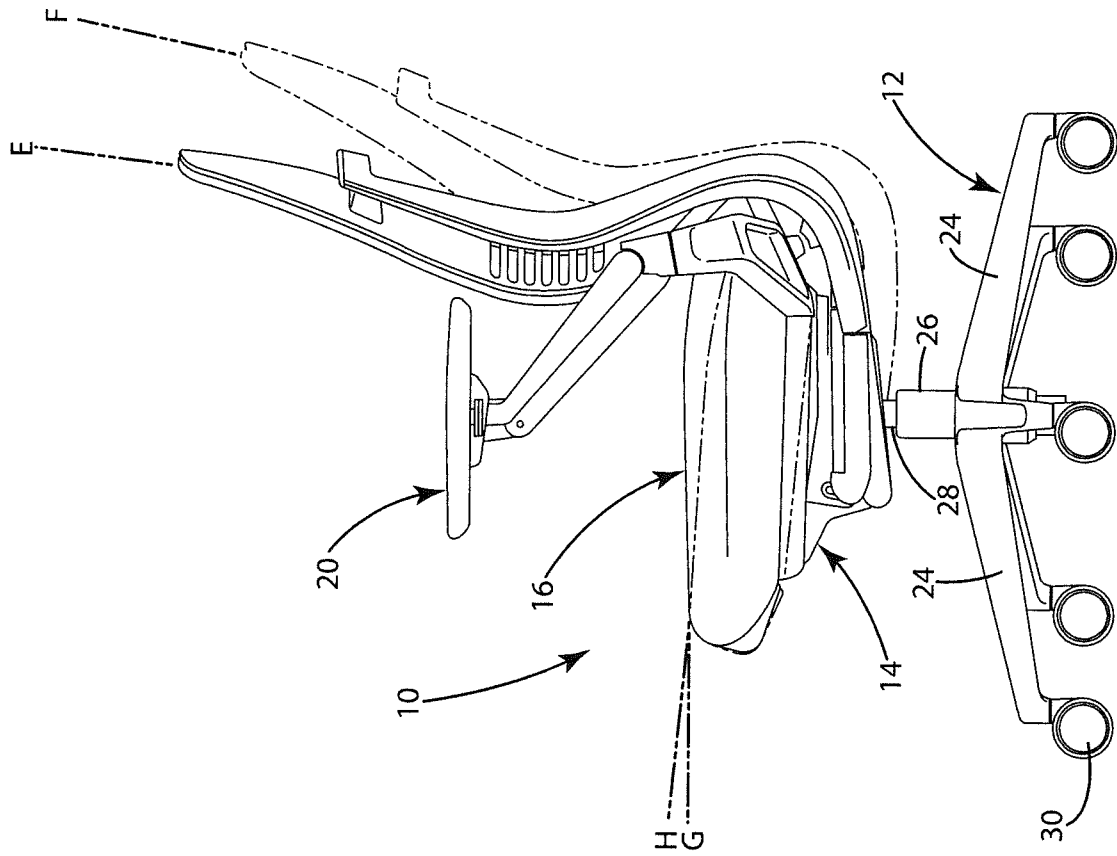


Fig. 4

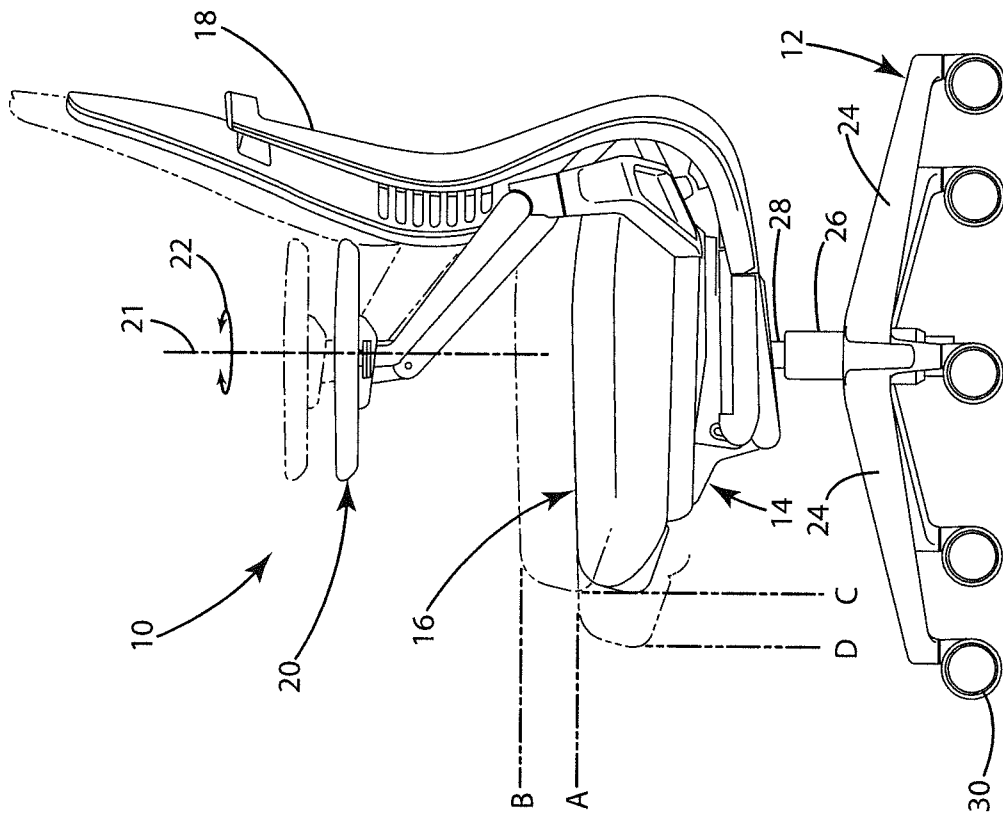


Fig. 3

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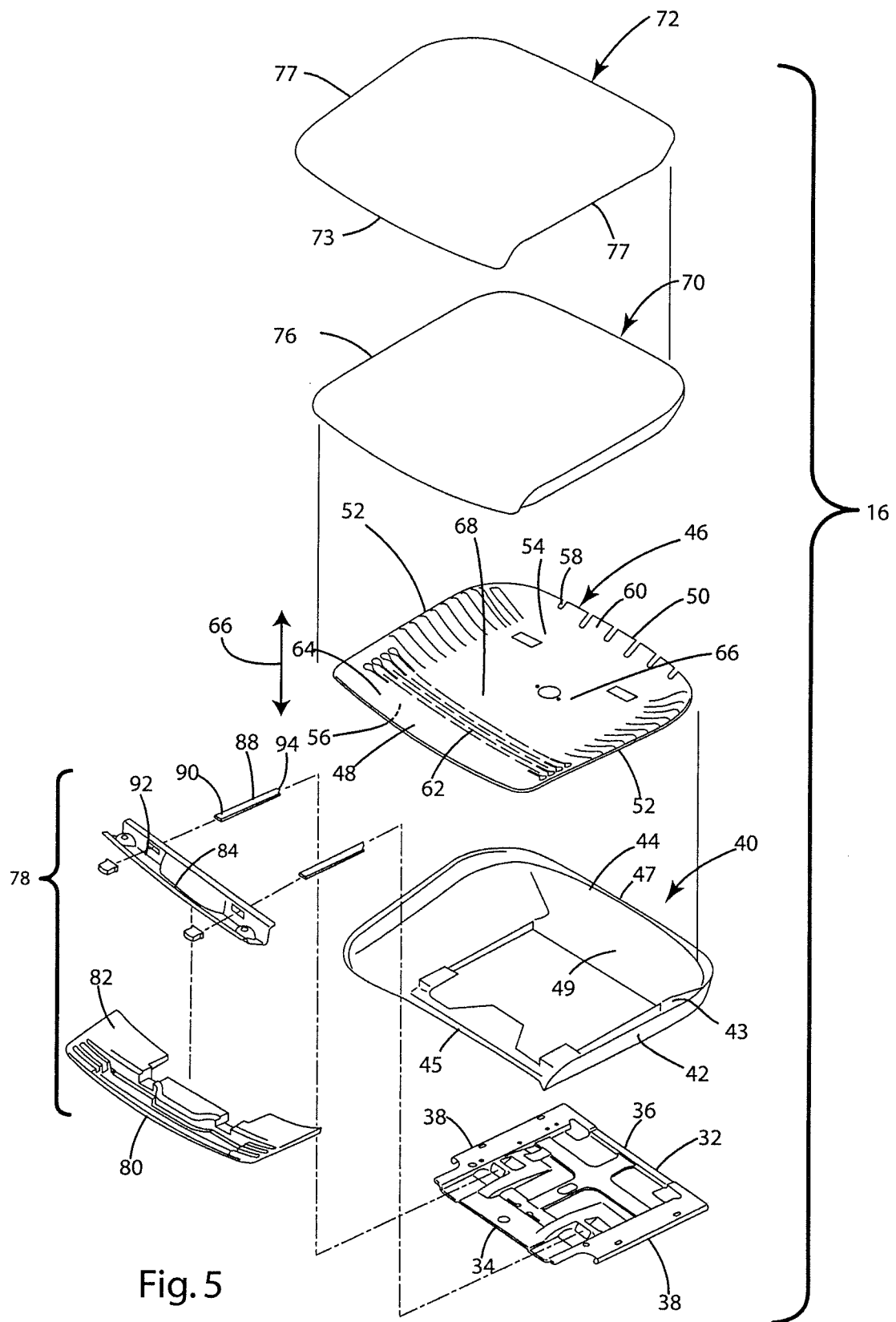


Fig. 5

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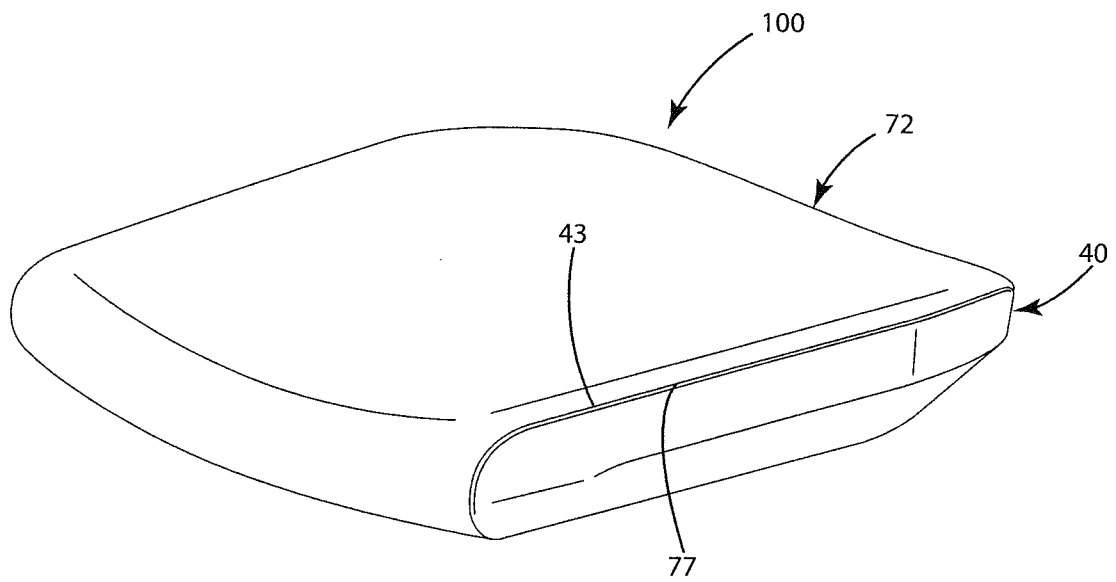


Fig. 6

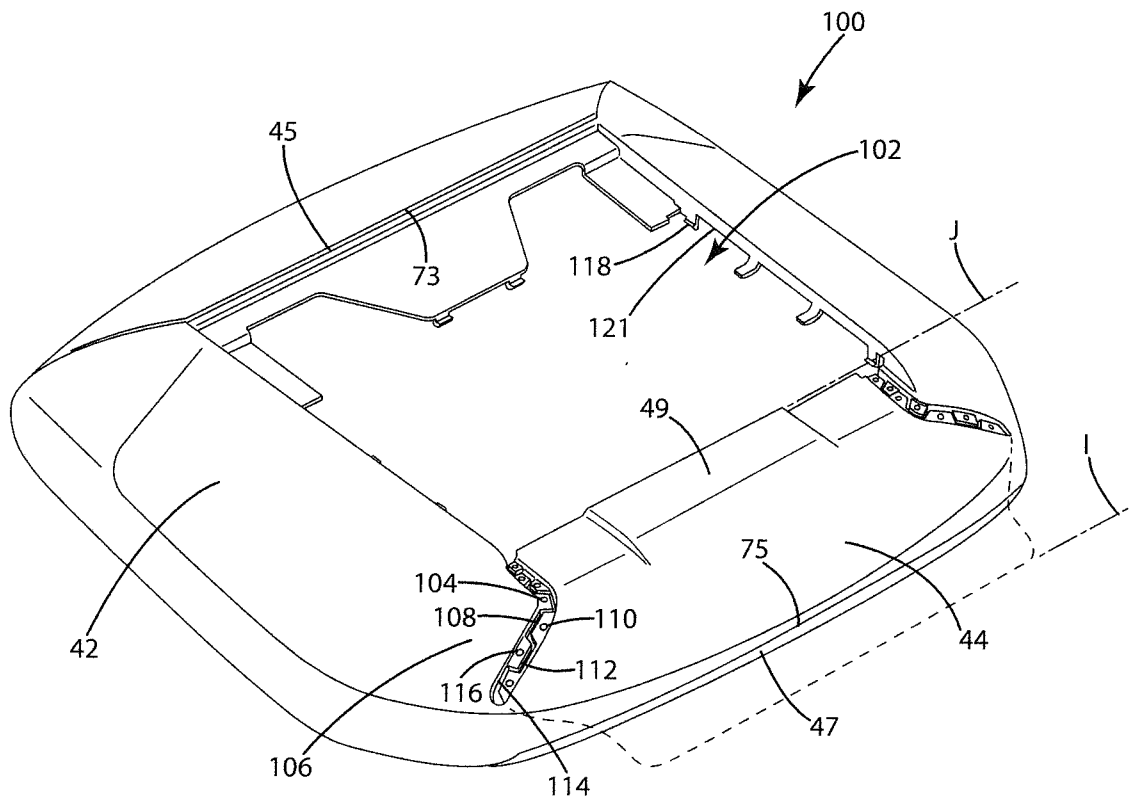
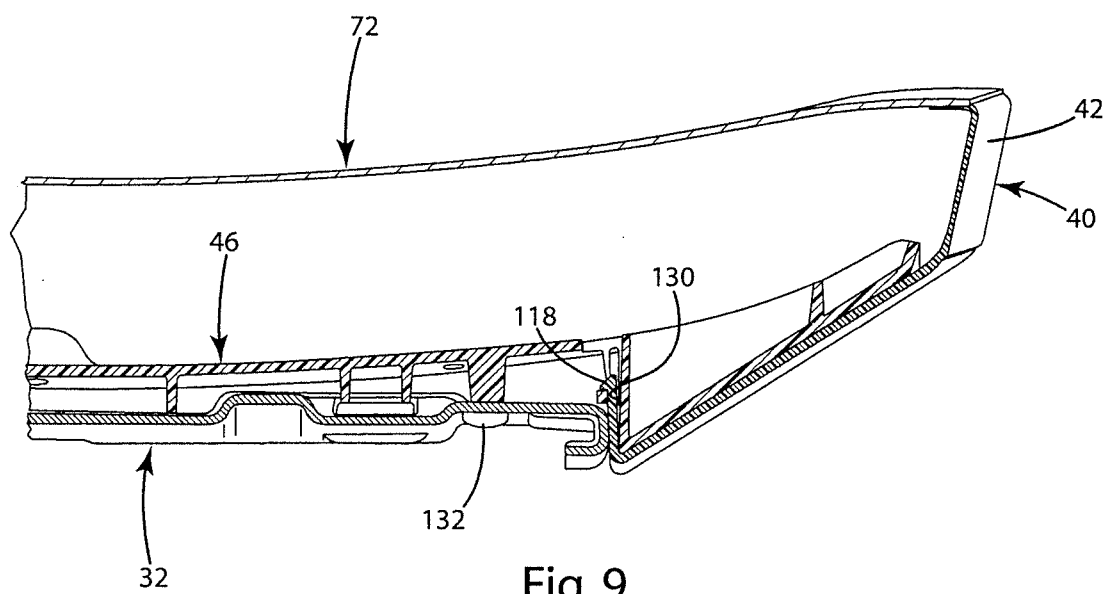
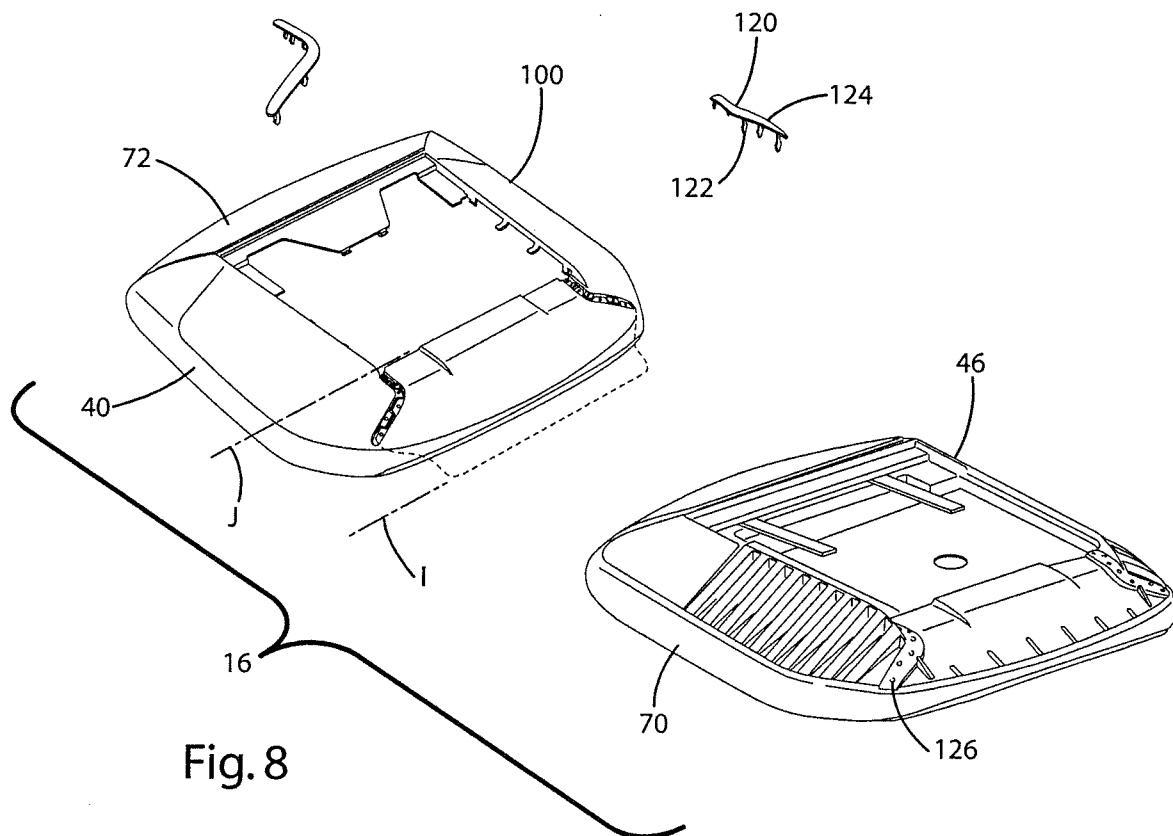
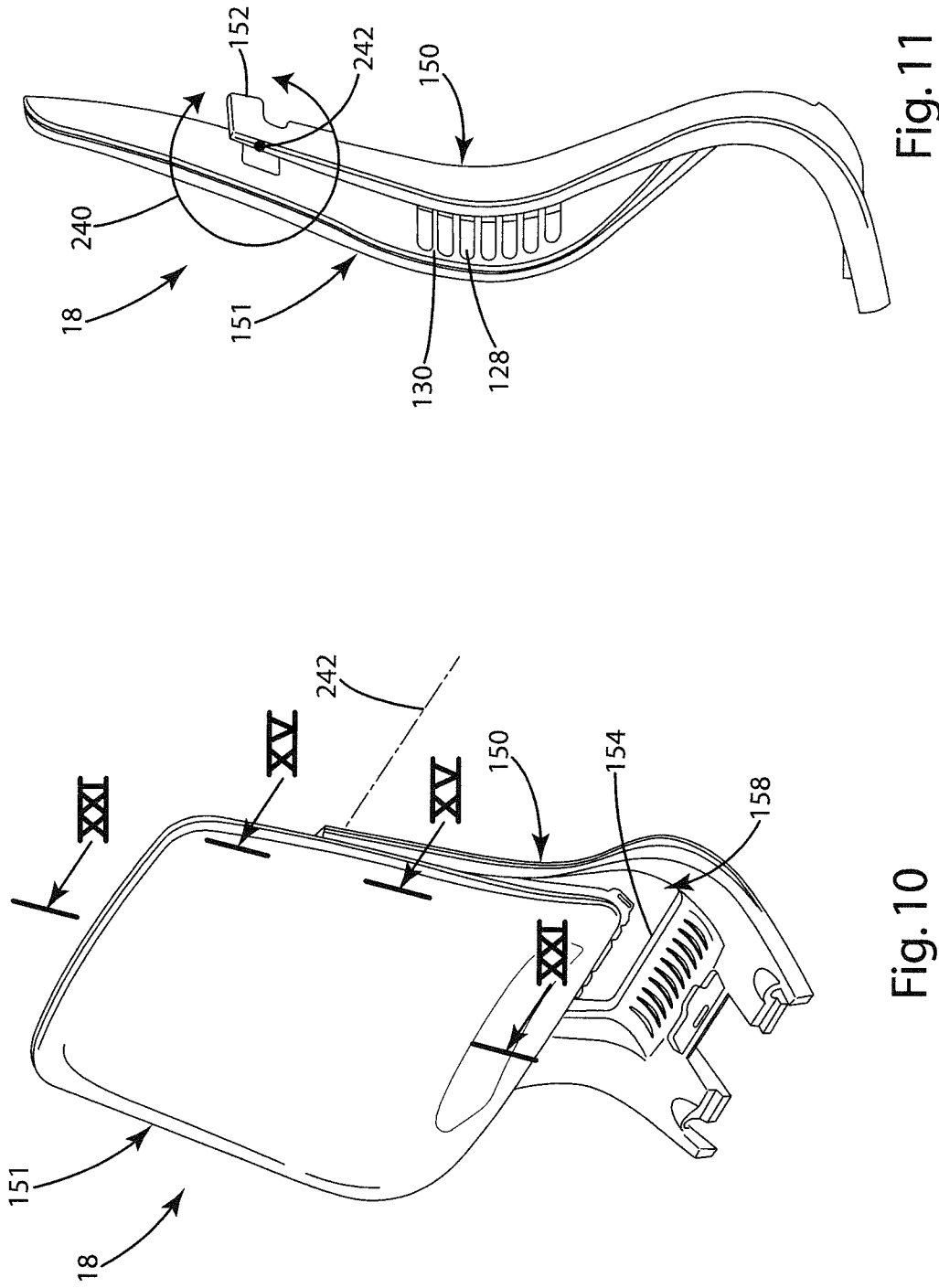


