



- (51) **International Patent Classification:**
H01L 21/673 (2006.01) *H01L 21/677* (2006.01)
- (21) **International Application Number:**
PCT/US2016/024213
- (22) **International Filing Date:**
25 March 2016 (25.03.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/138,229 25 March 2015 (25.03.2015) US
- (71) **Applicant:** ENTEGRIS, INC. [US/US]; 129 Concord Road, Billerica, MA 01821 (US).
- (72) **Inventors:** ANDERSEN, Christian; 1020 Sunny Ridge Drive, Carver, MN 55315 (US). JOHNSON, Michael, L.; 5514 Edgewater Boulevard, Minneapolis, MN 55417 (US). ZABKA, Michael; 24496 West Cedar Lake Drive, New Prague, MN 56071 (US).
- (74) **Agents:** OLSTAD, Stuart, J. et al.; Christensen Fonder P.A., 33 South Sixth Street, Suite 3940, Minneapolis, MN 55402 (US).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,

[Continued on next page]

(54) **Title:** WAFER CONTAINER WITH CROSS-SLOTTING PROTECTION

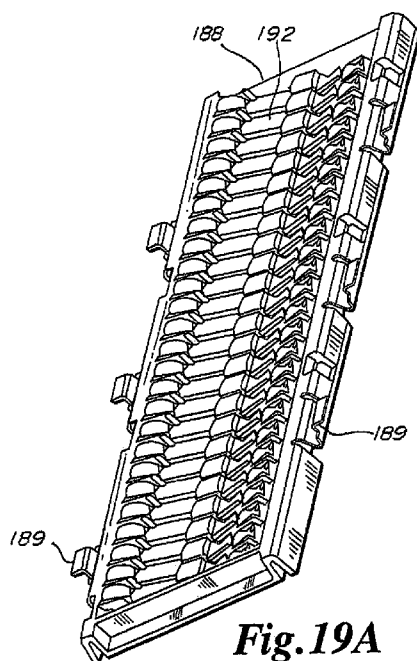


Fig. 19A

(57) **Abstract:** A front opening wafer container has a container portion and a door sized to close an open front of the container portion. The container portion has shelves for holding wafers defining a shelf seating position and has forward and rearward wafer supports to suspend wafers therebetween in a transport seating position above the shelf seating position. Shock condition projections are arranged adjacent the transport seating position of the wafers for protecting the wafers during a shock condition. The projections may be unitary with the chassis of the front door and the container portion back wall.



LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, **Published:**
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, — *with international search report (Art. 21(3))*
GW, KM, ML, MR, NE, SN, TD, TG).

WAFER CONTAINER WITH CROSS SLOTTING PROTECTION

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 62/138,229
5 filed March 25, 2015, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

Semiconductor wafers are processed into integrated circuit chips. Wafer containers hold wafers during transport from the original manufacture of the wafers to fabrication
10 facilities, and in between processing steps in the fabrication facilities. The wafers go through dozens or hundreds of processing steps to the final integrated circuit product. The wafers are extremely fragile and expensive. The more processing steps that wafers have undergone, the greater the investment, the greater the value in the wafers, and the greater the loss if damaged.

15 Wafers may be of various sizes up to 300 mm in diameter and equipment for 450 mm wafer processing is being developed. Wafer containers are required to protect the wafers from contaminants and damage, both during transport of the containers with the wafers, and during loading and unloading steps of the wafers, and during closure of the wafers. The wafers are generally supported in containers that support the wafers only at
20 their edges. Wafer containers, particularly for 300 mm wafers are known as FOUPS and FOSBS, acronyms for “front opening unified pod” and “front opening shipping box.” These front opening containers have a front opening container portion and a door that closes the front opening and latches onto the container portion. The wafers are supported by shelves in the container portion positioned at the two sides of the container. The wafers
25 are also supported forwardly and rearwardly by wafer supports (also termed wafer restraints) in which the wafer edges seat in V-shaped or U-shaped recesses in the forward and rearward supports with the supports providing a compressive force on the forward and rearward edge. The wafer supports may be cushions that have thin polymer springs connecting to wafer edge engagement portions for providing resilient support of the wafer
30 edges. In FOUPS, the wafers will typically be elevated off of the shelves and supported only by the forward and rearward supports during shipment. The wafer edge engagement

portions are “spring supported”. By industry convention, an x - y - z coordinate system is applied to FOUPS and FOSBS with the insertion and retraction direction being associated with the z direction, the vertical direction being associated with the y direction, and lateral, left and right directions being associated with the x direction. FOSBS may be rotated 90
5 degrees rearwardly for shipping with the wafers suspended vertically between the front and rearward wafer supports.

Demand from consumers and product manufacturers, as well as manufacturing efficiencies, have driven downwardly the size and thickness of integrated circuits. This is reflected at the wafer processing level by increased “circuit density” and reduced
10 thicknesses. The reduced thicknesses, particularly in large wafer sizes, such as 300 mm, equates to greater demands on protecting the wafers particularly during transportation of the loaded wafer container. For example, the thinner wafers will deflect more than thicker wafers during shock conditions and have a greater fragility. This creates greater demands of the forward and rearward supports. For example, they may need greater range of
15 movement and toward and away from the wafer (z direction) and more delicate support, which includes less compressive force on the wafer.

Generally, improvements in the capability of forward and/or rearward wafer supports to effectively support thinner wafers in front opening wafer containers would be well received. Moreover, improvements in supporting wafers in shock conditions to
20 prevent damage and cross slotting of wafers would be well received.

It is always desirable to find solutions that are cost effective and provide optimal performance. To the extent enhanced cushioning systems are overly expensive or create other problems such as cleaning difficulty, such solutions are less desirable.

Most recently, very thin wafers that are not capable of effectively supporting
25 themselves are bonded to a carrier substrate so that the very thin wafers can be processed and handled. The “bonded wafer” thus has a carrier substrate side and face and a thinned wafer side and face. In such bonded wafers, the very thin wafer is eventually separated from the carrier substrate before being finally transformed into the integrated circuits. The carrier substrate may be supported by its edge with the thinned wafer edge offset
30 inwardly from the carrier substrate edge. Forward and/or rearward wafer supports configured particularly to support and protect these bonded wafers are needed.

SUMMARY

A front opening wafer container includes a container portion and a door portion, the container portion having interior shelves and a rearward wafer edge support at a back wall or at the rearward portion of the wafer shelves. The front door sized to be received in the open front and latched to the container portion and having a door chassis with a removable forward primary wafer support provided on the inside surface of the door. Each wafer support having two columns of cantilevered spring finger portions, each finger portion having a wafer edge receiving portion with a V-shaped recess. The spring finger portions each connecting to a base portion that attaches to the inside surface of the front door. The forward wafer support providing a compressive force on the wafers in the container when the door is latched onto the container portion whereby the wafers are retained within the V-shaped recesses at a primary transport seating position in a first wafer edge engagement portion formed of a first polymer. In some embodiments, a second wafer engagement portion is positioned intermediate the two columns of cantilevered spring portions. The second wafer engagement portion comprising a plurality of projections, each in a linear alignment and each positioned in-between slots defined by the V-shaped recesses. The projections are positioned to prevent disengagement of the wafers from the V-shaped recesses in a shock condition or other condition that urges the wafers out of their respective recesses and out of the transport seating position. In some embodiments the second wafer engagement portion is formed of a polymer softer than the polymer of the first wafer support. The shock condition cushion may be an elastomeric material and may have an I-shape. In some embodiments, the second wafer engagement portion has a vertical strip attached to the forward primary wafer support with the plurality of projections extending therefrom. The strip may be configured to engage the wafers when the wafers are in their normal transport seating position in the V-shaped recesses. Or the strip may be configured to not engage the wafers when the wafers are in their normal transport seating position in the V-shaped recesses. The front opening container may be a 300 mm front opening shipping box known as a "FOSB" such that after wafers are loaded horizontally, the door is applied and latched, and the container is rotated rearwardly 90 degrees, such that the wafers are oriented vertically, for shipping.