Fig. 7

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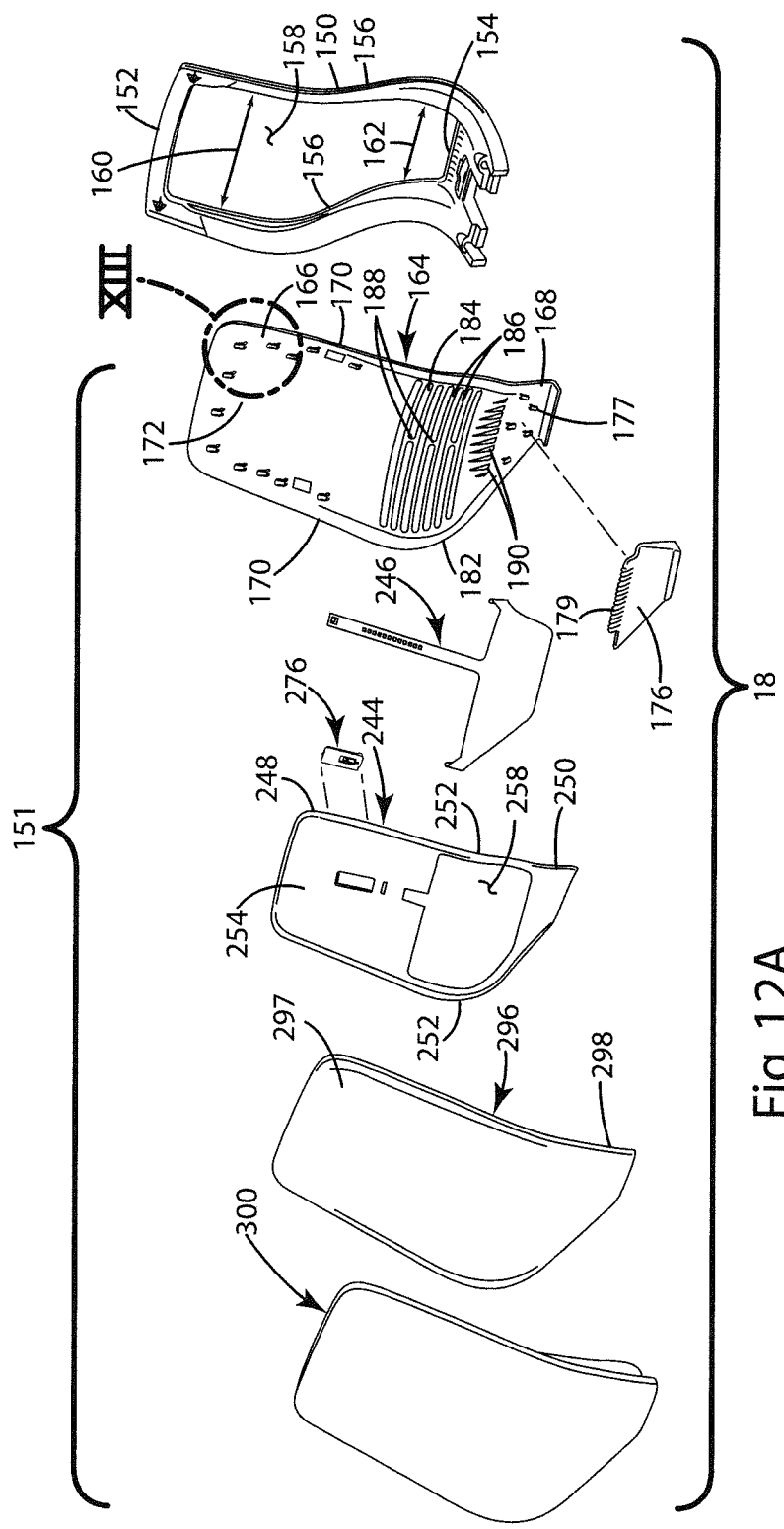
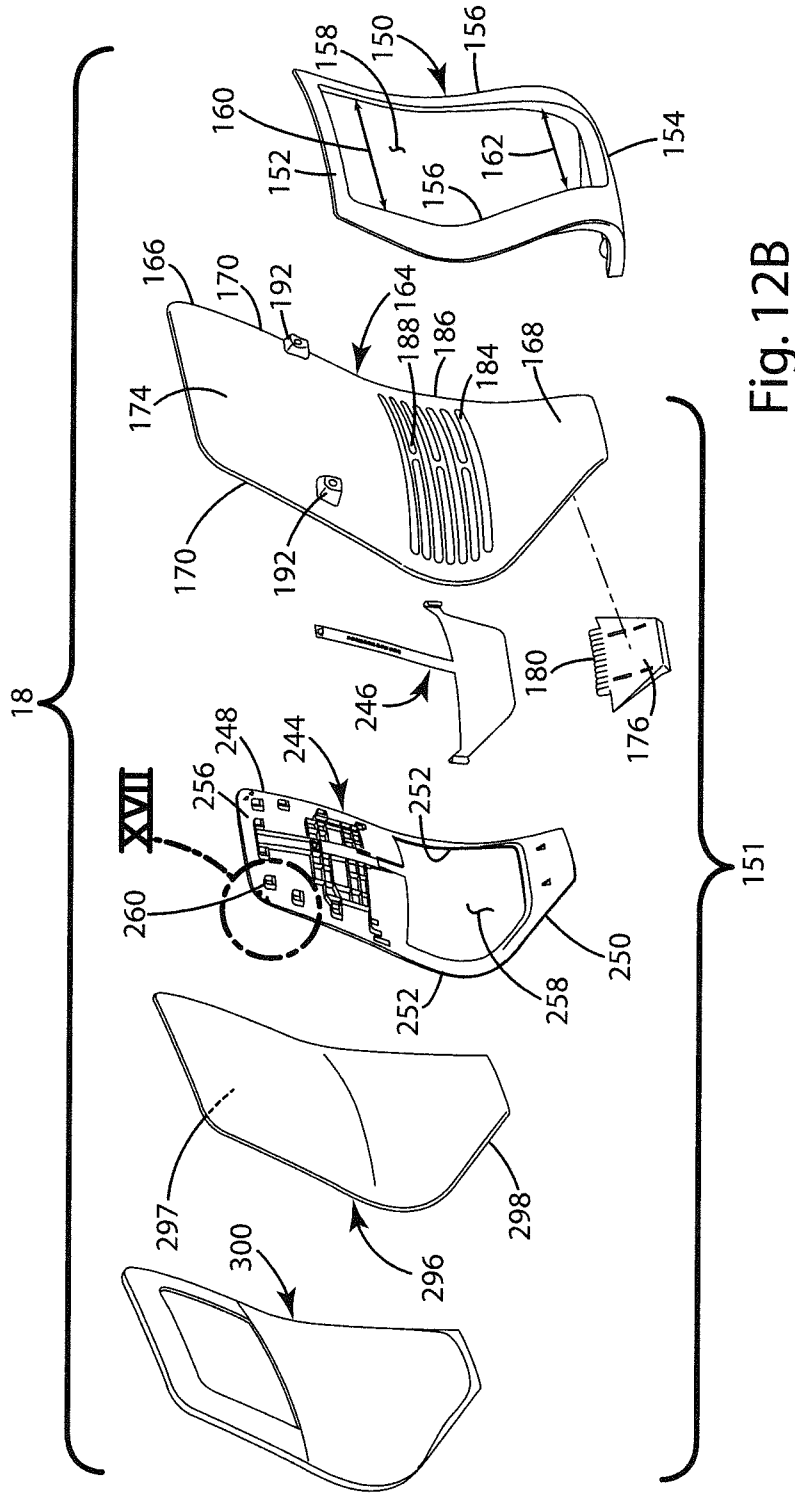


Fig. 12A



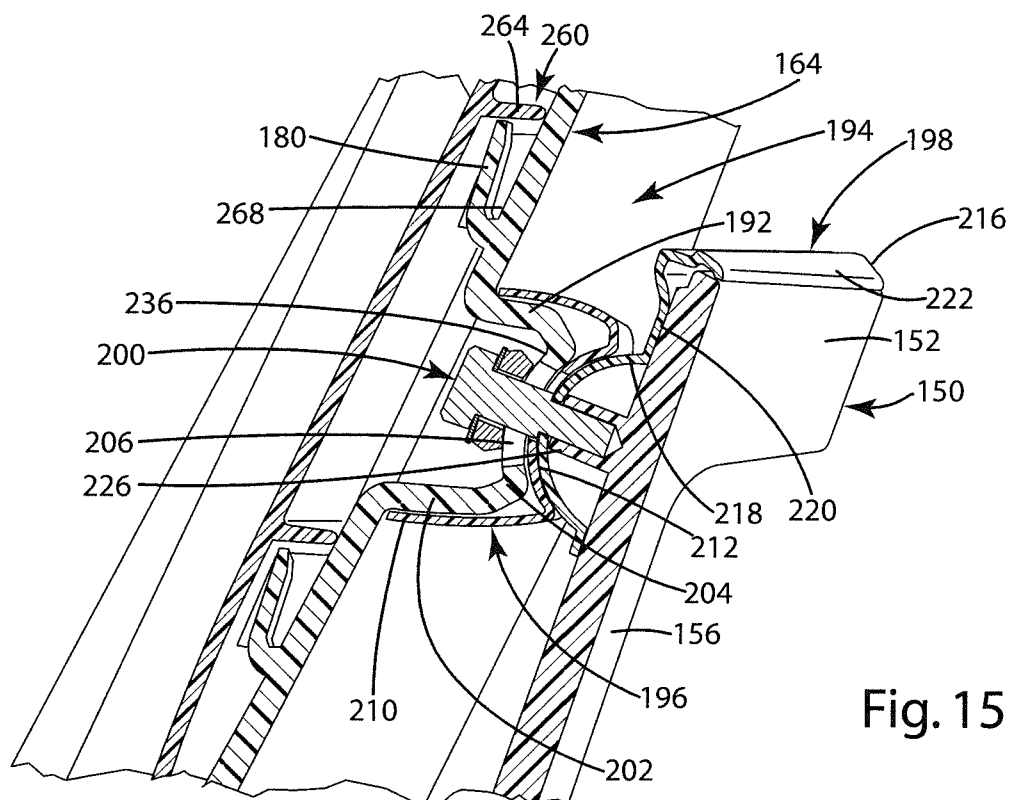
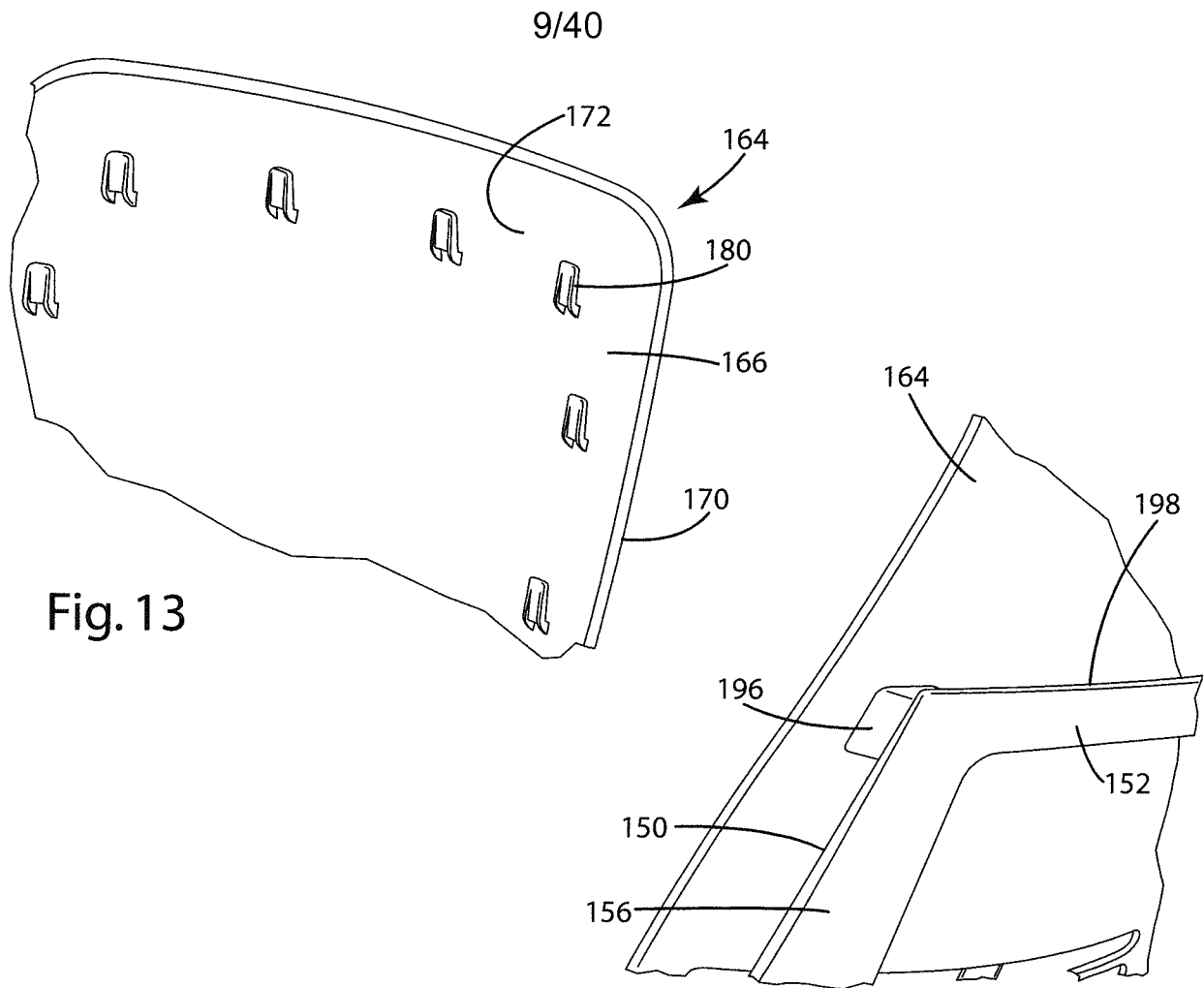
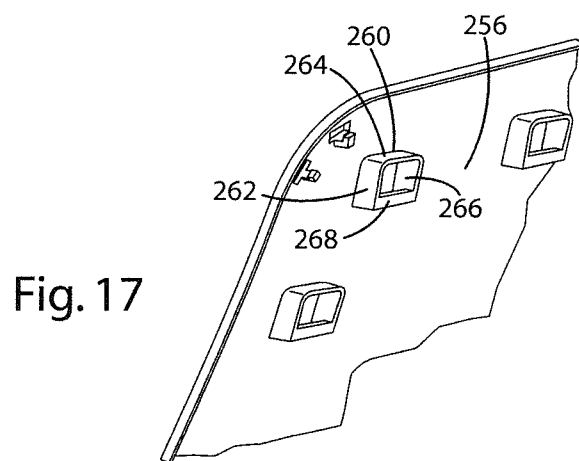
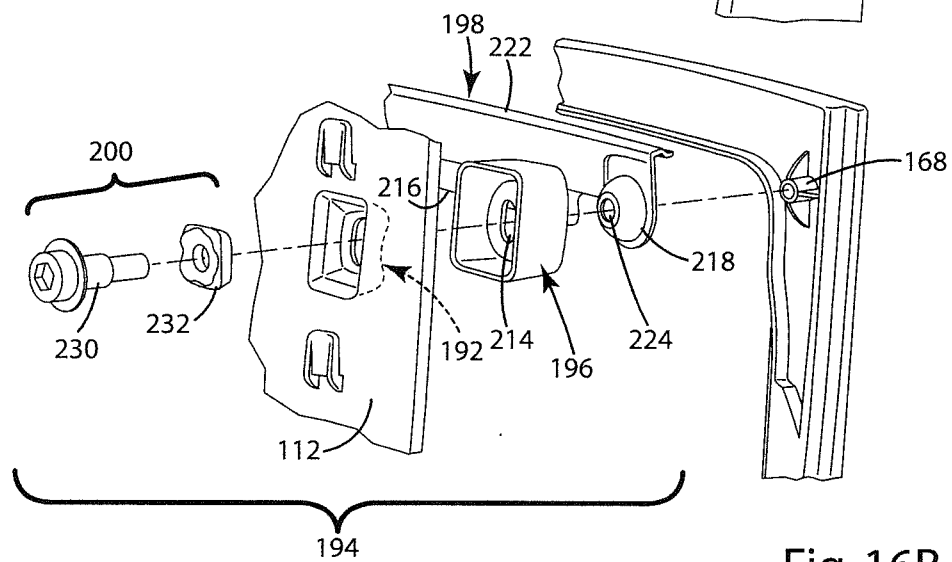
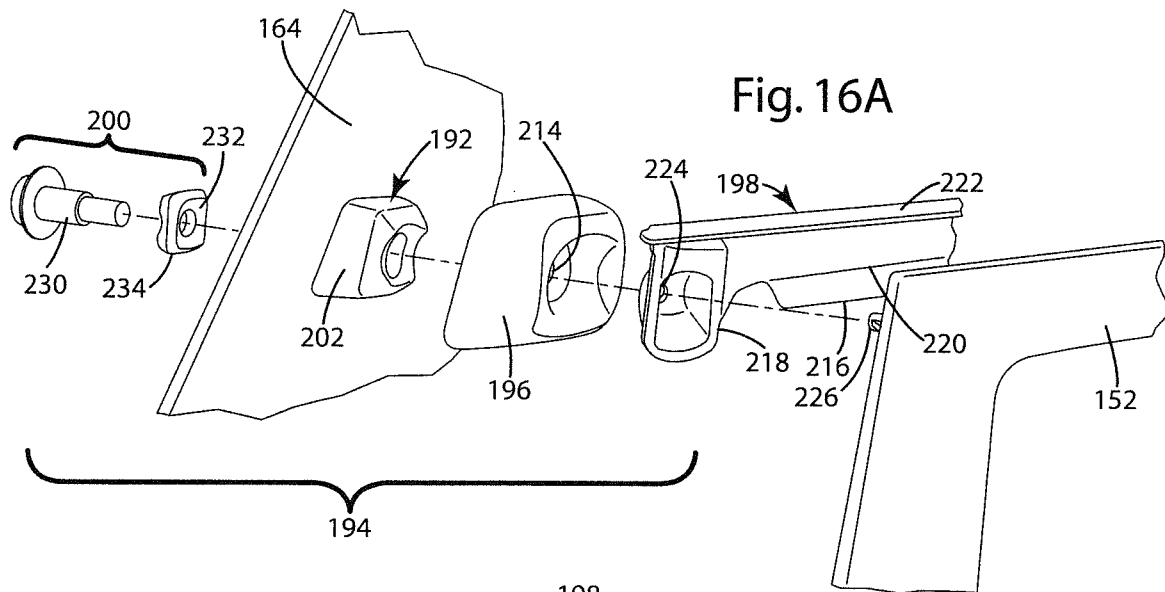