In various embodiments particularly suited for bonded wafers, the wafer edge receiving portions defining the V-shaped recess and having an edge seating position located at the bottommost region of the recess defining a transport seating position and a second

wafer engagement portion displaced from the transport seating position formed of a material softer than the material at the primary position. In some embodiments of the disclosure, the V-shaped forward or rearward wafer support having a first surface forming a first angle with the carrier substrate side and a second angle with the thinned wafer side of the bonded wafer. The second angle being greater than the first angle. In some embodiments, the wafer edge receiving recess has, in an end or cross sectional view, four legs, each leg corresponding with a surface or face of the recess. The wafer edge receiving recess having a first leg facing the carrier substrate face, the first leg connecting to a second leg with the juncture defining a deepest most receiving region, the second leg facing the thinned wafer face and third leg connecting to the second leg and also facing the thinned wafer face, the juncture of the second and third leg defining a shock event limit region. In some embodiments, the rearward wafer support has two columns of wafer engagement portions with the wafer edge receiving recess with the four legs (and faces). In some embodiments, the wafer edge receiving portions are not sprung on fingers, that is, the receiving portions are not supported by discrete spring members for each wafer engagement portion.

In some embodiments, a wafer container with a plurality of wafer engagement portions each with a first face and a second face are connected at a juncture to define a wafer edge receiving recess for a bonded wafer, the bonded wafer having a carrier substrate side surface and a thinned wafer side surface, when the bonded wafer is seated in the wafer edge receiving recess, the first face and the carrier substrate side surface defining a first converging region and the second face and thinned wafer side surface defining a second converging region. The first converging region being “sharper” and “narrower” than the second converging region. The second converging region being more “blunt” and “wider” than the first converging region. The wafer engagement portions may be formed of rigid polymers such as polycarbonate.

In some embodiments, a bonded wafer container with a plurality of wafer engagement portions each with a recess having a first and second margin of the recess, with each first margin facing a substrate carrier side of a wafer received in the recess, and the second margin facing a thinned wafer side of the recess, the wafer edge receiving portion positioned, elevation wise to be closer to the first margin than the second margin thereby providing greater clearance for the thinned wafer side of the bonded wafer in a shock condition. In some embodiments, a plurality of secondary wafer engagement

portions configured as shock condition wafer engagement portions are provided outside a normal transport seating position to engage the bonded wafer in a shock condition. In some embodiments, the secondary wafer engagement portions provide an elastomeric engagement with the bonded wafer.

5 In various embodiments of the disclosure, a front opening wafer container has shock condition wafer engagement portions that are axially displaced from a wafer transport seating position. In some embodiments of the disclosure, a front opening wafer container has shock condition wafer engagement portions that do not engage the wafers except in a shock condition. In some embodiments of the disclosure, a front opening
10 wafer container has shock condition wafer engagement portions that are spring finger supported. In some embodiments of the disclosure, a front opening wafer container has shock condition wafer engagement portions that are elastomeric. In some embodiments of the disclosure, a front opening wafer container has shock condition wafer engagement portions and their associated respective primary engagement portions are formed by
15 overmolding, one on the other.

In various embodiments of the disclosure, a wafer container with a forward primary wafer support has a central base strip with opposing pairs of cantilevered spring finger portions arranged in two columns and the finger portions extending outwardly toward the wafers and laterally toward the sides of the wafer container, each spring finger
20 portion connecting and unitary with a wafer edge receiving portion configured as a pad. In some embodiments, the forward wafer support has a central aperture extending substantially the vertical length of the wafer support. The door has a chassis to which the primary wafer support is attached. The chassis has the plurality of projections unitary therewith and positioned intermediate wafer slots defined by V-shaped recesses of the
25 spring fingers. The plurality of projections extending inwardly toward the central interior of the container portion and extending over faces of wafers engaged by the forward primary wafer support, the plurality of projections positioned to not engage the wafers except in a shock condition. Conventionally the chassis of the door may be formed of polycarbonate and the unitary projections are similarly formed of polycarbonate. The
30 rigid surface of polycarbonate is believed to not be suitable for providing the shock protection and/or cross slot prevention for bonded wafers.

In some embodiments, the wafers are bonded wafers with a thinned wafer side and the projection extends over the thinned wafer side. In some embodiments, the projections each have a widest portion facing the wafer thinned wafer side. The widest portion configured as a flange with a central narrower portion opposite the widest portion. In
5 some embodiments, the projection is I-shaped, and extends from a unitary base portion with nubs for attachment to the primary wafer support or to the door chassis.

A wafer container having a container portion with an open front and a door for closing the open front, the wafer container having a forward or rearward wafer support with a plurality of wafer edge engagement portions that each define a static wafer seating
10 position for one of the wafers. An additional plurality of secondary wafer shock event engagement portions are positioned outside the static wafer seating position to engage the wafers only in a shock condition and to generally prevent cross slotting. In some embodiments the secondary wafer shock engagement portions are elastomeric and have an I-shape. In some embodiments, the secondary wafer shock engagement portions are part
15 of a strip with projections extending along a length of the forward or rearward wafer support. In some embodiments the secondary wafer shock engagement portions include projections extending in a direction inwardly.

In some embodiments a wafer container for bonded wafers has forward or rearward wafer support that has a first wafer support with a bonded wafer edge receiving
20 portions with a recess that receives the edge of the bonded wafer, the wafer container further has secondary wafer support portion that has first engagement portions that engage the bonded wafer in a static condition and second engagement portions that are positioned outside of a normal transport wafer seating region and that contact the wafer only in a shock condition. The first and second engagement portions may be in a unitary
25 elastomeric strip that attaches to the first wafer support.

In some embodiments, when the front opening wafer shipper is loaded, wafers are installed horizontally to seat on the shelves. The door is applied and latched causing the wafers to ride up ramps on forward and rearward wafer supports to seat in wafer edge receiving recesses. In the forward support, the ramps are part of wafer edge receiving
30 portion configured as a pad and integral with spring finger portions. As the door is applied, the wafer edges first engage the pad and the pads and respective spring finger portions deflect and then the wafer edges may engage the secondary wafer support portion

configured as an elastomeric shock condition cushion. Upon engagement of the cushion the cushion deflects as the pad and spring finger portion continue to deflect. The pad deflects a distance less than the deflection of the pad and spring finger portion. The container is then rotated 90 degrees to arrange the wafers vertically.

- 5 Various embodiments of the disclosure provide enhanced protection in shock conditions is provided to wafers in wafer carriers.

DESCRIPTION OF THE FIGURES

Figure 1 is a perspective view of a 300 mm wafer container according to an embodiment of the disclosure.

- 10 Figure 2 is a side perspective view of the front opening wafer container of Figure 1.

Figure 3 is a front perspective view of the container portion of the wafer carrier of Figure 1.

- 15 Figure 4 is a perspective view of the inside surface of the front door of the wafer container of Figure 1 illustrating the wafer support system with shock protection.

Figure 5 is a perspective view of the inside surface of the front door of the wafer container of Figure 1 without forward wafer support system in place.

Figure 6 is a perspective view of the wafer support for the door of Figure 5.