Fig. 15

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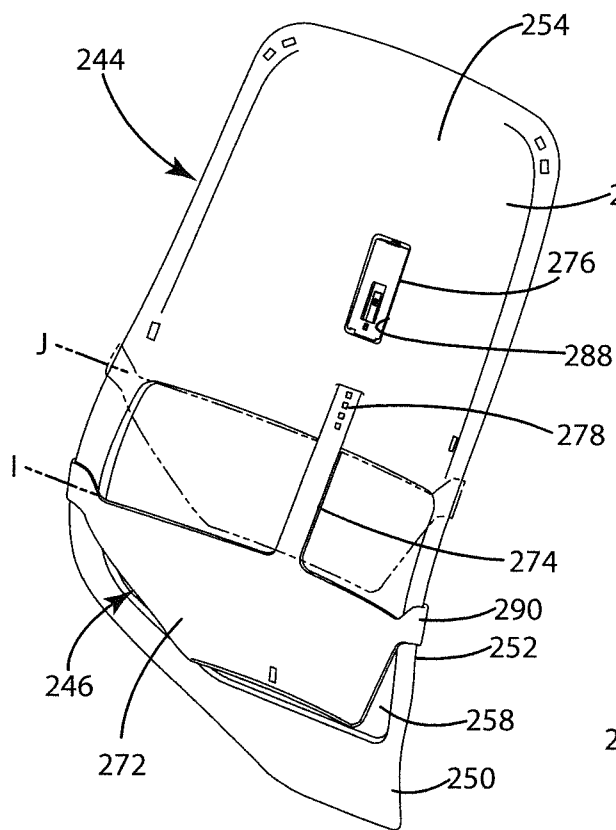


Fig. 18A

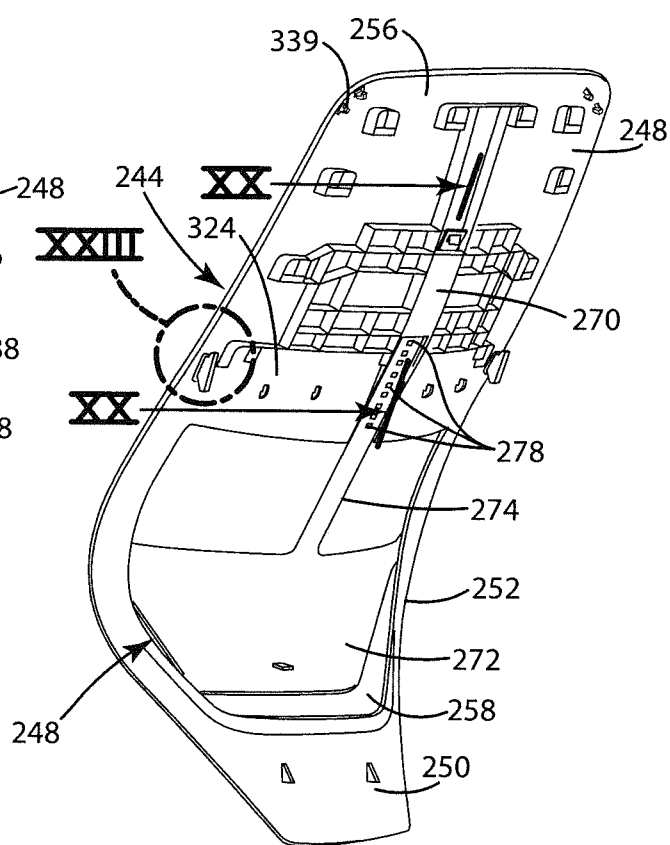


Fig. 18B

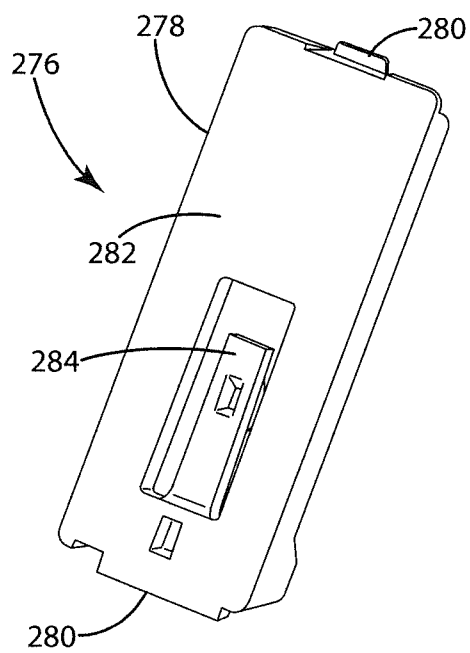


Fig. 19A

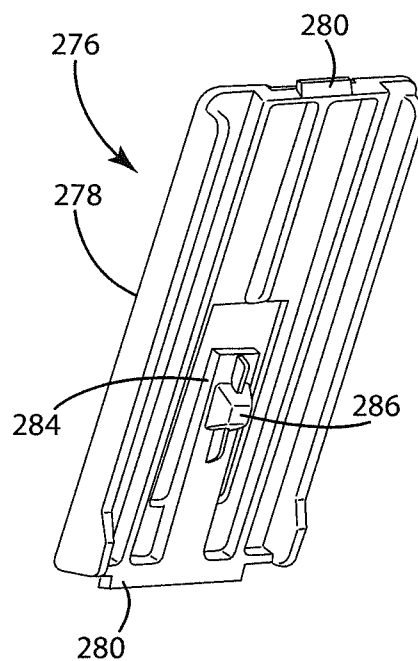
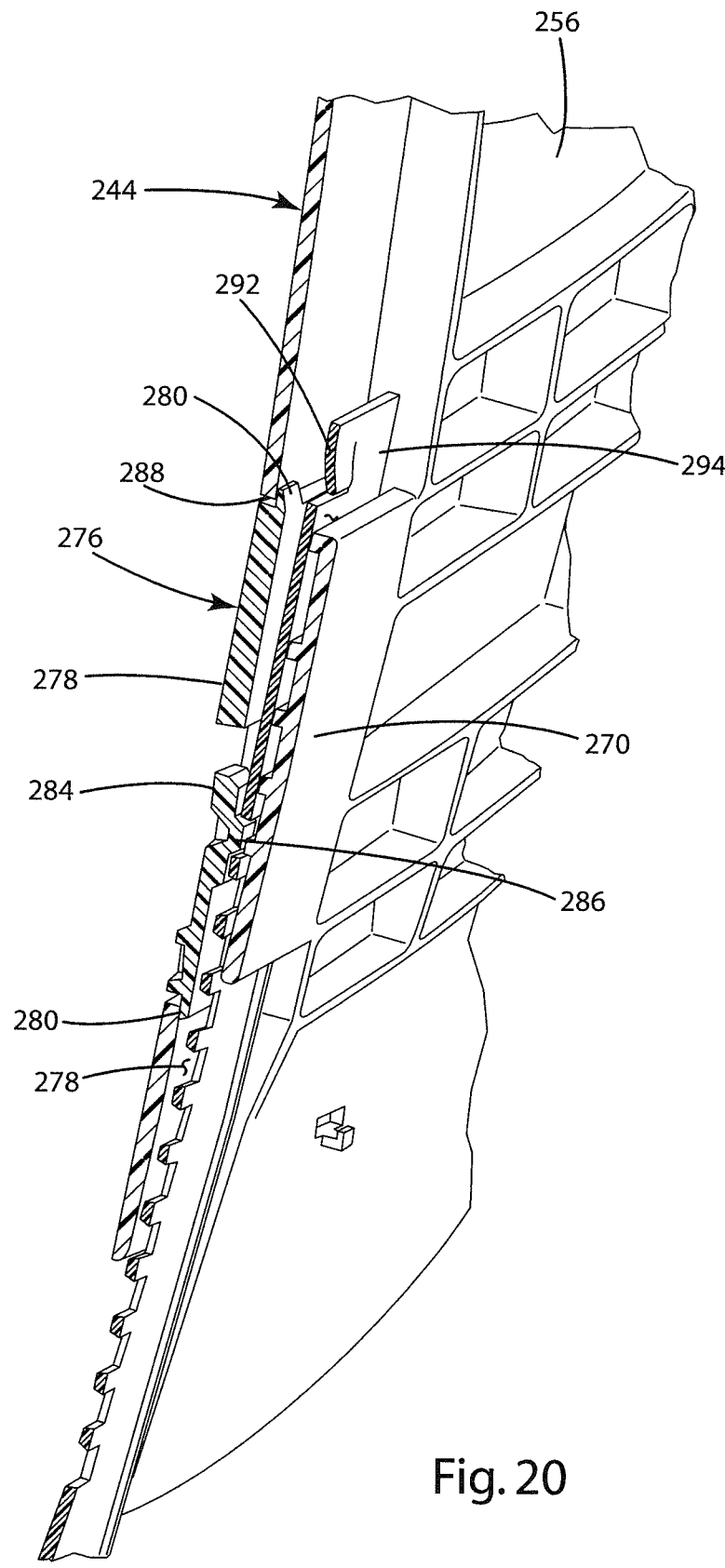


Fig. 19B

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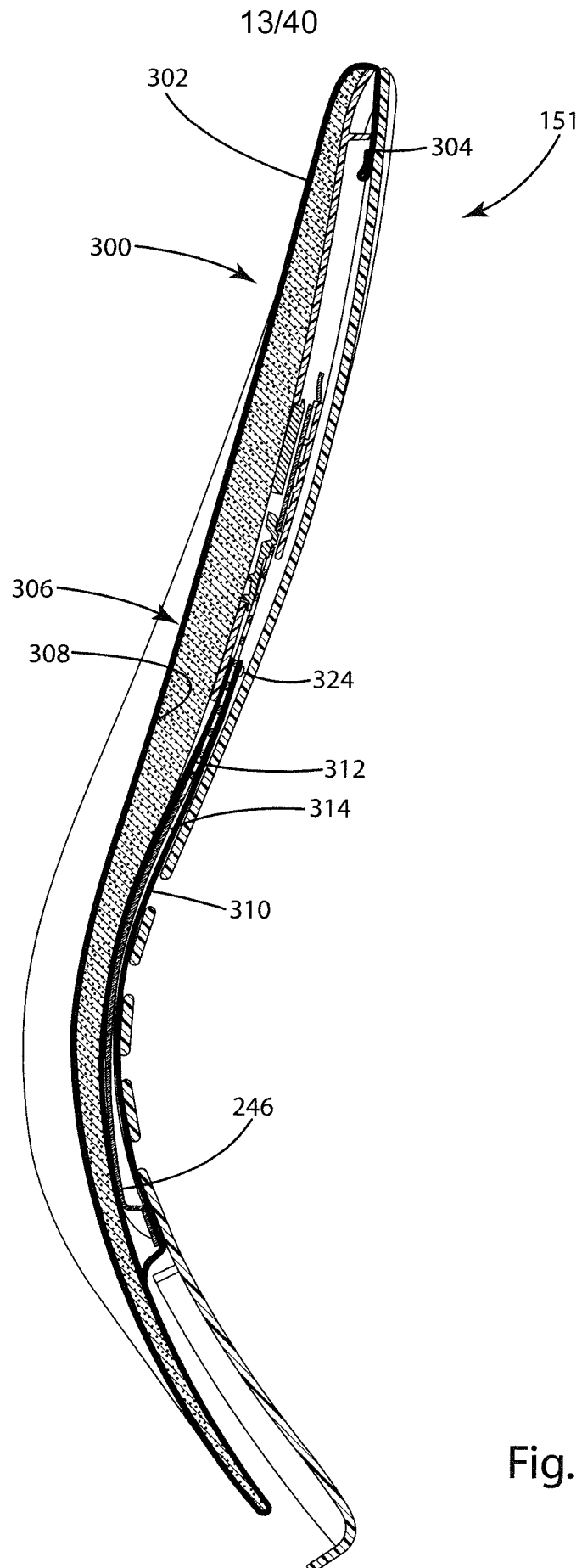


Fig. 21

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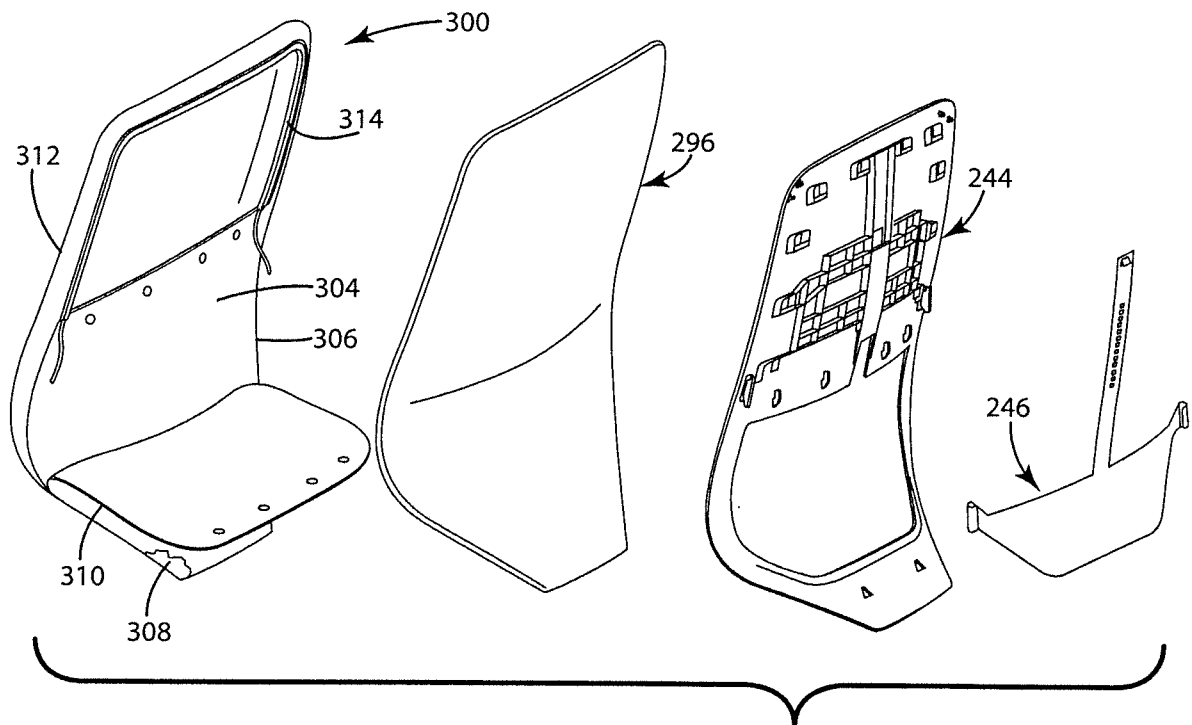