- 20 Figure 7 is an elevational view of the backside, facing the door, of the wafer support of Figure 1.

Figure 8 is an exploded view of the wafer support system of Figure 4.

Figure 9A is a detailed perspective view of the wafer support on the inside of the front door of the wafer container of Figure 1.

- 25 Figure 9B is a more detailed perspective view of the wafer support of Figure 9A and with a wafer shown in phantom.

Figure 9C is a cross sectional view through adjacent wafer edge engagement portions both shown engaged with bonded wafers.

Figure 9D is a perspective view of the back side, facing away from the wafers, of a shock event wafer engagement cushion.

5 Figure 10 is an elevational view of the rearward wafer support of Figure 3.

Figure 11 is a perspective view of the back side of the wafer support of Figure 10.

Figure 12 is a front side perspective view of the rear side wafer support system with shock protection of Figure 3.

Figure 13 exploded perspective view of the wafer support system of Figure 12.

10 Figure 14 is a side elevational view of a rearward wafer support system with shock protection features suitable for bonded wafers.

Figure 15 is a diagrammatic view of a front opening wafer container with the wafers seated on shelves and the door displaced from the front opening.

15 Figure 16 is a diagrammatic view of the front opening wafer container of Figure 15 with the front door in place—closed.

Figure 17 is a diagrammatic view of the front opening wafer container of Figure 15 in a transport orientation with the wafers vertical.

Figure 18 is a cross sectional view of the forward and backward wafer supports suspending a wafer therebetween in a vertical transport orientation.

20 Figure 19A is a perspective view of a forward wafer container that has a shock condition cushion with undulation extending down the center of a primary wafer support portion.

Figure 19B is a perspective view of the primary wafer support of Fig. 19A without a secondary wafer support portion attached.

Figure 19C is a perspective view of the elastomeric secondary wafer support portion of Fig. 19A.

Figure 19D is a perspective view of another elastomeric secondary wafer support portion suitable for attachment to the primary wafer support of Fig. 19B.

5 Figure 19 E is a cross sectional view of the secondary wafer support portion of Fig. 19D attached to a primary wafer support with the bonded wafer in a static condition (no-shock).

10 Figure 19F is a cross sectional view of the secondary wafer support portion of Fig. 19D attached to a primary wafer support with the bonded wafer in a shock condition with the thin wafer engaging the elastomeric shock engagement portion.

Figure 19G is a perspective view of a elastomeric secondary wafer support portion having cross slot preventing projections having an I-shape.

Figure 19H is a perspective view of the back side of the secondary wafer support portion of Figure 19G.

15 Figure 19I is a front elevational view of the I-shaped projections of Figures 19G and 19H.

Figure 20 is a cross sectional view of bonded wafer engagement with the wafer support of Figure 19.

20 Figure 21 is a side cross sectional view of a wafer edge engagement portion that deflects upon compressive loading of a wafer to allow shock condition cushions to be exposed to the wafer.

Figure 22 is a cross sectional view of the wafer edge engagement portion of Figure 19 deflected with shock cushions exposed and with the associated wafer container in a transport position with the wafers vertical.

25 Figure 23 is a perspective view of a front opening wafer container having a container portion and a door, the container having internal components according to an embodiment of the disclosure.

Figure 24 is a perspective view of the inward wall of the chassis of the front door of the container depicted in Figure 23.

Figure 25 is a perspective view of a wafer cushion that attaches to the door chassis of Figure 24 according to embodiments of the disclosure.

5 Figure 26 is a detail perspective view of the inside surface of the chassis of Figure 24.

Figure 27 is a front perspective view of the container portion of the wafer container of Figure 23.

10 Figure 28 is an upwardly looking perspective view of the container portion of Figure 27.

Figure 28A is a perspective view of a column of wafer shelves and with a rearward primary wafer support.

Figure 29 is a perspective view of the shell of the container portion of Figures 27 and 28.

15 Figure 30 is a cross sectional view of the shell of Figure 29.

Figure 31 is a detail view of rearward projections of the shell of Figures 29 and 30.

Figure 32 is a diagrammatic plan view of a wafer container before the door is seated with the wafer seated on the shelf according to embodiments of the disclosure.

20 Figure 33 is a diagrammatic plan view of the wafer container of Figure 32 with the door seated and with the wafers elevated off of the shelves in the normal transport seated position.

Figure 34 is a diagrammatic side elevational cross section view of the wafer container of Figure 32 before the door is seated and with the wafers in the normal shelf seated position.

Figure 35 is a diagrammatic side elevational cross section view of the wafer container of claim 34 with the door seated and with the wafers elevated off of the shelves in the normal transport seated position.

DETAILED DESCRIPTION

5 Referring to figures 1-6, a wafer container 20 generally comprises a container portion 30 and a door 32 defining an open interior 33 for holding wafers 34. The container portion has a door frame 36 defining an open front 38, A left side 42 a right side 44, a back side 45, a top side 46 and a bottom side 48, with respectively a left side wall 52, a right side wall 54, a top side wall 56, a back wall 57, and a bottom wall 58, each wall
10 with a respective inside facing surface and an outside surface. The back wall 57 has flattened surfaces configured as feet 59 adjacent the top wall and bottom wall for seating the container on the back side after rotating the container one quarter turn, 90 degrees, such as for transporting same.

The front door 32 has a pair of latch mechanism 60, 62, latch containments 63, and
15 a seal 64 that encircles a periphery 66 of the door. The door has a chassis 68, an inside surface 70 and an outside surface 72.

The wafer container has wafer engagement features on in the container portion and on the inside surface of the front door. In the container portion, the wafers seat on wafer shelves 80 at the inside surfaces of the left and right side walls and engage a rearward
20 wafer support system 82 with shock event protection feature 84. The rearward wafer support system cooperates with a forward wafer support system to compressively restrain the wafers therebetween such as is illustrated in U.S. Pat. No. 6,267,245; see Figure 11B. This patent is owned by the owner of the instant application and is hereby incorporated herein by reference. The wafer container illustrated herein and in the '245 patent, falls
25 within the FOSB category. These wafer containers are configured for receiving and transporting 300 mm wafers. The wafers may be received in the open front, the door then attached and latched to the container portion, and then the container may be rotated rearwardly 90 degrees to orient the wafers vertically, such as shown in Figures 17 and 18. Similar wafer containers for 300 mm wafers that are used more exclusively in the
30 fabrication facility setting, as opposed to shipping, are known as FOUPS, or front opening unified pods. Various embodiments disclosed herein may be suitable for use in FOUPS

and may also be applicable to containers for other wafer sizes. For example, front opening wafer containers are also being developed for 450 mm wafers and the embodiments disclosed herein are suitable for incorporating in such containers.

In the depicted embodiments, each of the forward and rearward wafer supports may be provided with shock event protection and are particularly suitable for bonded wafers. In some embodiments, the shock or cross slotting protection may be displaced from the wafer supports. Referring to Figures 14, 18, and 20, bonded wafers 100, have a carrier substrate 102, a thinned wafer 104, and an adhesion layer 106 that secures the thinned layer to the carrier substrate during processing. The bonded wafers have a thinned wafer side 108, a carrier substrate side 110, a wafer edge 112, and edge corners 114.