Fig. 22A

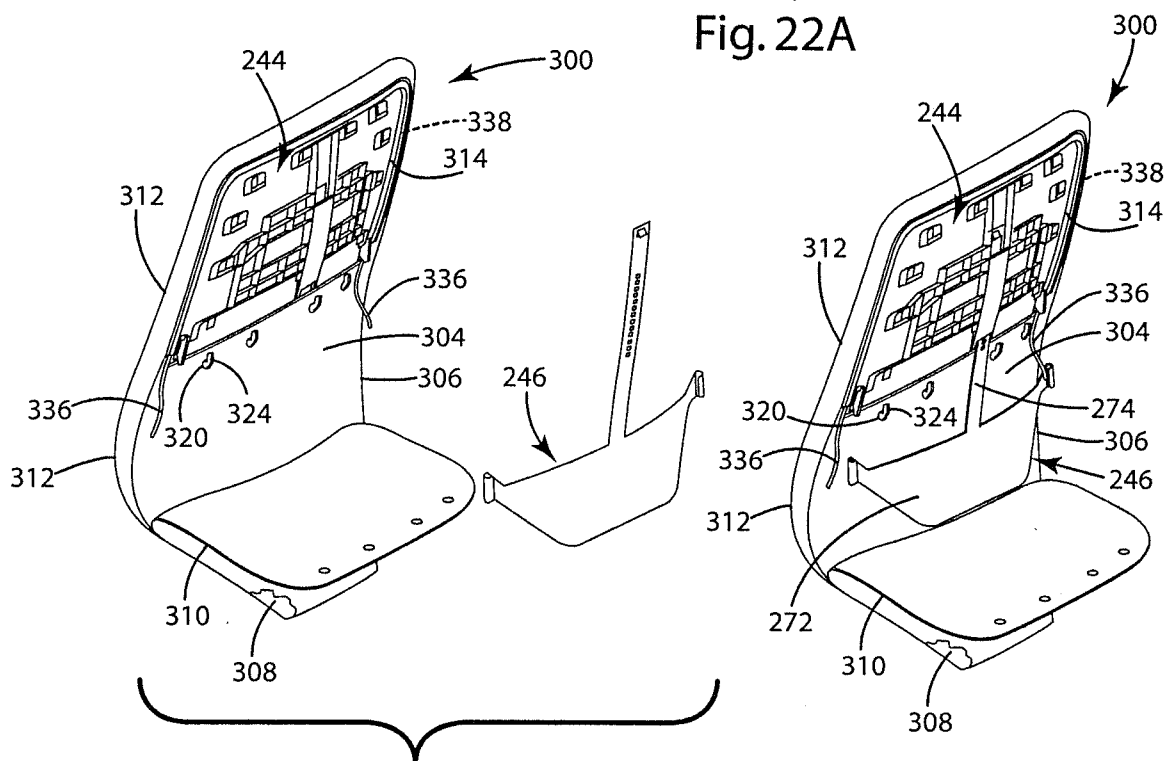


Fig. 22B

Fig. 22C



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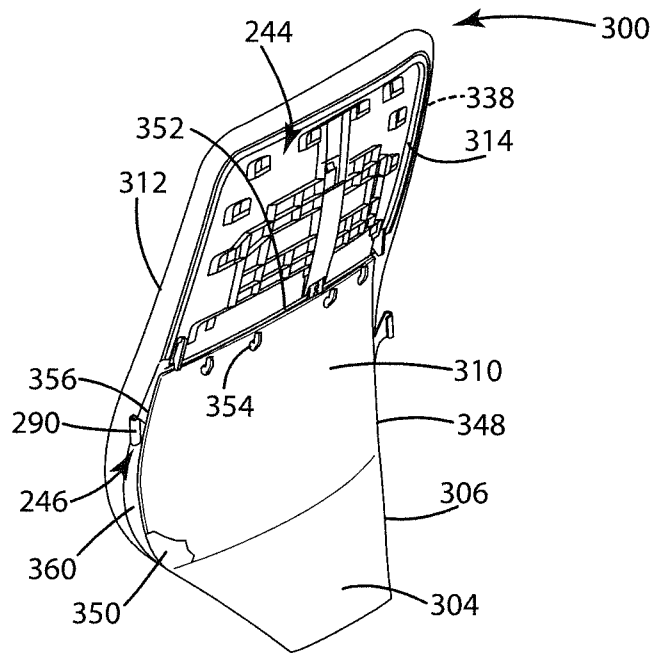


Fig. 22D

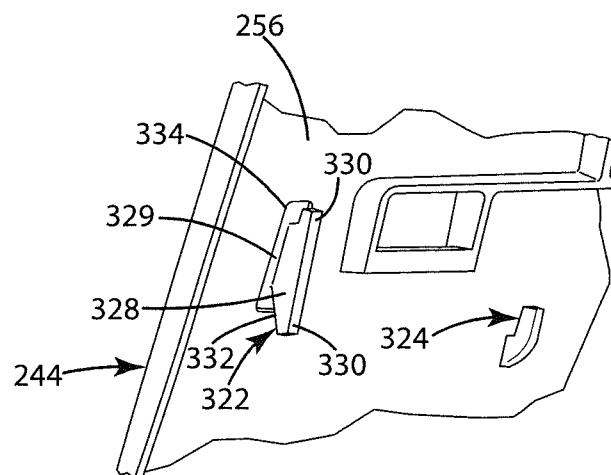


Fig. 23

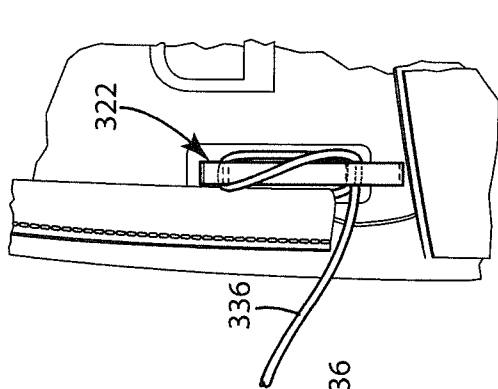


Fig. 24A

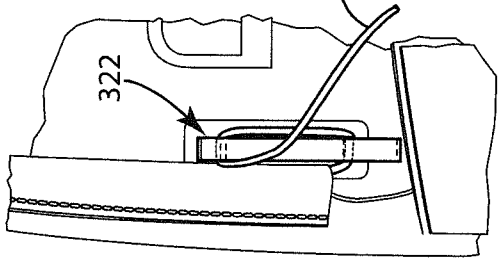


Fig. 24B

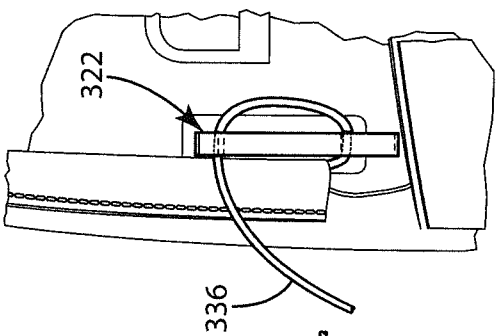


Fig. 24C

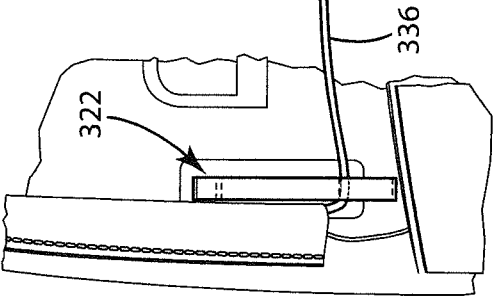


Fig. 24D

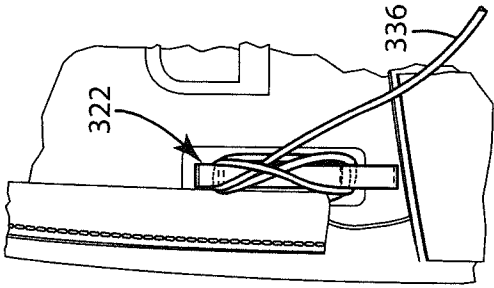


Fig. 24E

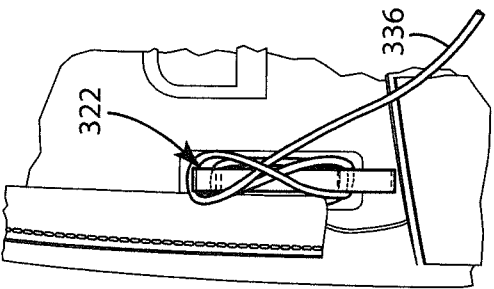


Fig. 24F

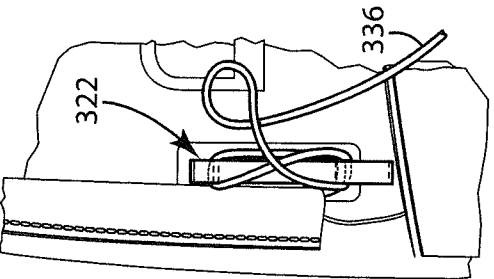


Fig. 24G

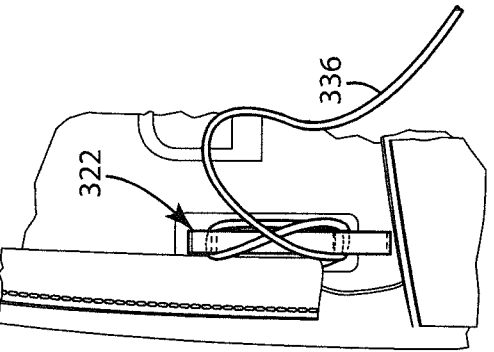


Fig. 24H

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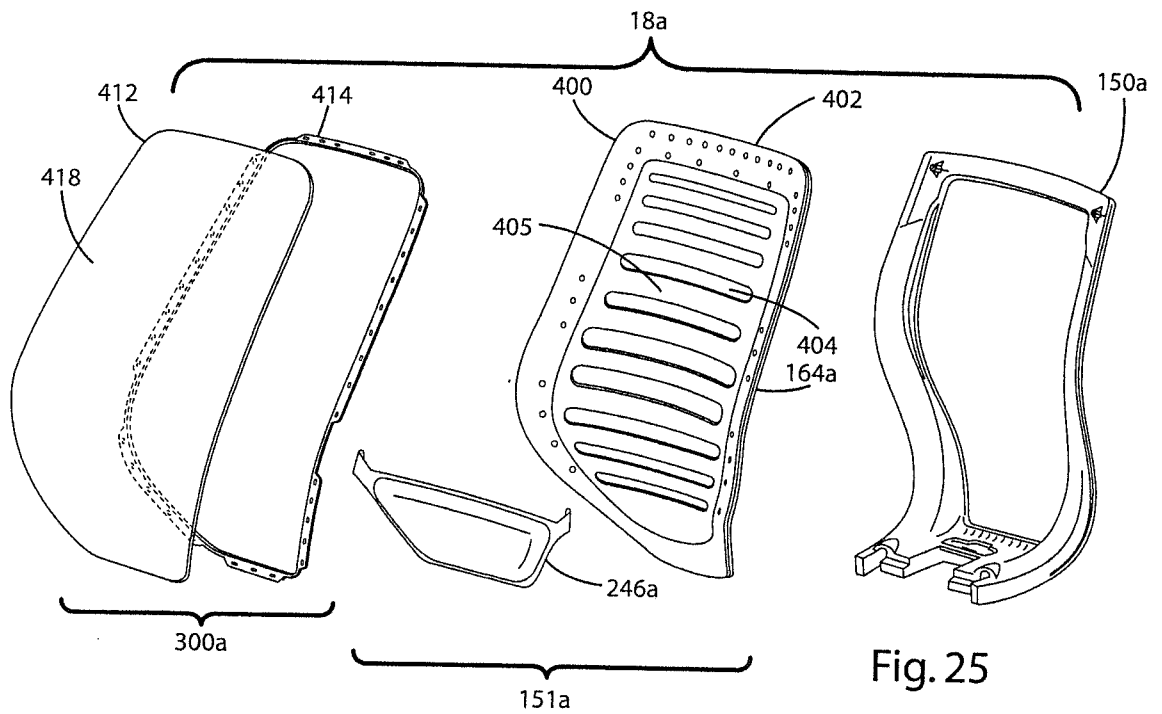


Fig. 25

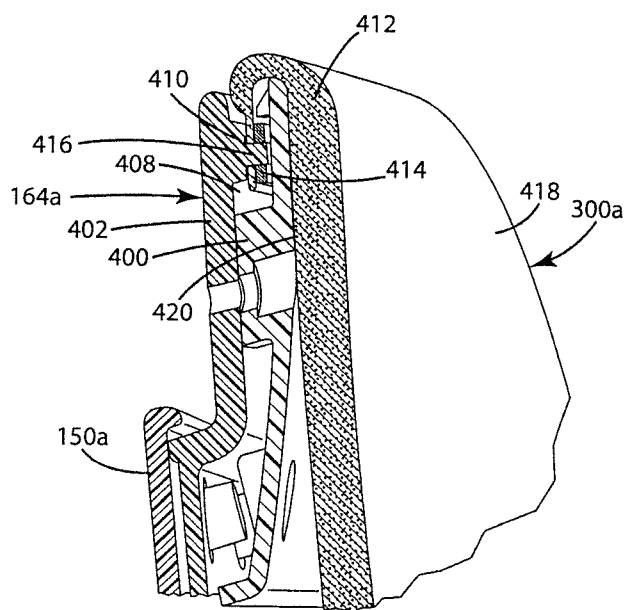


Fig. 26

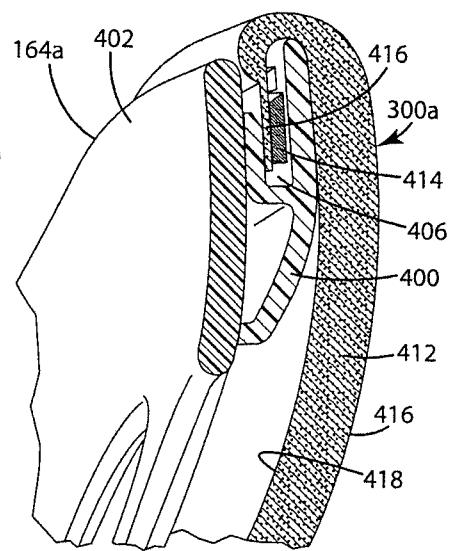


Fig. 27

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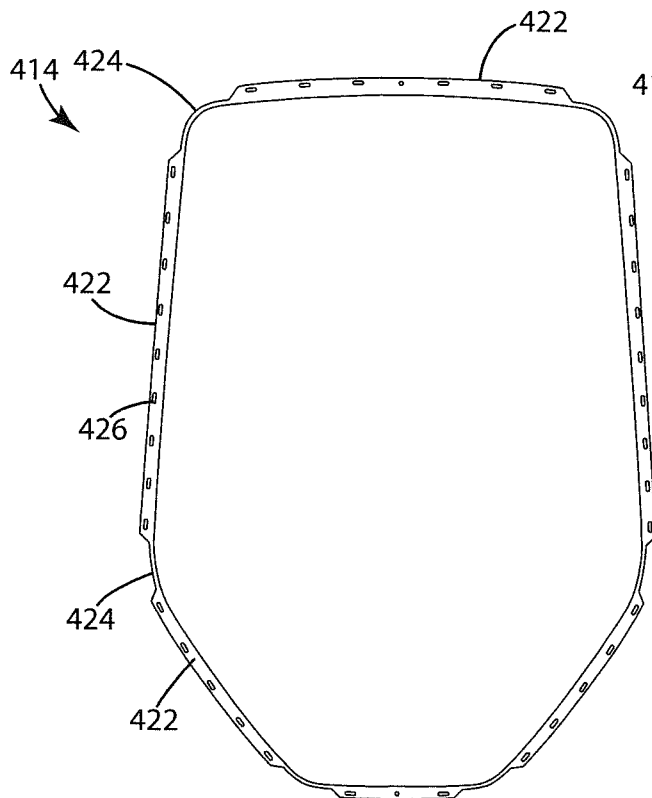


Fig. 28

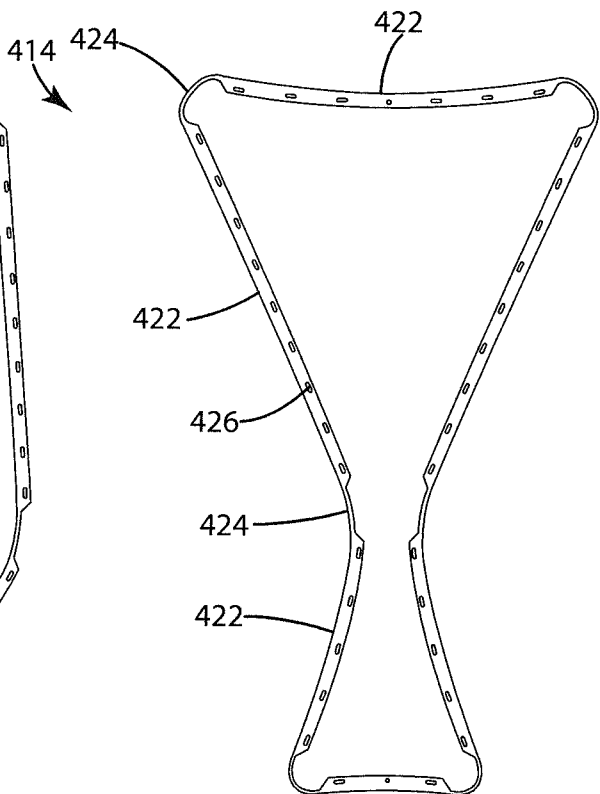


Fig. 29

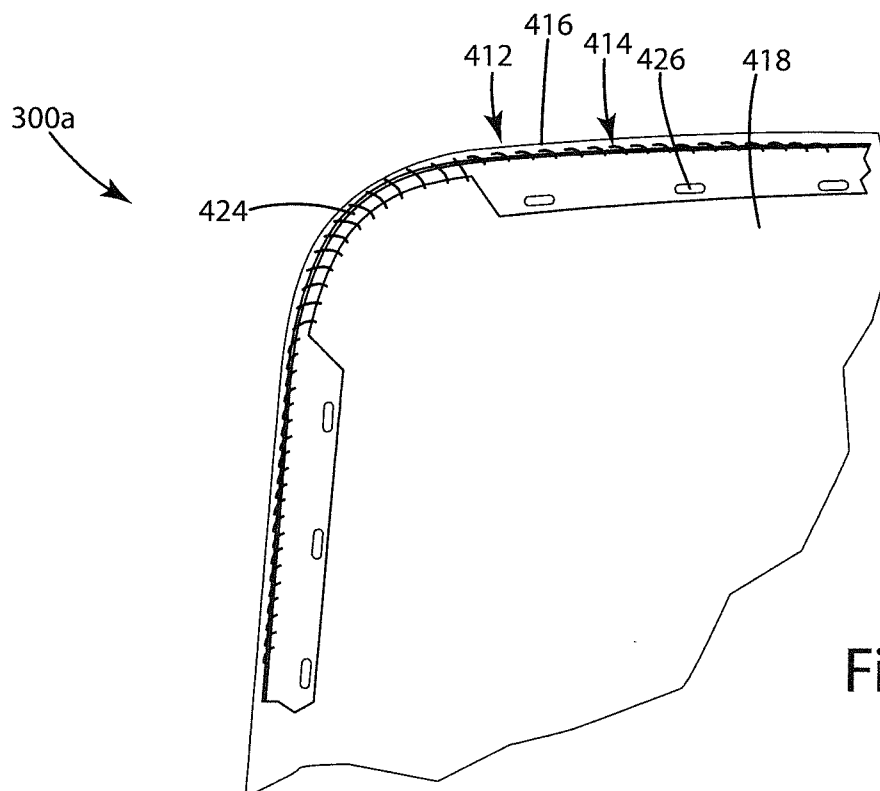


Fig. 30

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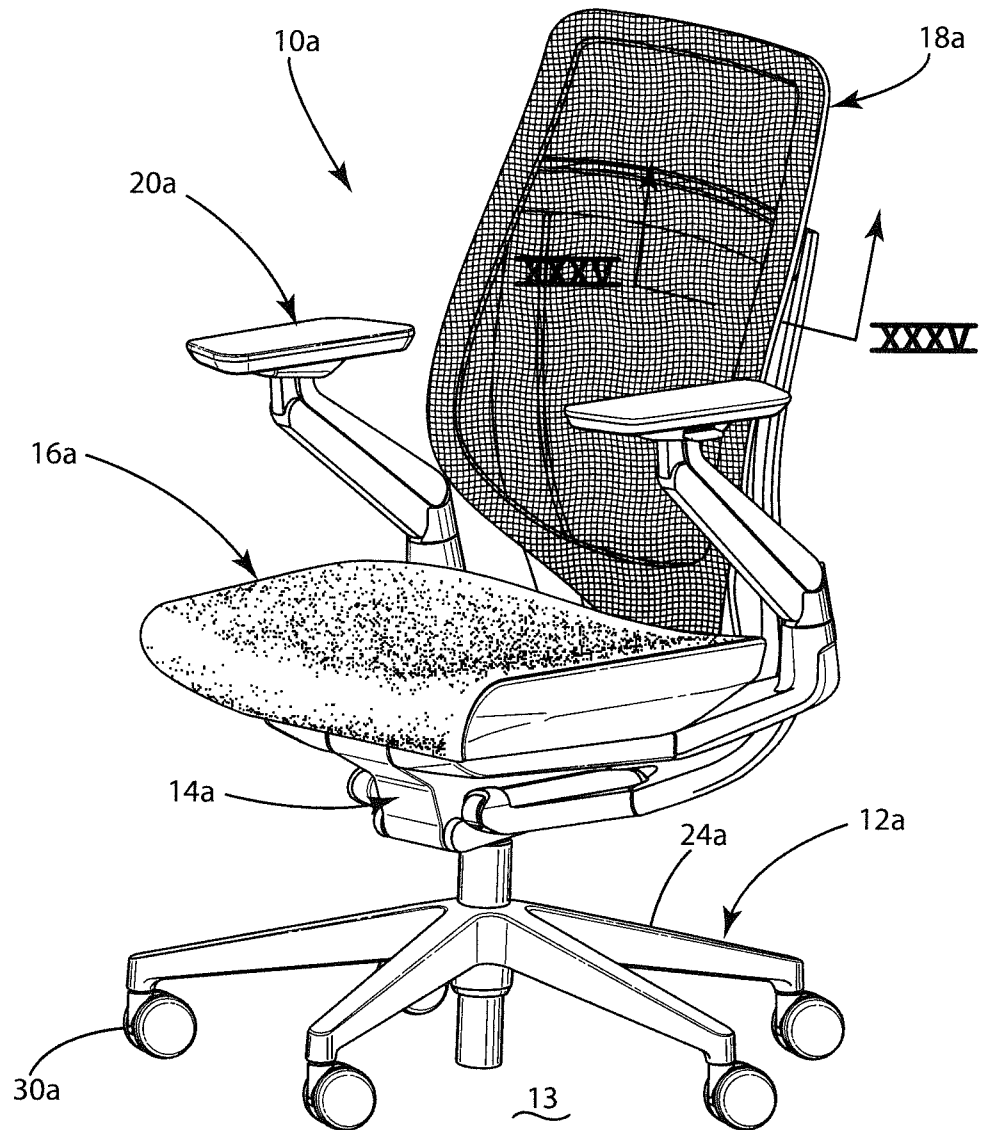


Fig. 31

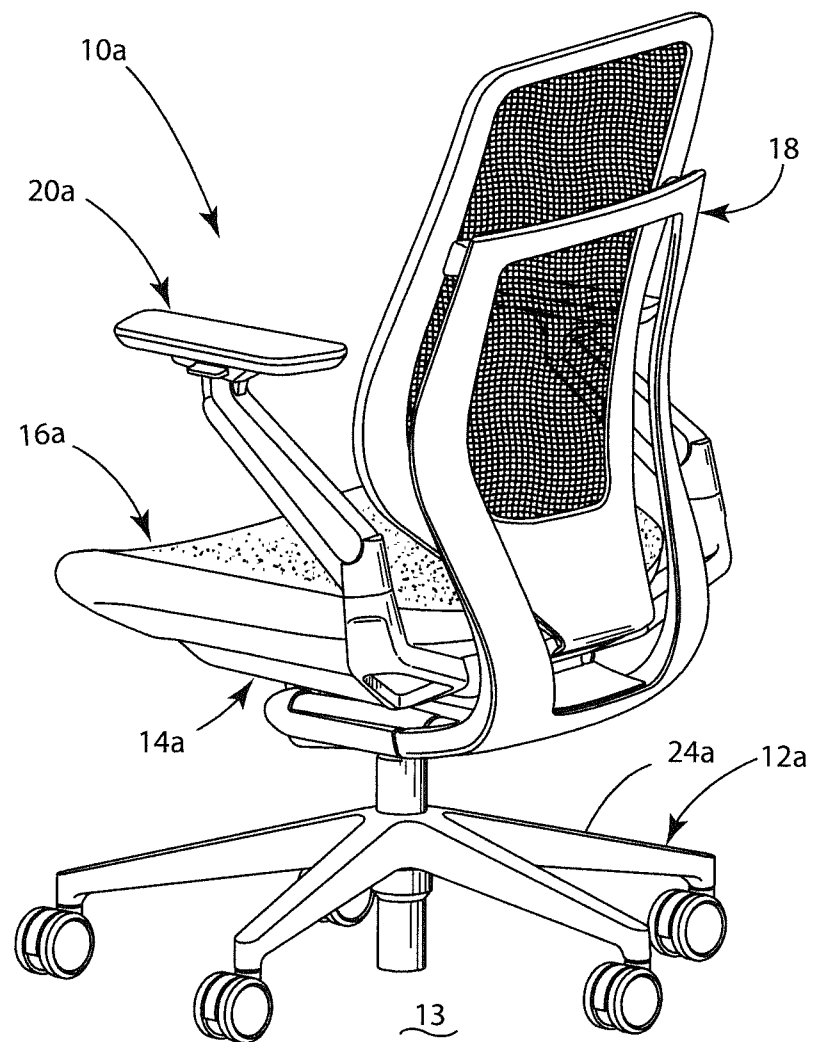
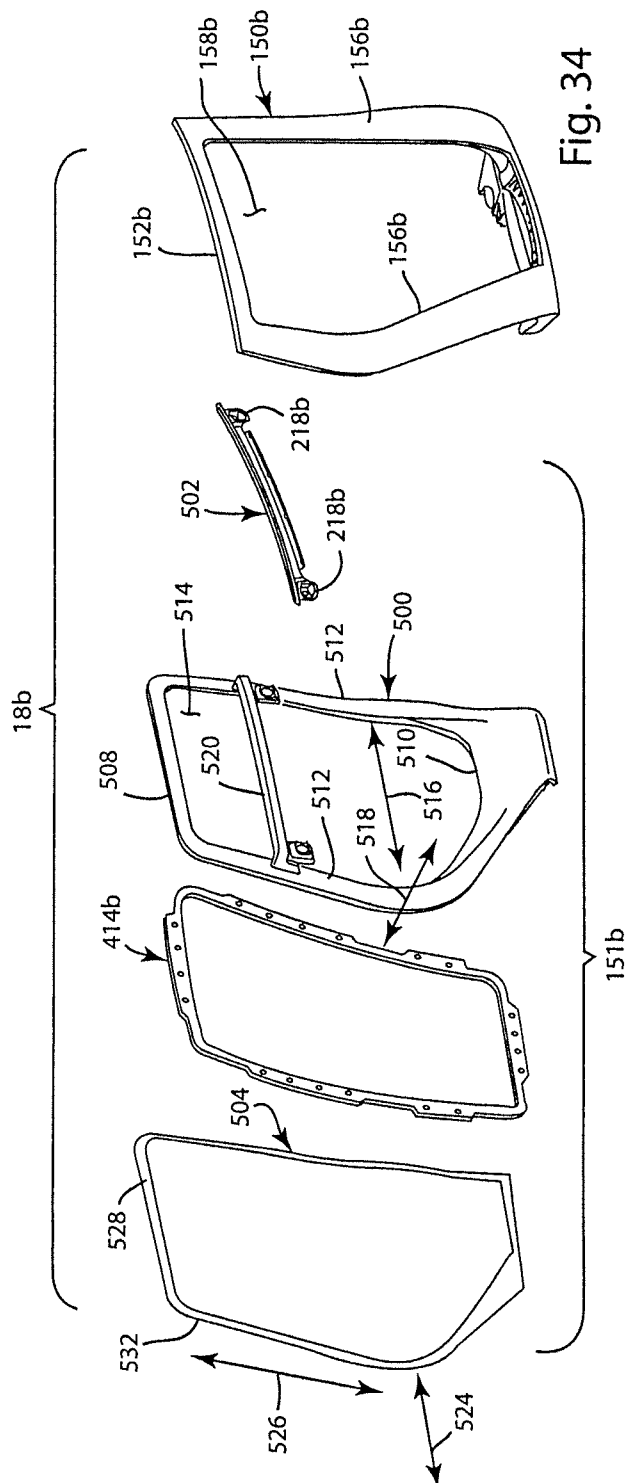
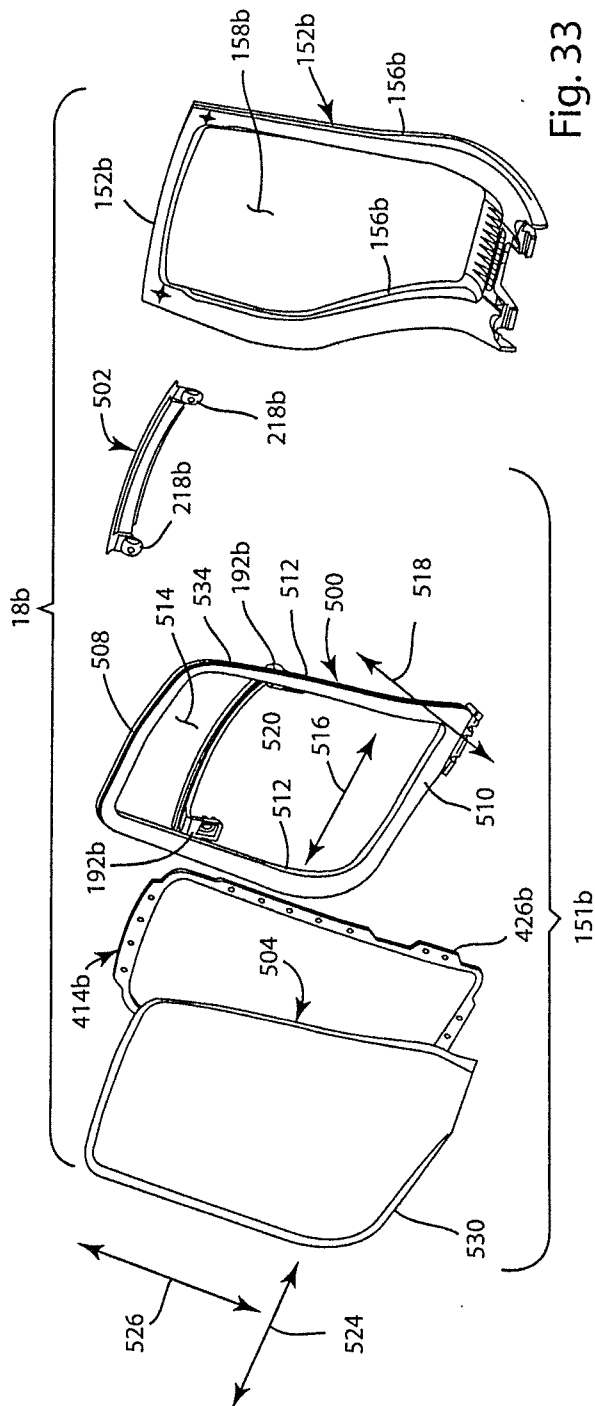


Fig. 32



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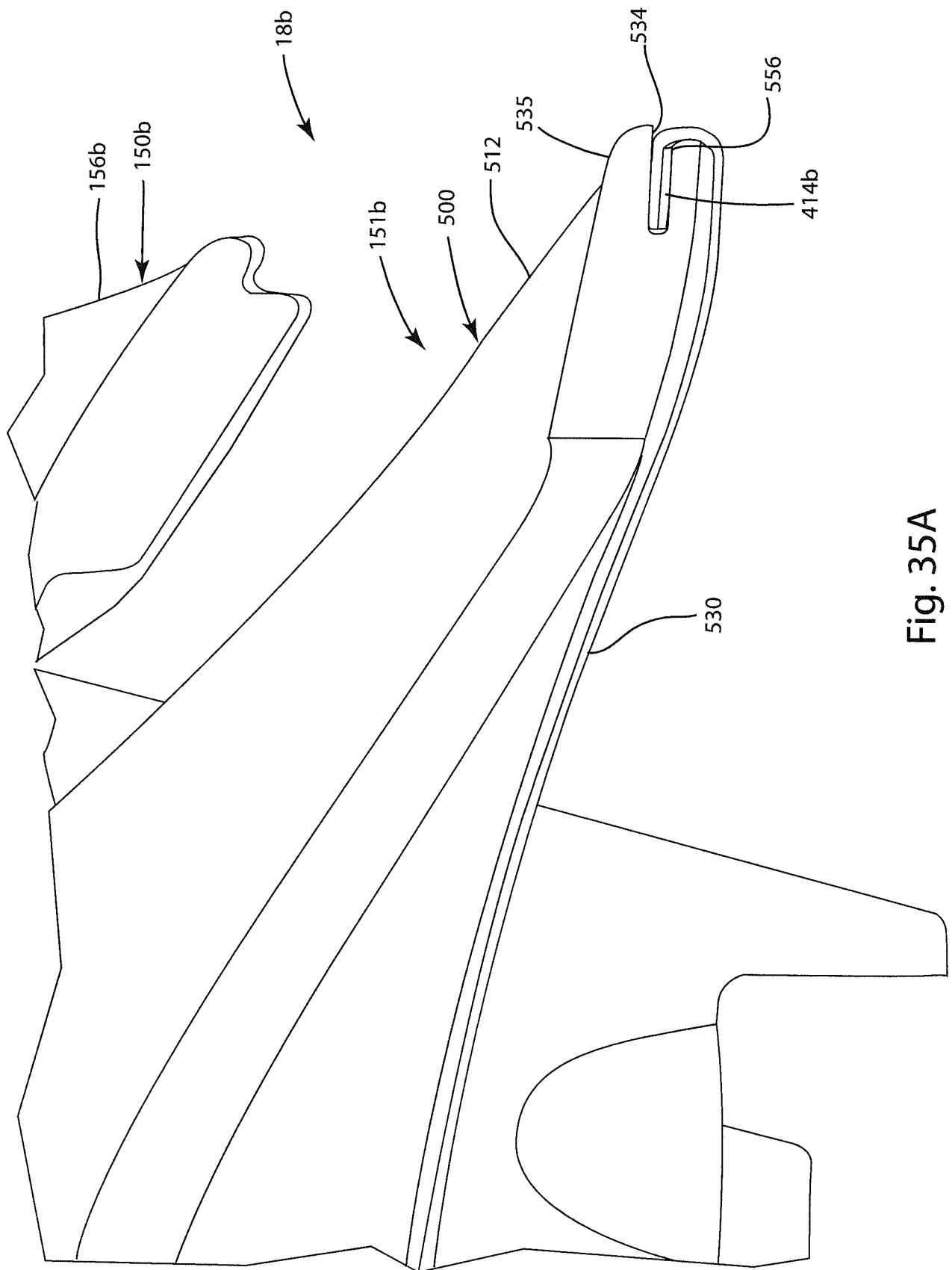


Fig. 35A



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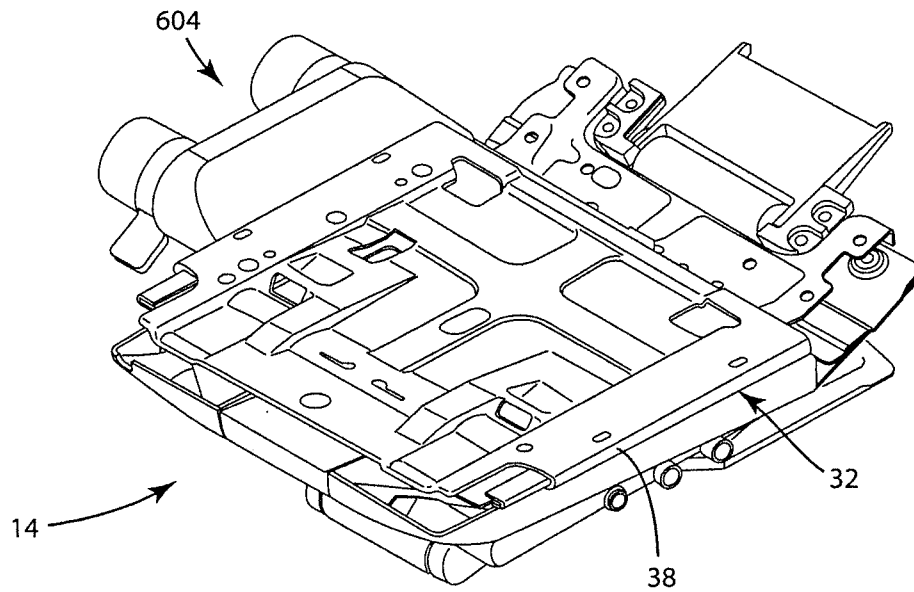