Details of forward wafer supports are provided in Figures 4-9D and 19A-20. Referring first to Figures 7-9D, the forward wafer support 88 has two components, a primary wafer support 120 and a secondary wafer support portion configured as a shock event wafer engagement cushion 122. The primary wafer support has a rectangular frame 124 with latching portions 126 on the long rails 128. A window 130 defined by the rectangular frame, frames central base strip 134 with opposing pairs of unitary cantilevered spring finger portions 136 extending outwardly toward the wafers and laterally toward the sides of the wafer container, each spring finger portion connecting and unitary with a wafer edge receiving portion 140 configured as a pad with a V-shaped recess 141 for receiving the edge of the wafer 100. The rectangular frame 124 engages elongate ribs 144 on the inside surface 70 of the door 32 and the central base strip 134 seats on the central attachment portion 146 configured as rib and structural projections and attached with nubs 152 engaging apertures 154 in the base strip. The base strip is attached at the top and bottom of the strip to the rectangular frame and the spring fingers and pads on the left side, when engaged with wafers in the container portion, provide a moment to the central base strip that is offset by the moment provided by the spring fingers and pads on the right side. Such balancing of the forces allows less structure to be used for supporting the compressive forces provided by the forward wafer support.

The shock event wafer engagement cushion 122 of Figures 7-9D comprises a central strip 160 with a plurality of pairs 162 of arms 164 extending therefrom that correspond with each pair 168 of spring fingers and pads. Inwardly extending projections 172 are positioned axially and/or circumferentially offset from the primary transport

seating positions 176. In some embodiments, the primary wafer support 120 is formed of a more rigid polymer such as polycarbonate, nylon, or polyethylene, than the polymer of the shock event cushion 122 which may be a thermoplastic elastomer or other elastomeric material. The shock event cushion may be attached such as by the protrusions or nubs 180 that plug into apertures 182 in the primary wafer support 120. In other embodiments, individual discrete shock event cushions may be provided on the wafer supports for each wafer such as illustrated by the cushion 186 on Figure 8. In other embodiments, the shock event cushion may be overmolded on the primary wafer support (or vice versa). The shock event cushion may be positioned to be engaged only upon a shock condition, that is, not engaged in a non-shock condition, or it may be positioned to be lesser engaged during a non-shock condition than during a shock condition. Or it may have a portion that is engaged in a normal non-shock condition and another portion that is engaged in a shock condition. Referring to Figures 19A- 20, a primary wafer support 188, has engagement structure 189 for attachment to the front door and has a secondary wafer support portion 192 configured as a shock condition cushion. Figure 19D illustrates another embodiment of a secondary wafer support portion 191. The secondary wafer support portion may be a strip extending lengthwise on the primary wafer support with undulations 193 and with inward projections 194. Cooperating engagement structure such as nubs 196 of the secondary wafer support portion may be secured into apertures 197 in the primary wafer support portion. The wafer edge 112 may be engaging, slightly engaging, or spaced from the shock condition cushion during a non shock condition. The projections 194 may be positioned to engage the thinned wafer side 108 of the bonded wafer when in a shock condition thereby preventing the thinned wafer side from contacting other surfaces that would be more likely to damage the thinned wafer. Figure 19E illustrates a bonded wafer in a static normal seating position in a recess 199 and a wafer deflection region 273. Figure 19F illustrates a shock condition with the thinned wafer portion of the bonded wafer 100 engaging the projection 192 at a shock deflection contact region 198. In the shock condition, the wafer may or may not be still engaged with the pad. In some embodiments, the secondary wafer support portion may be overmolded onto the primary wafer support portion.

Figures 19G, 19H, 19I depict another secondary wafer support portion that is consistent with Figures 19E and 19F. A strip 205 has undulations 206 and I-shaped projection 207. Each projection has a pair of flanges 208 that provide a generally flat

engagement surface 209 for the wafer faces upon a shock condition or a near cross slotting event. The I-shape provides improved molding performance with minimal shrinkage and less polymer. Generally, a thermoplastic elastomer with a Shore D hardness of 30- 35 is suitable. In some embodiments a Shore D hardness of 28- 38 is suitable. Nubs 210 are on
5 the back surface for attachment in apertures of the primary wafer support or inward wall of the door.

Referring to Figures 3 and 10-14, various embodiments of a rearward wafer support 82 are illustrated. The rear wafer support comprises a primary wafer support 200 and a shock event cushion 202. The primary wafer support has a rectangular framework
10 210, with rails 212 that snap-in or otherwise engage the back wall 57 for retaining the rearward wafer support attached thereto. The shock condition cushions may be a strip as illustrated in Figures 12 and 13 or may be discrete cushions position for each wafer. The shock condition cushion, like the forward shock condition cushion(s) may be engaged, partially engaged, or separated from the wafer edge in a non-shock condition. Upon a
15 shock condition the engagement will be increased, or will occur. The shock condition cushion may be an elastomeric material or other material softer than the material of the primary rear wafer support. The materials are typically polymers.

Referring to Figures 13, 14, and 18, the rearward primary wafer support has a plurality of wafer edge engaging portions 222 that overall present a U-shape, see element
20 226, and have an internal V-shaped recess 228 that includes the non-shock transport seating position 232 for the wafer 102. The V-shaped recess has a pair of faces 238, 239 or legs 242, 244 in the cross section with a juncture 246 connecting the faces or legs. The juncture essentially defines the non-shock transport seating position of the wafers and has an apex 248. The angle 250 between the wafer and face 237 facing the carrier substrate
25 side 110 of the wafer is less than the angle of the face 238 facing the thinned wafer side 108 and the wafer. Described in another way, the region 270, defined by the carrier substrate and the face of the V-shaped recess facing the carrier substrate is sharper or narrower towards the transport seating position compared to the region 272 defined by the thinned wafer and the face of the V-shaped recess facing the thinned wafer. A wafer
30 deflection region 273 is defined where the edge of the wafer is anticipated to extend in a shock condition. As illustrated in other views, a shock condition cushion is suitably positioned to contact the wafer when the wafer extends into the wafer deflection region. The above configurations provide more clearance for the thinned wafer in a shock

condition so that engagement of the thinned wafer with the primary wafer support is less likely. This configuration may also be provided to the springed pads 260 of the forward wafer supports, also shown in Figure 18.

5 The wafer edge engagement portions 222 of the primary rearward wafer support have apertures 280 that may facilitate precisely molding the components and control of the interface between the thinned wafer and the wafer edge engagement portion. In some embodiments, apertures may receive inserts that provide a shock condition cushion insert 283. Such may be molded and inserted or joined to the primary wafer support by an overmolding process. In some embodiments, the shock condition cushion insert is a softer
10 polymer material than the polymer material of the wafer edge engagement portion. Although the wafer edge engagement apertures are illustrated in the rearward wafer support, such may be used in the forward wafer support as well.

Referring to Figures 15-17, diagrammatic illustration of a front opening wafer container 300 has a container portion 302, a front door 304, wafer shelves 306 defining a
15 wafer shelf seating position 310, forward wafer supports 314 and rearward wafer supports 318. The forward wafer supports have a spring 320. In a horizontal position with the door open, the wafers 324 are seated on the shelves. When the door is latched to the open front 326, the wafers are elevated by the wafer engagement portions 330 of the wafer supports 314, 318 to the transport position 327 as shown in Figure 16. The wafer container may be
20 partially rotated to the position of Figure 17 for transport. Figure 17 illustrates a shock condition with a force impacting a lower corner of the container causing displacement of the wafers such that they engage the shock condition cushions 333. The shock condition cushion may be fixed to the wafer support or may be attached to the front door wall or back wall. The wafer 324 as illustrated may be a bonded wafer as described herein and
25 with the thinned wafer side facing upward in Figures 15 and 16 and to the right in Figure 17 such that the engagement in the shock condition is with the thinned wafer side.