Fig. 36

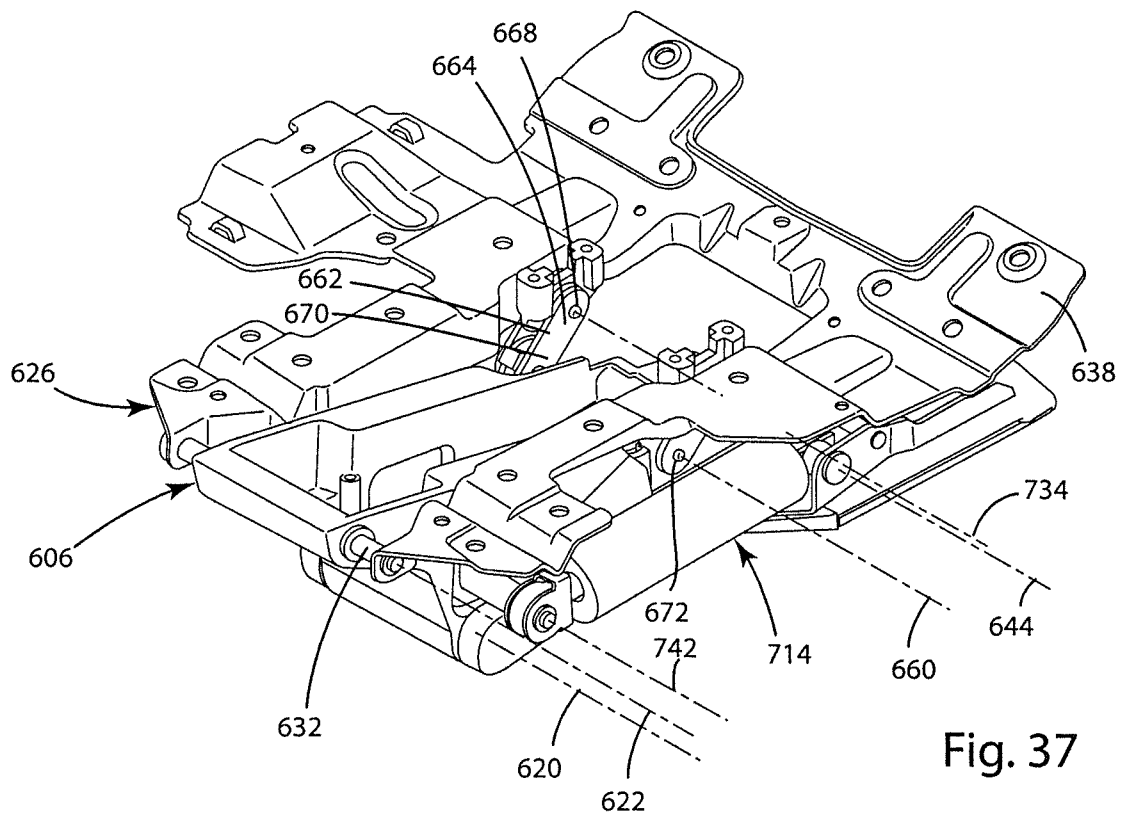


Fig. 37

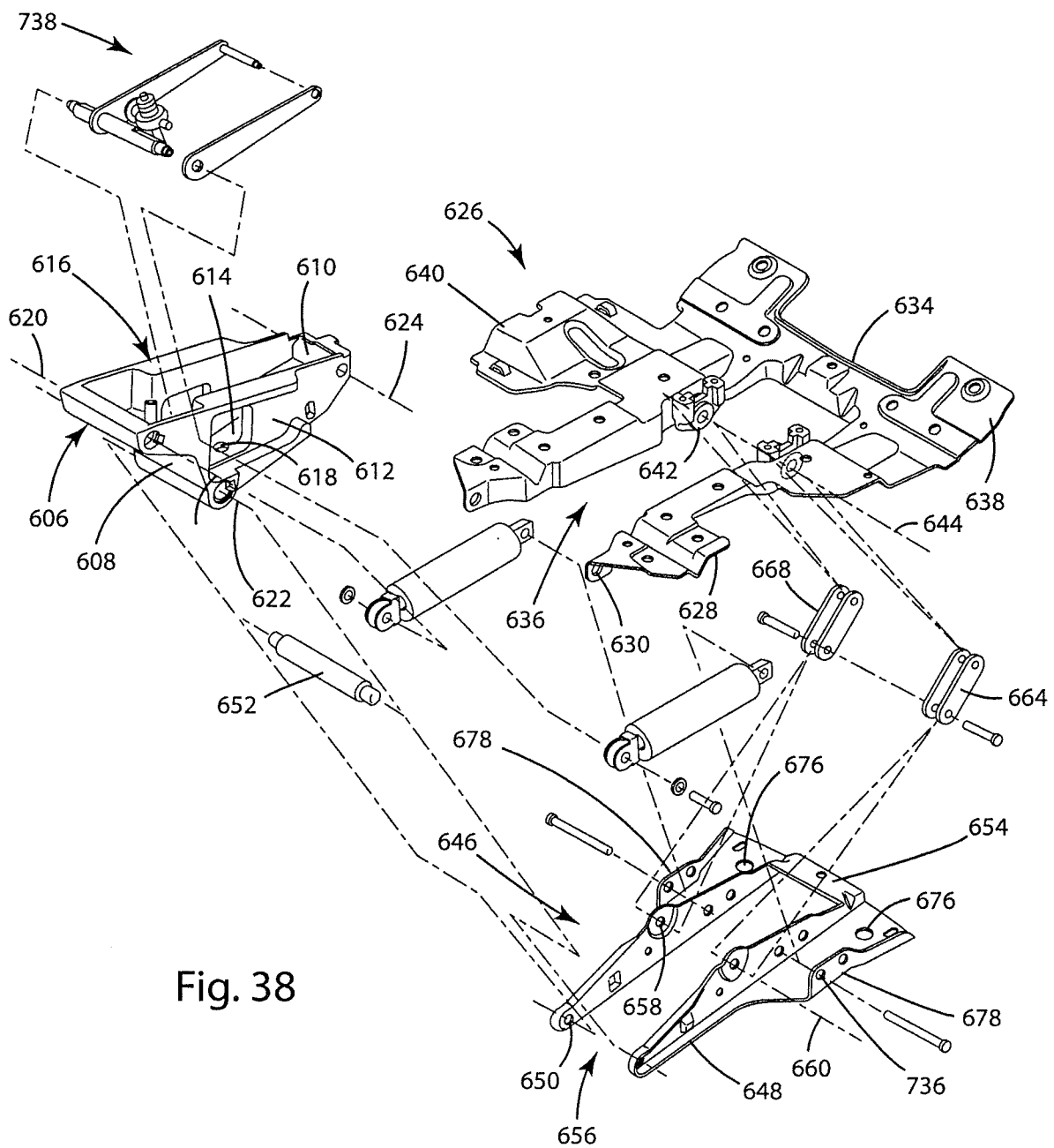


Fig. 38

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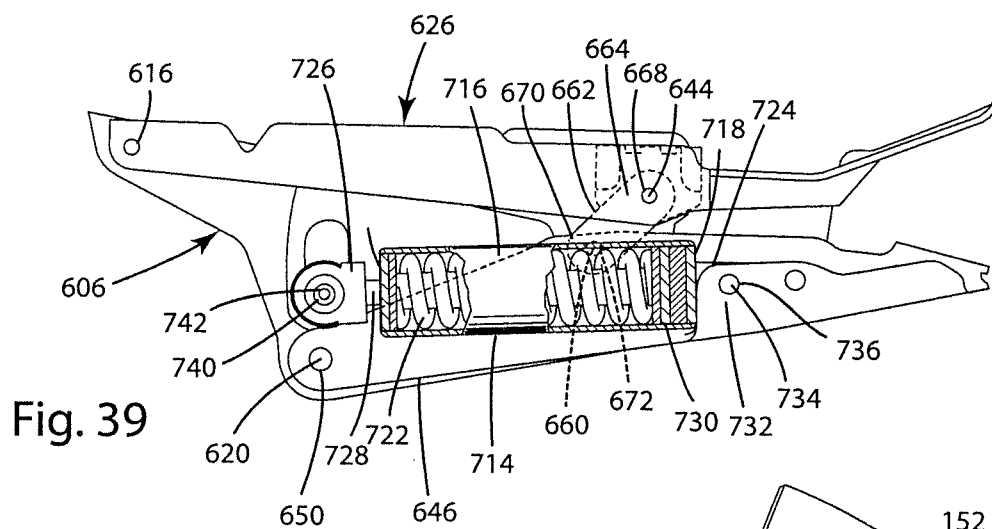


Fig. 39

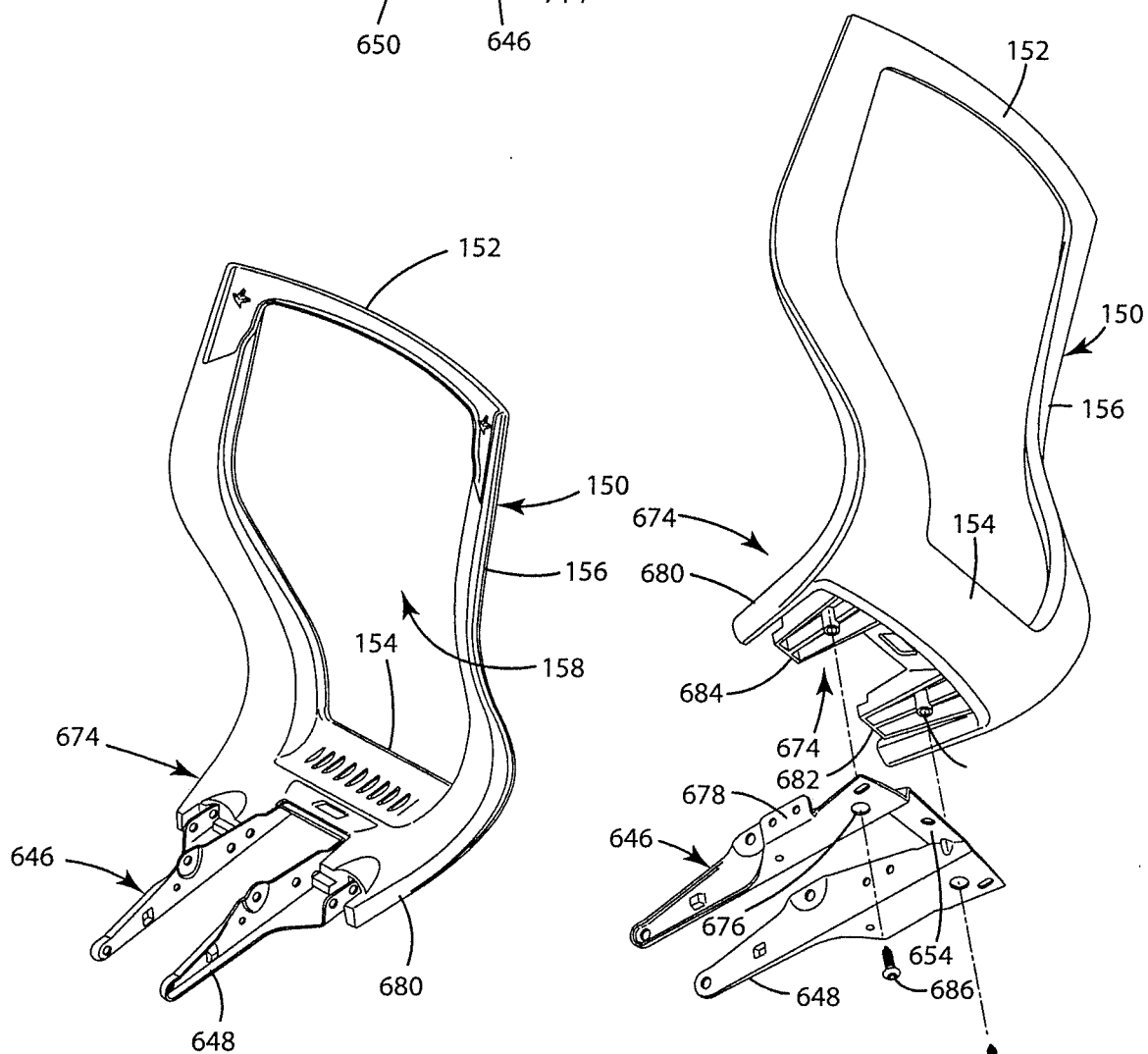


Fig. 40A

Fig. 40B

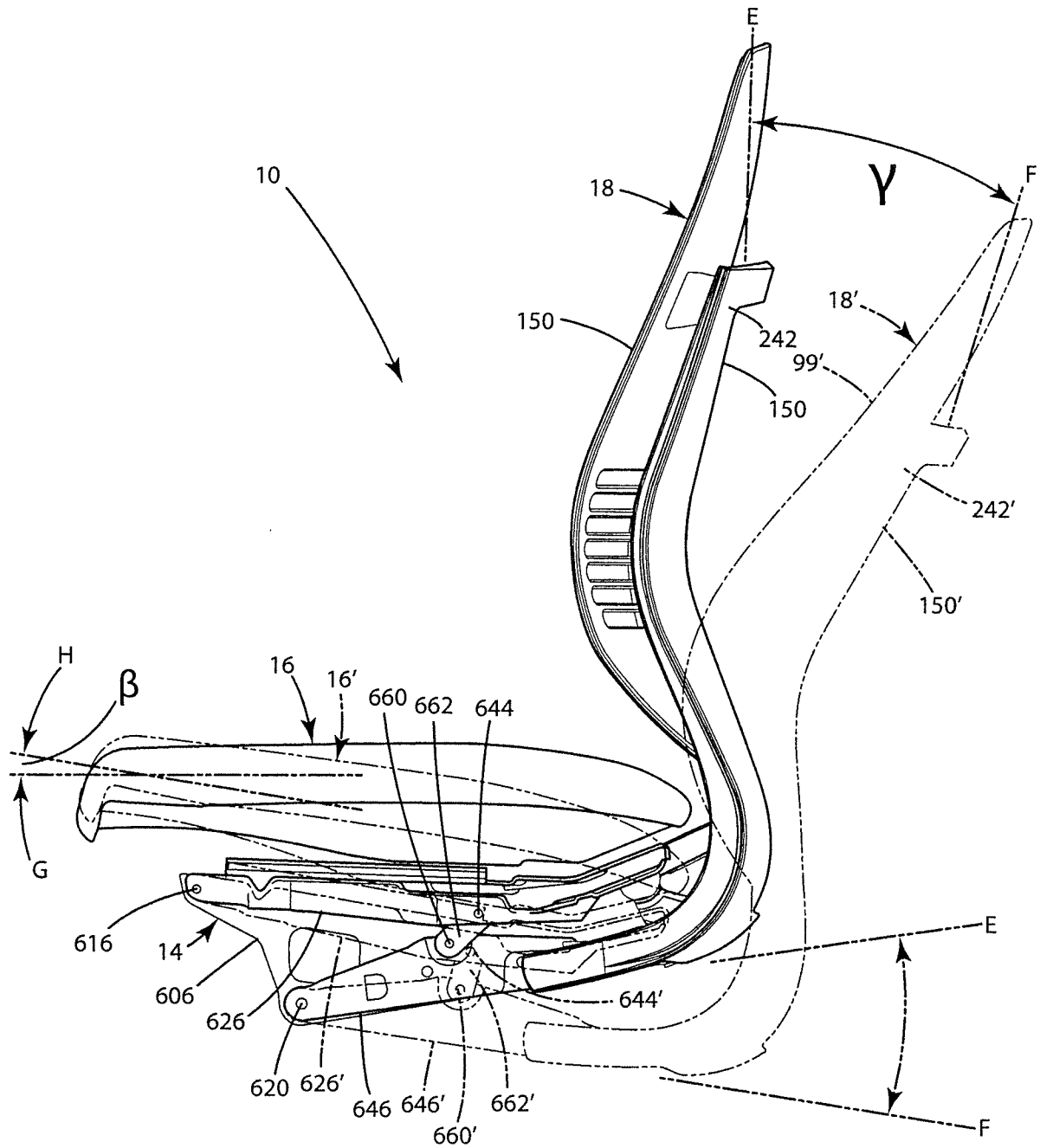


Fig. 41

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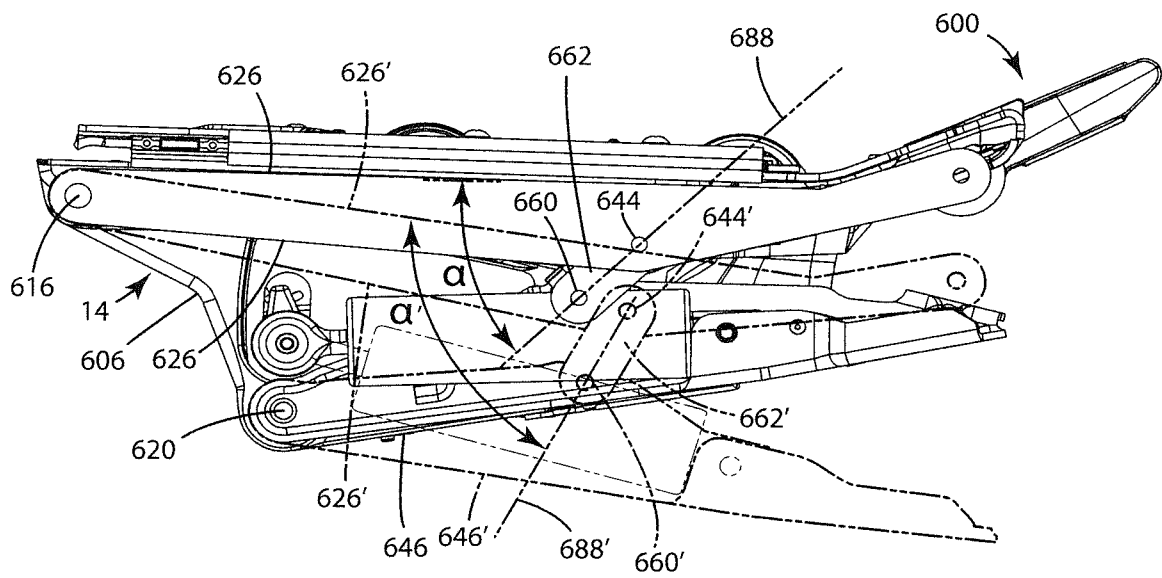


Fig. 42

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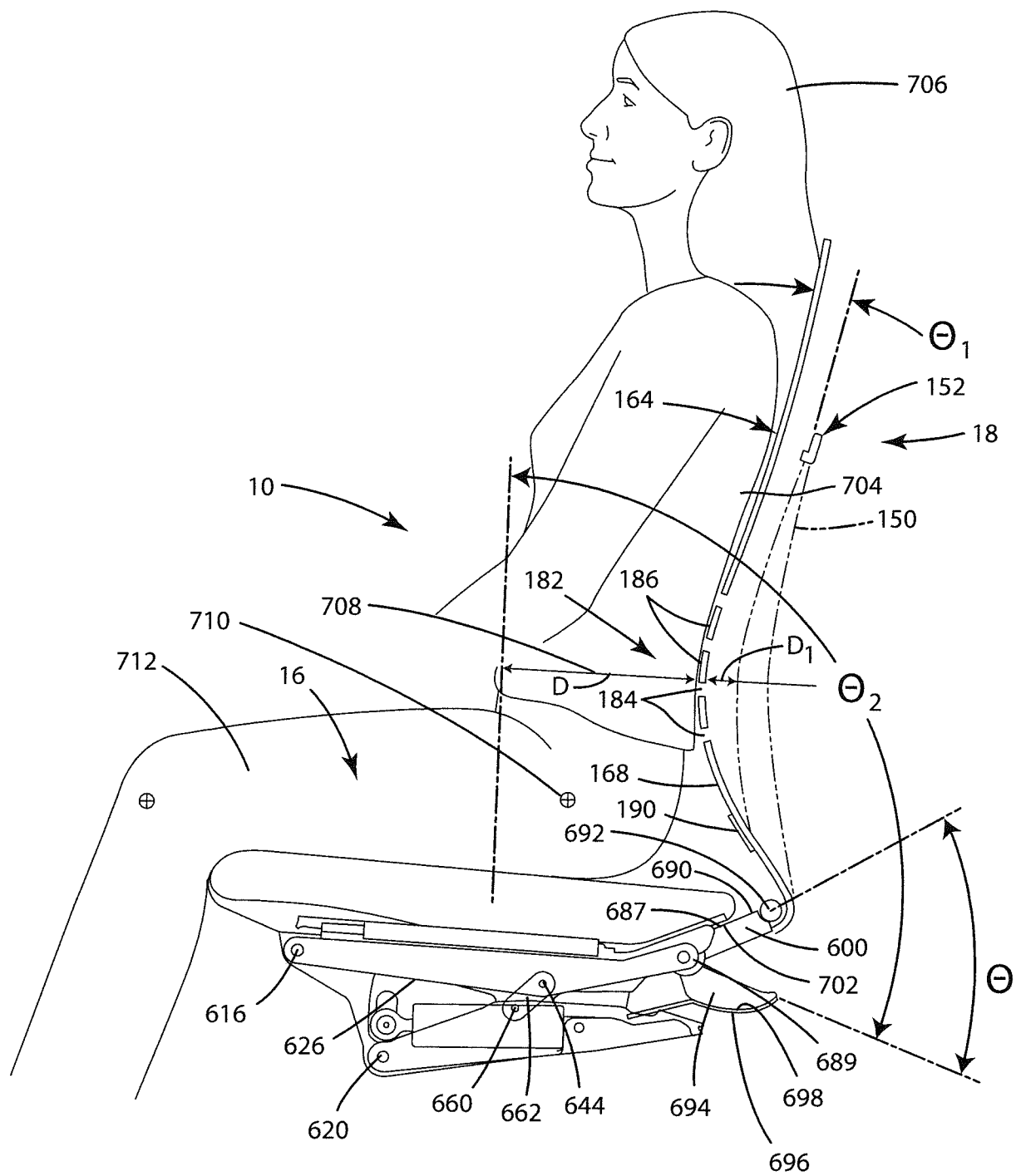


Fig. 43

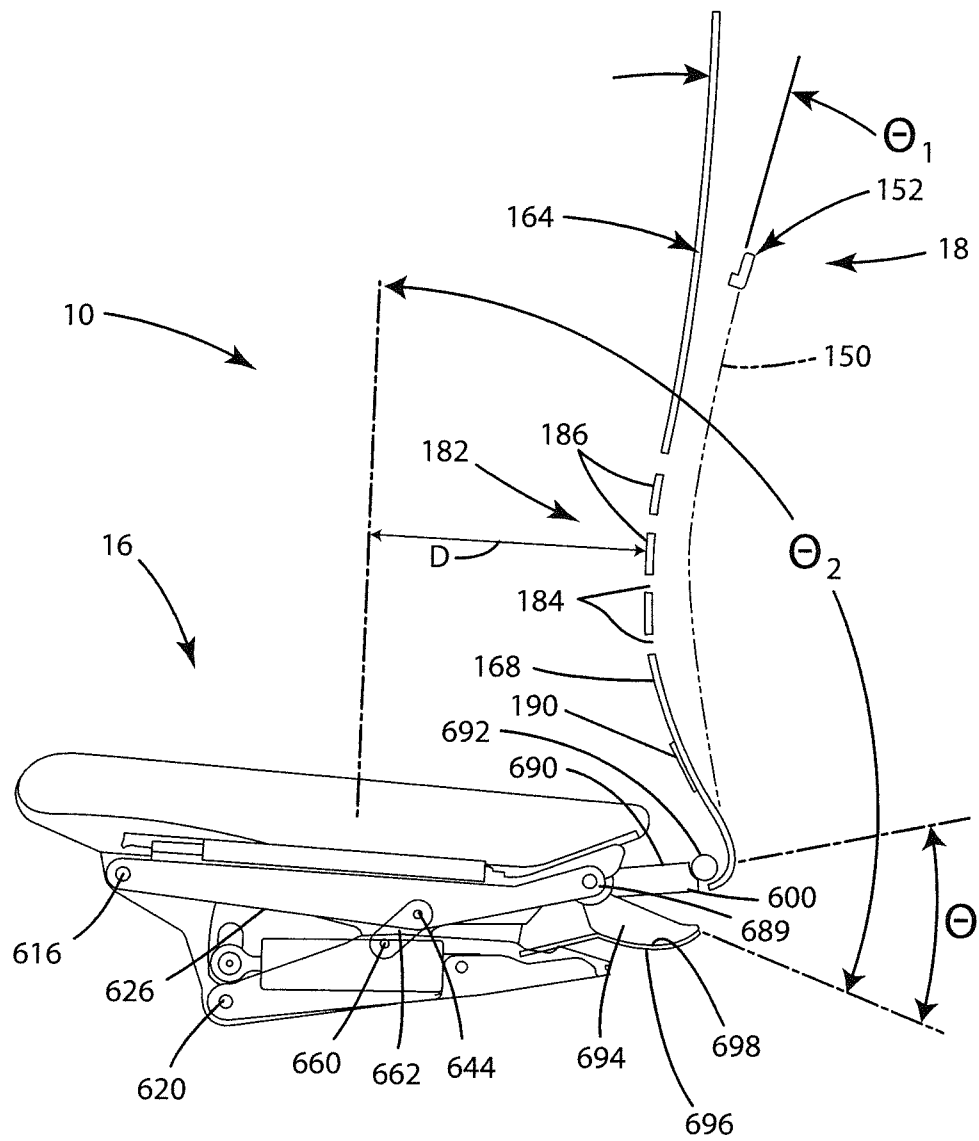


Fig. 44

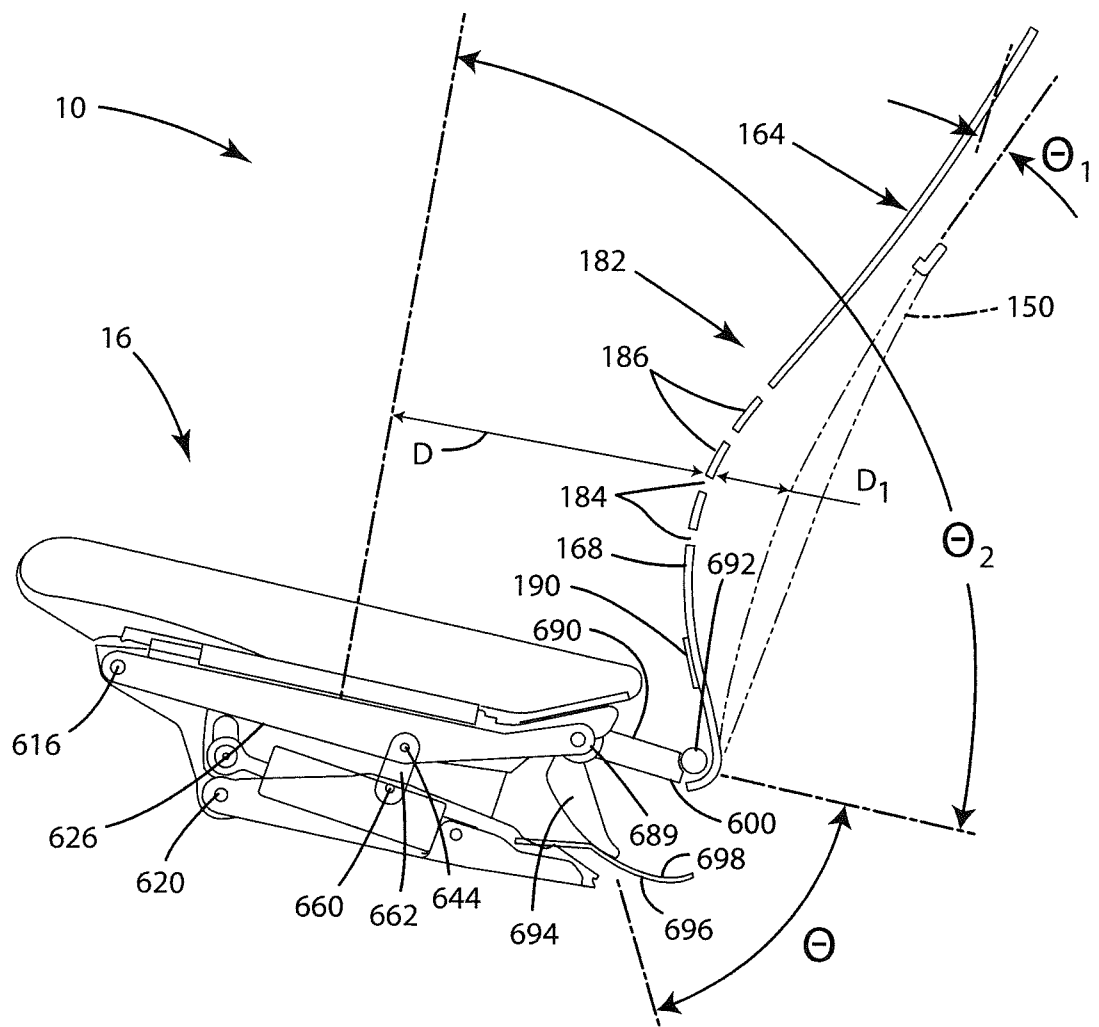


Fig. 45



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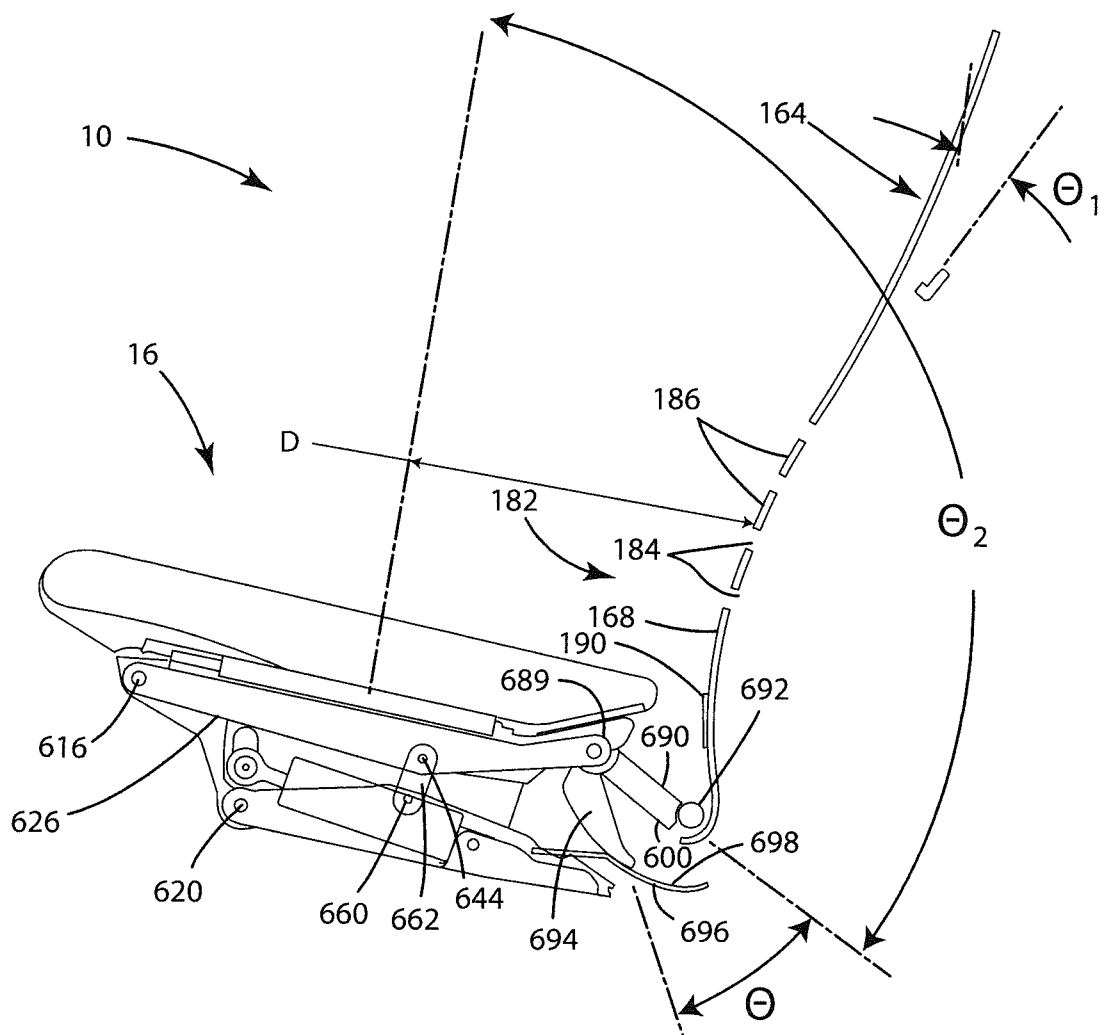


Fig. 46

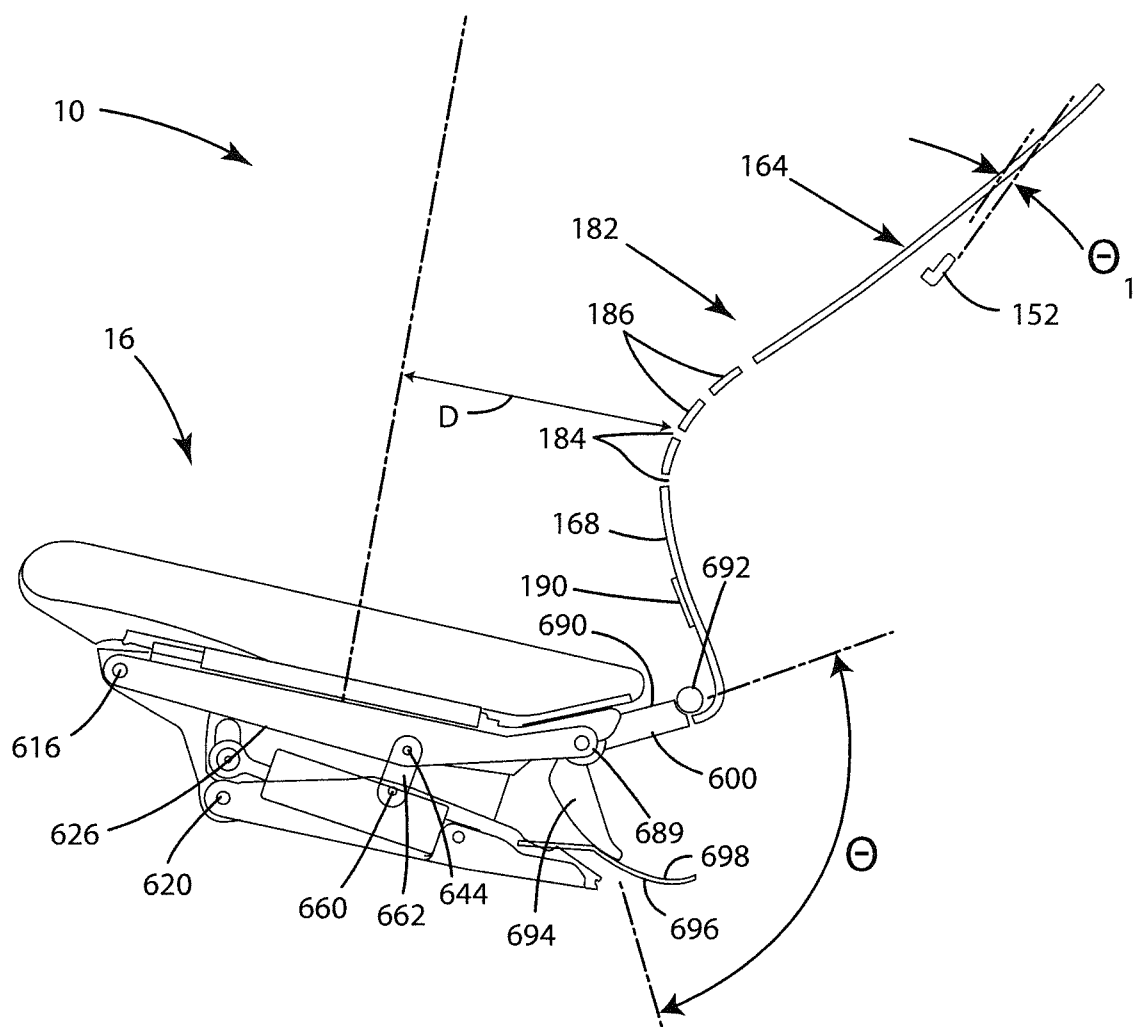


Fig. 47

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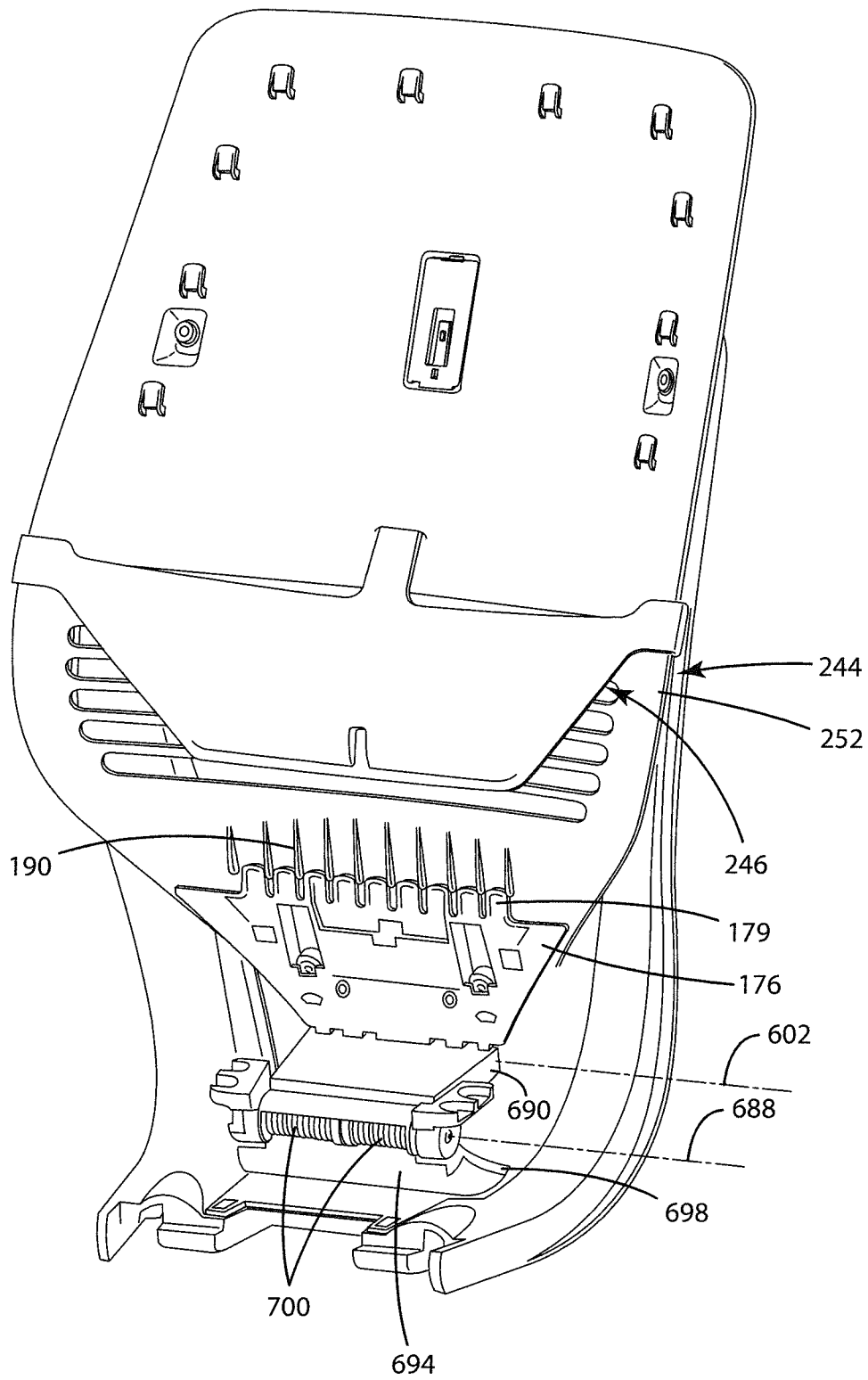