Referring to Figures 21 and 22, various embodiments of the disclosure may have shock condition cushions 350 on both sides of the primary non-shock transport seating position 353 of the wafer edge engagement portions 356. In a front loading wafer carrier,
30 the wafer 360 may engage a lower ramp of the wafer engagement portion, ride up the ramp to the primary transport seating position 353 and upon complete closure of the door deflect the spring portion 364 and pad 366 such that the shock condition cushions 350 are

exposed. In a shock condition, the shock condition cushions are available to protect the wafer, for example prevent disengagement with the wafer edge engagement portion and to provide shock absorption.

Referring to Figures 23-31, in an embodiment, a front opening wafer container 420 generally comprises a container portion 430 and a door 432. With specific reference to Figures 23-26, the door comprises a door chassis 438 having an inward wall 440 with a pair of latch mechanisms 442, 443 mounted to the chassis and exposed on the exterior side 445 of the door. A forward primary wafer support 450 is mountable on the inward wall 440 and has a pair of columns 454, 456 of cantilevered spring finger portions 469 with an elongate spring portion 470, wafer edge receiving portions 472 unitary with the spring portions. Each wafer edge receiving portion 472 has a V-shaped recess 476 for receiving the edge of a wafer. The forward primary wafer support further has structure 480 configured as spring latches 480 for attachment to cooperating structure 482 on the inward wall configured as bosses 482, for securing the forward primary wafer support to the interior facing side 485 of the door.

The inward wall 440 of the door chassis 438 further has unitarily formed projections 490 extending therefrom for preventing cross slotting. The projections are molded integrally with the chassis and are positioned to be intermediate the wafer slots defined by the shelf seating positions of the wafers on the shelves and intermediate the normal transport seating position of the wafers when supported by the forward primary wafer support and a rearward wafer support. In conventional shipping containers such as FOSBS, the wafers, when supported by the forward primary wafer support and the corresponding rearward support, will be elevated above the transport seating position on the shelves such as illustrated by Figures 34 and 35.

The forward cross slotting prevention projections 490 may have a taper narrowing in a direction away from the door and may have a plurality of nodes 492 that project away from the door. The nodes allow use of a minimal amount of polymer in the projections which is conducive to minimizing distortion in the molding process while providing a suitable upper contact surface and a lower contact surface for engaging wafer(s) that are moved out of their transport seating position. Three nodes are suitable.

Referring to Figures 27 to 31, details of the container portion 430 of the front opening wafer container of Figure 23 are depicted. The container portion comprises a shell 502, depicted in isolation in Figure 29, which provides a unitary wall 504 which extends around the left side 505, right side 506, top 507, bottom 508, and back side 509.

5 The container portion further comprises a robotic flange 510 attached at the top 512 of the shell, a pair of columns 516, 517 of wafer shelves 518 attached to an inside surface 520 of the shell, and kinematic coupling components 526 attached to the exterior surface 528 at the bottom 508 of the shell. Attachment structure 532 is provided on the unitary wall 504 for receiving handles on the left and right sides and the shell includes a forward door

10 frame 536. The shelves attach to rearward back wall structure 537 and side wall structure 538. In some embodiments, the columns 516, 517 of wafer shelves 518 include rearward primary wafer supports 540 unitary with the shelves 518. Each wafer support comprises a a column of wafer engagement portions 544, each having a lower ramp portion 546 and a V-shaped recess 550 at the normal transport seating position. The ramp portions raise the

15 rearward edges of the wafers upwardly off of the wafer shelves when the door is seated in the door frame 536.

The rear wall projections 490 provide cross-slotting prevention at the rear wafer supports unitary with the columns of shelves under a shock condition or other condition that might dislodge a wafer or wafers from their normal transport seating position. In that

20 the projections are intended to rarely contact the wafers, they are not subject to wear or other deformation common to conventional wafer supports. Therefore they do not need to be replaceable. This provides the advantage of less capture regions for particles and less problematic drying areas after cleaning as compared to a attachable piece with the projections.

Referring to Figures 32-35, diagrammatic illustrations of a front opening wafer container 600 has a container portion 602, a front door 604, wafer shelves 606 defining a wafer shelf seating position 610, forward wafer supports 614 and rearward wafer supports 618. In this embodiment, the rearward wafer supports are located at the columns 617 of shelves with the wafer supports comprising ramps 619 positioned proximate the rearward

25 most portion of each of the columns of shelves. The forward wafer supports 614 have a spring arm 620 portrayed by a coiled spring symbol and a ramp portion 621. In a horizontal position with the door open, as depicted in Figures 32 and 34, the wafers 624 are seated on the shelves. When the door is latched to the open front 626, the wafers are

30

elevated by the wafer engagement portions 630 of the wafer supports 614, 618 to the transport seating position 627 as shown in Figure 33 and 35. The wafer container may be partially rotated rearwardly one quarter turn for transport whereby the wafers are vertically oriented, not shown. The cross slot prevention projections 654, 655 extend from the front door and may be unitary with or may be attached to the front door inward wall or shell back wall.

“Shock condition cushion portions” when used herein may refer to a discrete component or a part or section of a component. Shock condition cushions, portions, and projections may be formed of more than one polymer, for example a rigid polymer with a coating or overmolded portion of a softer and/or elastomeric polymer. In some embodiments, the softer coating may be molded first and the more rigid support polymer molded secondly.

The above references in all sections of this application are herein incorporated by references in their entirety for all purposes. For purposes of interpreting the claims, it is expressly intended that the provisions of Section 112, sixth paragraph of 35 U.S.C. are not to be invoked unless the specific terms “means for” or “step for” are recited in a claim

All of the features disclosed in this specification (including the references incorporated by reference, including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including references incorporated by reference, any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s), but rather extends to any novel one, or any novel combination, of the features disclosed in this specification (including any incorporated by reference references, any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps

of any method or process so disclosed. The above references in all sections of this application are herein incorporated by reference in their entirety for all purposes.

Although specific examples have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement calculated to achieve the same purpose could be substituted for the specific examples shown. This application is intended to cover adaptations or variations of the present subject matter. Therefore, it is intended that the invention be defined by the attached claims and their legal equivalents, as well as the following illustrative aspects. The above described embodiments of the disclosure are merely descriptive of its principles and are not to be considered limiting.

Further modifications of the embodiments herein disclosed will occur to those skilled in the respective arts and all such modifications are deemed to be within the scope of the invention.

Claims

1. A front opening wafer container for receiving and transporting wafers, the wafer container comprising a container portion with an open front and a door that closes the open front defining an open interior, the door having an inside surface, the wafer container further comprising a forward primary wafer support for securing a plurality of wafers axially aligned in the wafer container in an orientation with the wafers horizontal in a normal orientation, the wafer container rotatable rearwardly one quarter rotation and seatable on flattened portions of a back wall of the container portion to an orientation with the wafers vertical in a transport orientation;

each of the plurality of wafers to be received and transported having an upper side and a lower side and comprising a carrier substrate at the lower side and a thinned wafer adhered to the carrier substrate at the upper side, the carrier substrate having an edge and the thinned wafer having an edge displaced radially inward from the edge of the carrier substrate,

the forward primary wafer support formed of a polymer and being attached to one of the inside surface of the front door and the container portion at the back wall, the wafer support having a plurality of pairs of wafer edge engagement portions, each wafer edge engagement portion having a normal wafer seating region providing a normal transport wafer seating position,

a secondary wafer cushion comprising an elongate strip centrally attached to the forward primary wafer support and a plurality of projections aligned intermediate the normal transport seating regions, each of the plurality of projections extending radially inwardly beyond radial positions of the wafer edge engagement portion of the forward primary wafer support, each of the projections presenting an I-shape with an upwardly facing flange portion and a downwardly facing flange portion, the secondary wafer cushion formed of a polymer softer than the polymer of the primary wafer support.