Fig. 48

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Fig. 49



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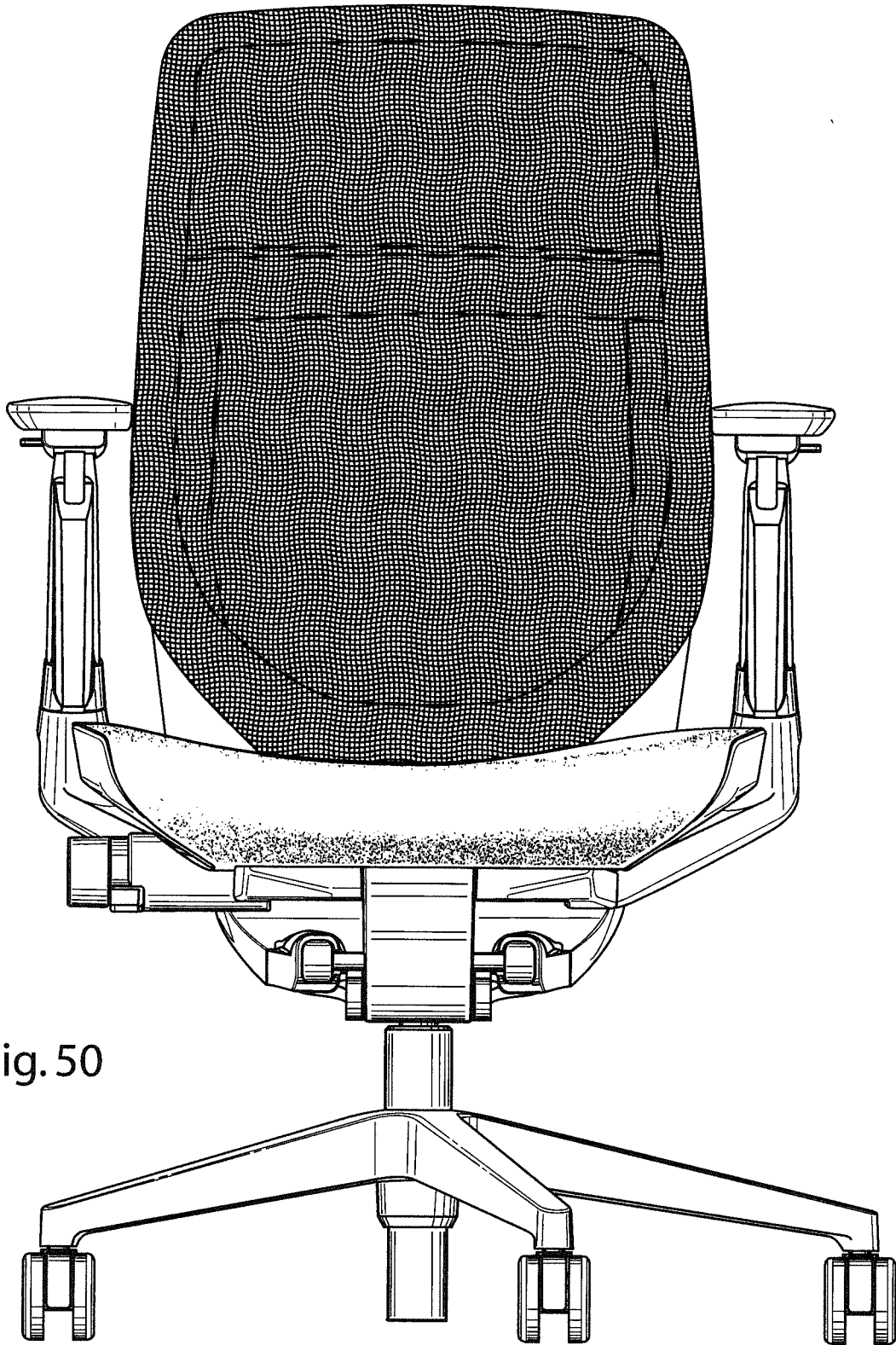
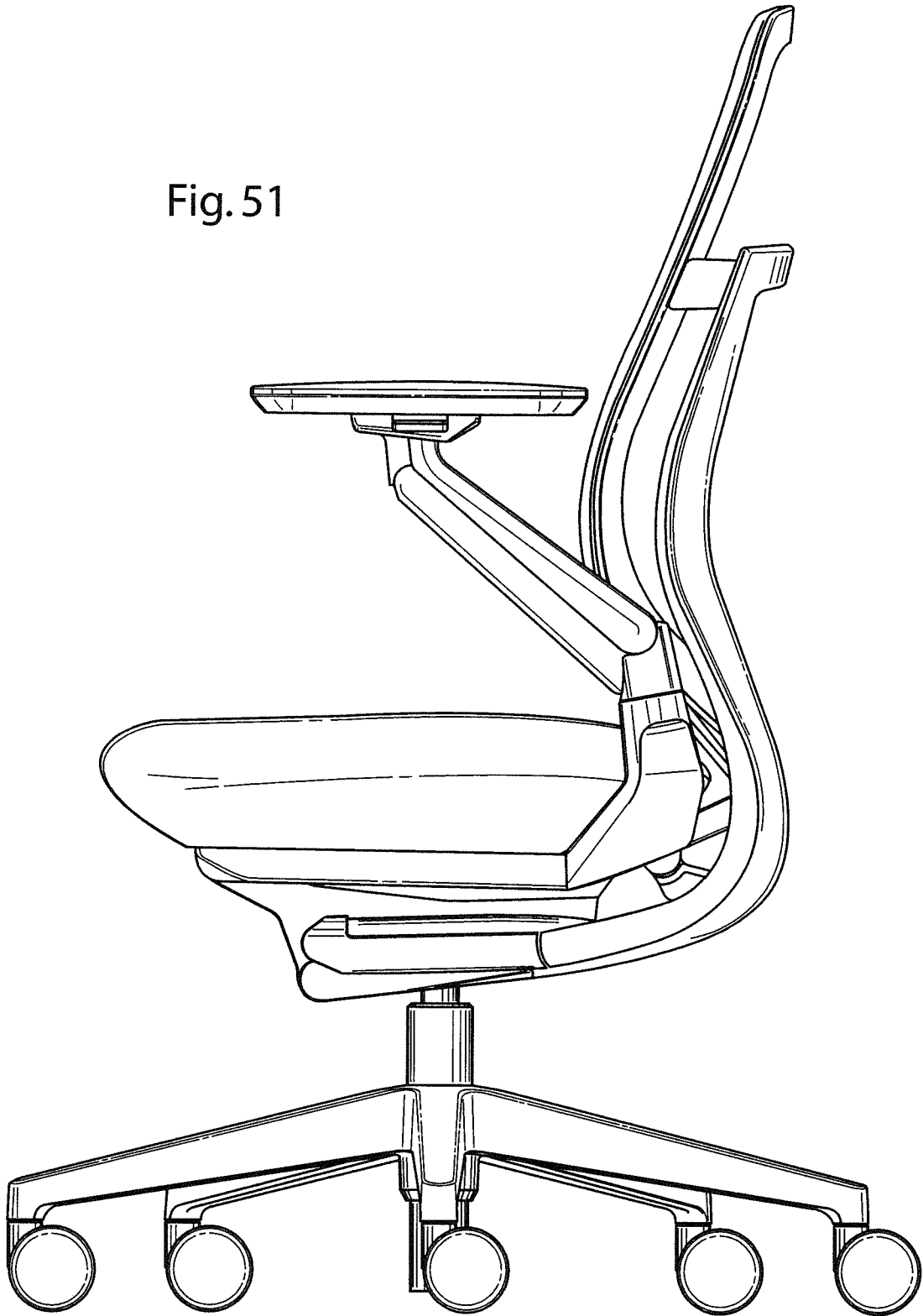


Fig. 50

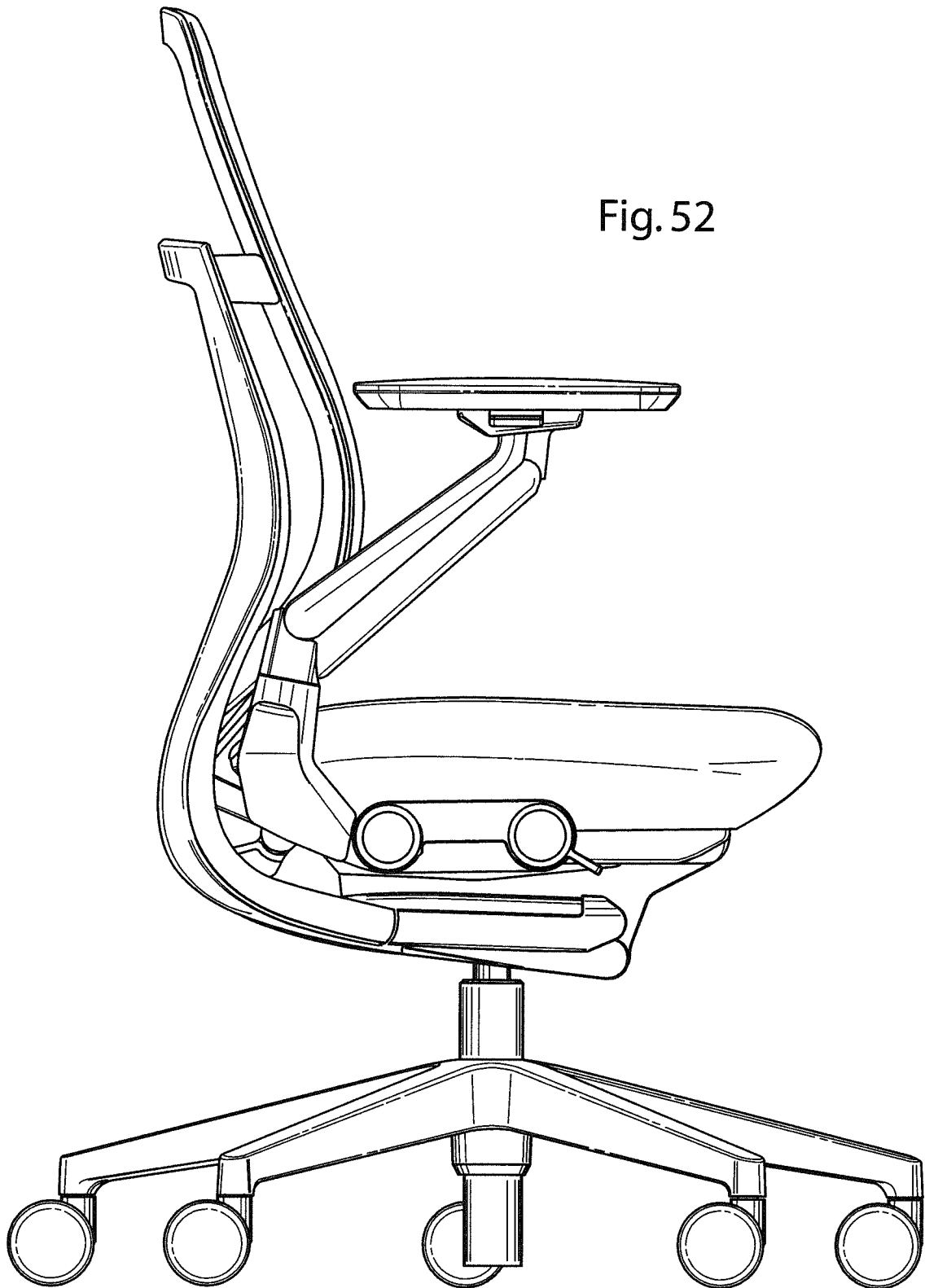
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Fig. 51



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Fig. 52



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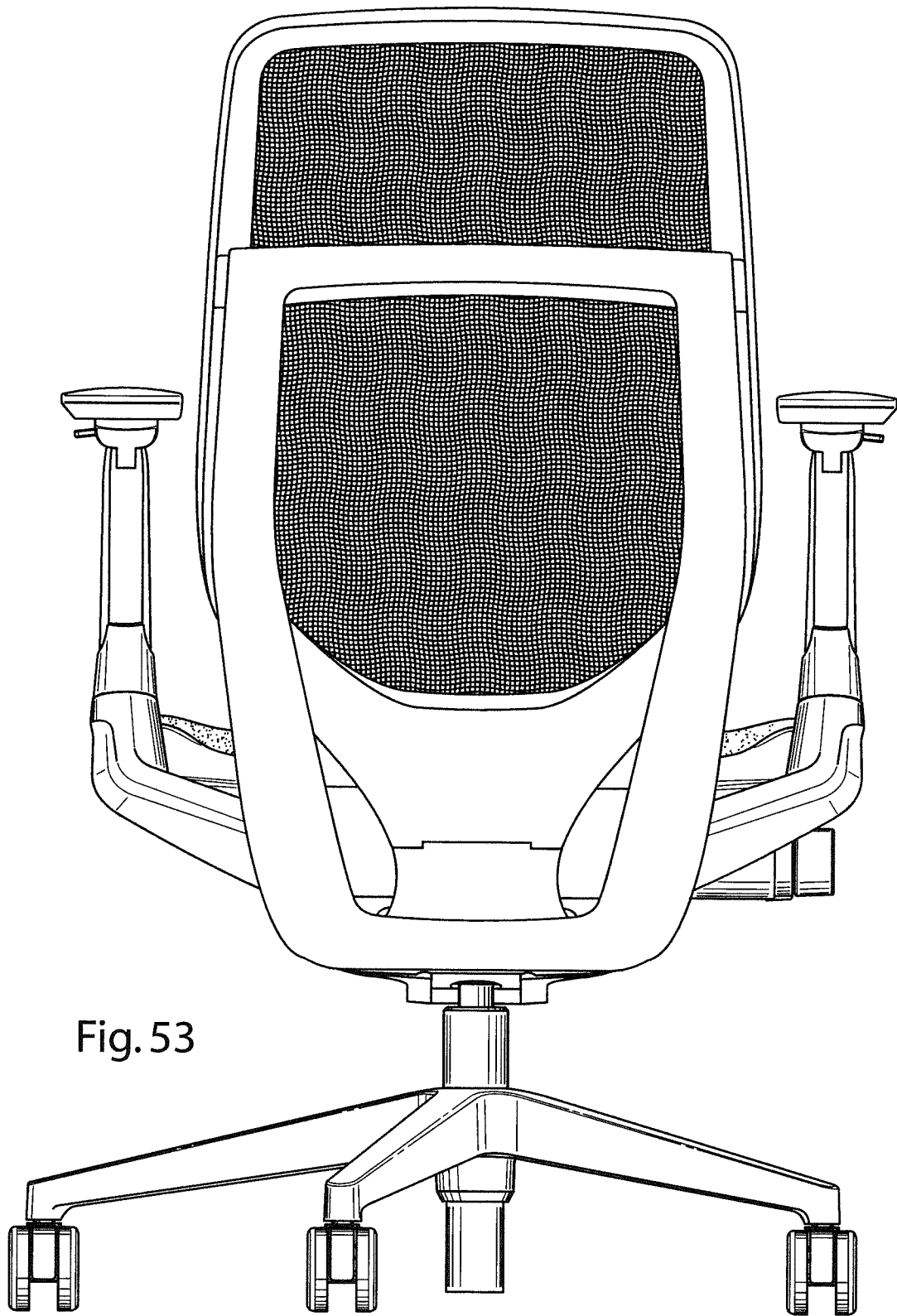
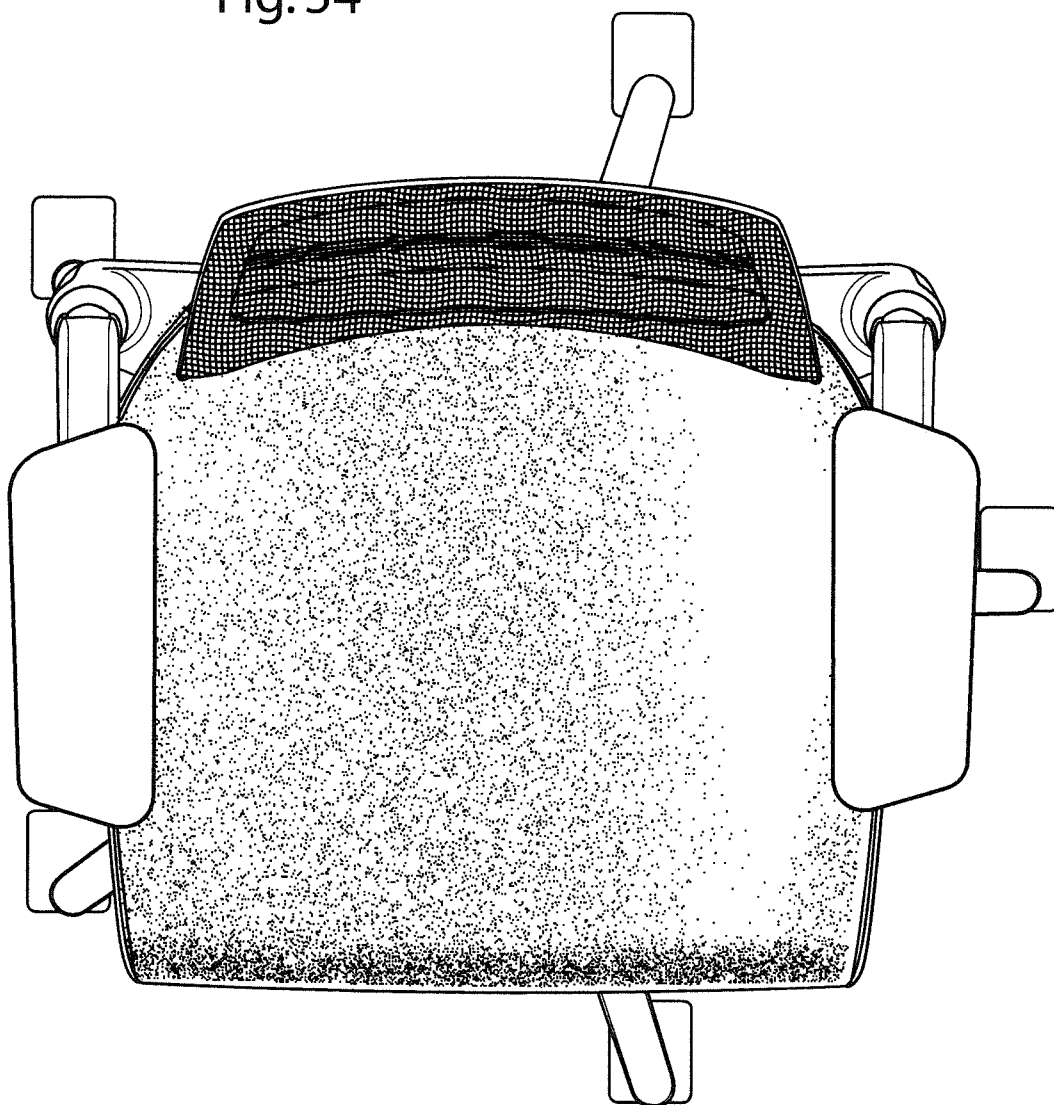


Fig. 53



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Fig. 54



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Fig. 55