2. The front opening wafer container of claim 1 wherein the shock deflection contact region comprises a thermoplastic elastomer with a Shore D hardness of from 30-35.

3. A front opening wafer container for receiving and transporting wafers, the wafer container comprising a container portion with an open front and a front door that closes the open front defining an open interior, the door having a chassis with an inside surface, the wafer container further comprising a forward primary wafer support for securing a plurality of wafers axially aligned in the wafer container in an orientation with the wafers horizontal in a normal orientation, the wafer container rotatable rearwardly one quarter rotation and seatable on a back wall of the container portion to an orientation with the wafers vertical in a transport orientation;

each of the plurality of wafers having circular shape with an edge;

the forward primary wafer support formed of a polymer and being attached to an inside surface of the front door, the wafer support having a plurality of pairs of wafer edge engagement portions defining two columns of wafer edge receiving portions, each wafer edge engagement portion having a normal wafer seating region defining a normal wafer transport seating position corresponding to the shape of the plurality of wafers;

the front door further comprising a plurality of projections aligned in a single column and positioned intermediate the normal wafer transport seating positions, each of the plurality of projections projecting radially inwardly beyond a radially inward position of the wafer edge engagement portions of the forward primary wafer support, each of the projections formed unitary with the front door chassis.

4. The wafer container of claim 3 wherein the container portion has a column of projections extending from and unitarily formed with the back wall of the wafer container, each projection positioned intermediate the normal wafer transport seating positions and projecting radially inward of the normal wafer transport seating regions of the wafers.

5. The wafer container of claim 4 further comprising a pair of rearward primary wafer supports, each of said pair unitary with a column of wafer shelves attached to the sidewall of the container portion.

6. The wafer container of claim 4 wherein each of the projections of the column of projections is tapered in a direction away from the wall and a plurality of the projections have three nodes.

7. A front opening wafer container for receiving and transporting wafers, the wafer container comprising a container portion with an open front and a front door that closes the open front, the container portion comprising a shell with a unitary wall, a pair of columns of wafer shelves mounted to the shell in an interior of the shell and defining a plurality of wafer slots, a three groove kinematic coupling at a bottom side of the shell, and a robot flange positioned at the top of the shell, the unitary wall having a rearward column of unitarily formed projections extending inwardly and with each projection positioned intermediate sequential pairs of the wafer slots, the door comprising a chassis with an inward wall, a pair of latching mechanisms mounted on the chassis, and a primary wafer cushion mounted to the inward wall of the door, the inward wall of the chassis having a forward column of projections corresponding to the rearward column of projections and with each projection positioned intermediate sequential pairs of the wafer slots.

8. A bonded wafer container comprising a container portion and a door for closing the container portion, a wafer support assembly positioned on one of the door and a back wall of the container portion, the wafer support assembly having a first polymer component for engaging bonded wafers in a non-shock condition and a second polymer component position for engaging the bonded wafers in a shock condition, the second polymer being softer than the first polymer, the second polymer component comprising a column of I shaped wafer shock engagement members.

9. A bonded wafer container comprising a container portion and a door for closing the container portion, a wafer support assembly positioned on one of the door and a back wall of the container portion, the wafer support assembly having a first polymer component for engaging bonded wafers in a non-shock condition and a second polymer component position for engaging the bonded wafers in a shock condition, the second polymer being softer than the first polymer, the second polymer component comprising a column of I shaped wafer shock engagement members..

10. A wafer container comprising a container portion with a front opening for receiving wafers and seating the wafers in the container portion in a horizontal orientation, and a door sized to the front opening, the door having a latch for attaching to the container portion and a forward wafer support on an inwardly facing door surface, the wafer support having a vertical polymer strip positioned centrally on the inside of the front door, the strip

having a plurality of pairs of opposing finger members and wafer engagement pads integral with the strip and in vertical alignment, each one of the pair configured as a mirror image of the other of the pair about a vertical plane perpendicular to the door and through the vertical polymer strip;

the vertical polymer strip having side peripheries and wherein the pairs of opposing finger portions extend from the side peripheries;

wherein the vertical polymer strip is attached to a planar surface on the door and each finger extends at an acute angle with respect to the planar surface;

wherein each individual finger member and wafer engagement pad of each pair provides a force moment to the central polymer strip that is counteracted by the other individual finger member and wafer engagement pad of each pair.

further comprising an elastomeric strip with a column of I shaped projections extending from the strip and position for cross slot protection.

11. A wafer container with a first wafer support with a plurality of primary wafer edge engagement portions and an opposing second wafer support with a plurality of primary wafer edge engagement portions, the first and second wafer supports arranged to suspend a plurality of wafers therebetween in a normal wafer seating position, the wafer container having a plurality of shock condition projections at the front door that are unitary with a front door chassis.

12. The wafer container of claim 11 wherein the shock condition projections are of a material softer than a material of which the at least one of the first and second wafer supports.

13. The wafer container of claim 11 wherein a plurality of shock condition projections are unitary with a back wall of the wafer container.

14. The wafer container of any one of claims 10-12, wherein the shock condition projections of the first or second wafer support are all unitary with one another.

15. The wafer container of any one of claims 10-12, wherein the shock condition cushion portions are formed of an elastomer.
16. The wafer container of any one of claims 10-12, wherein the shock condition cushion portions are overmolded on a primary wafer support portion.
17. The wafer container of any one of claim 1-16 configured to hold 300 mm wafers and wherein the container has feet on the back wall for sitting the container with the door upward.
18. The wafer container of claim 17 in combination with 300 mm bonded wafers contained in the wafer container.

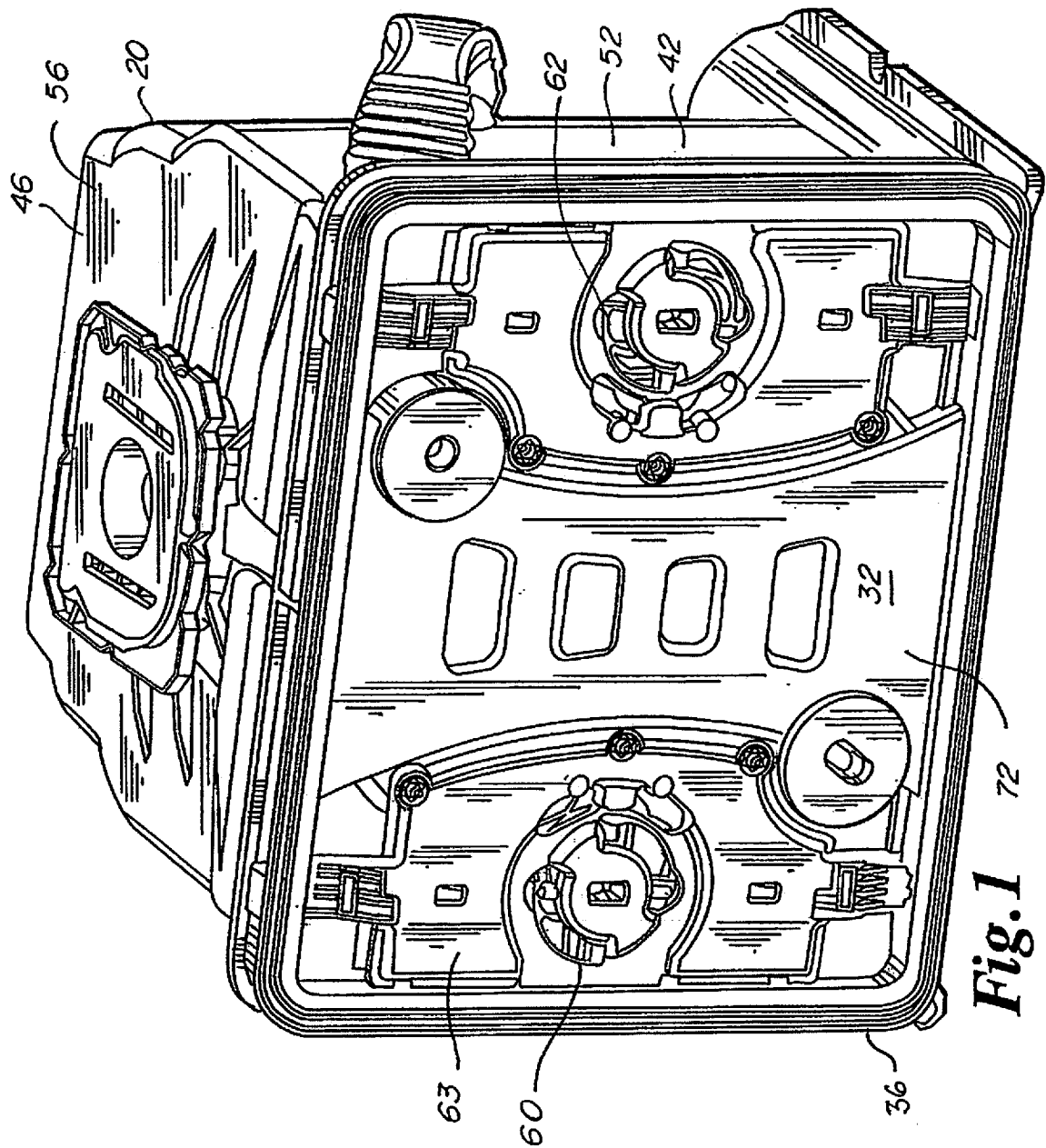


Fig. 1

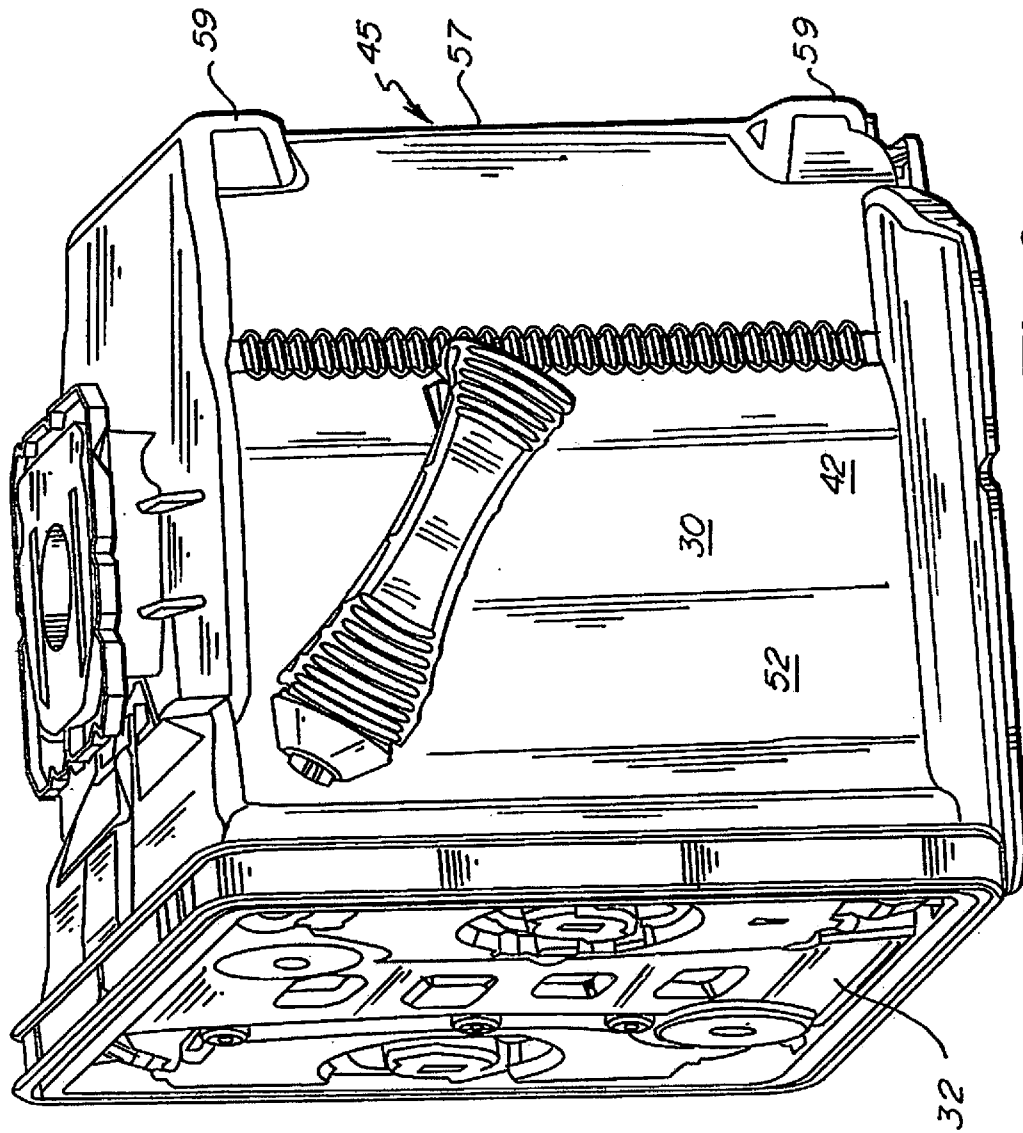


Fig. 2

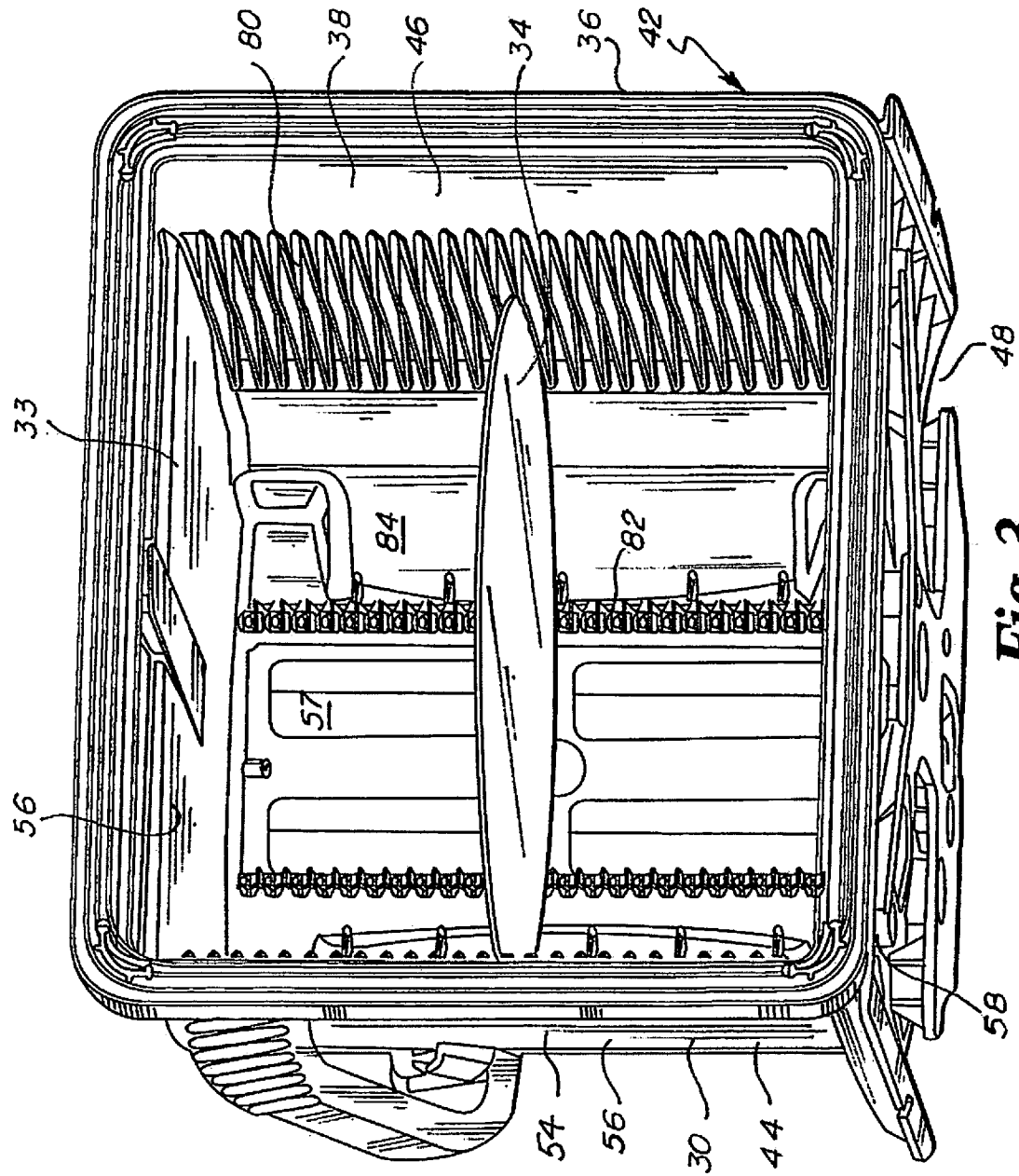
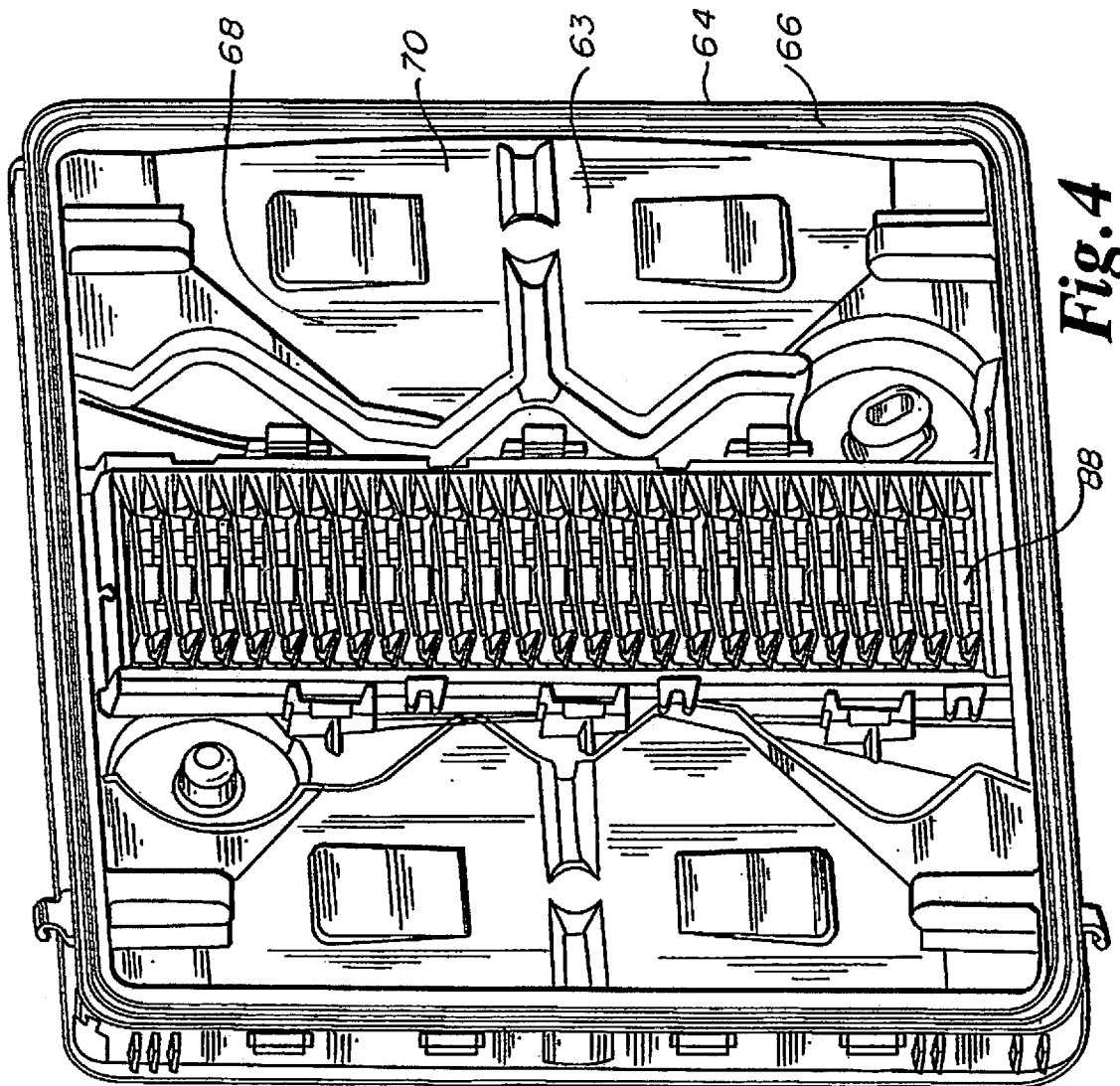
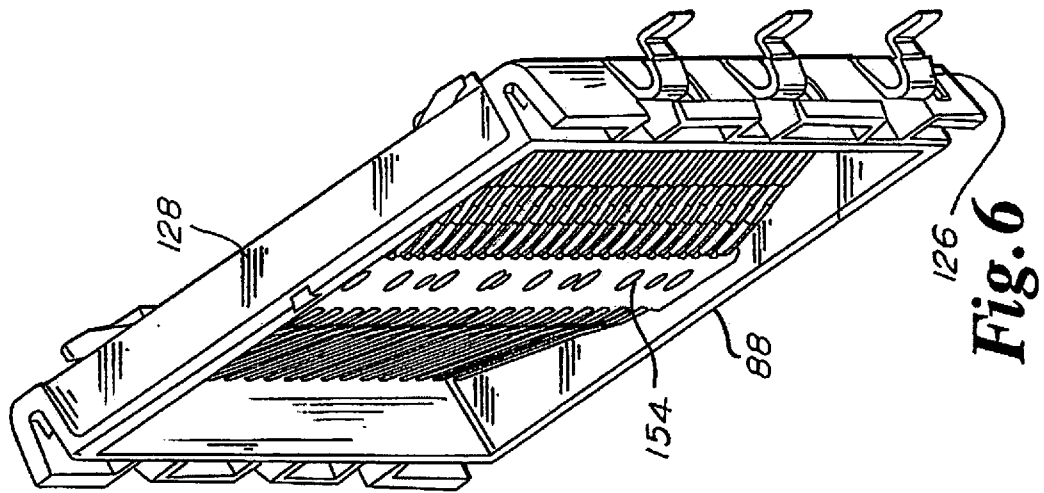
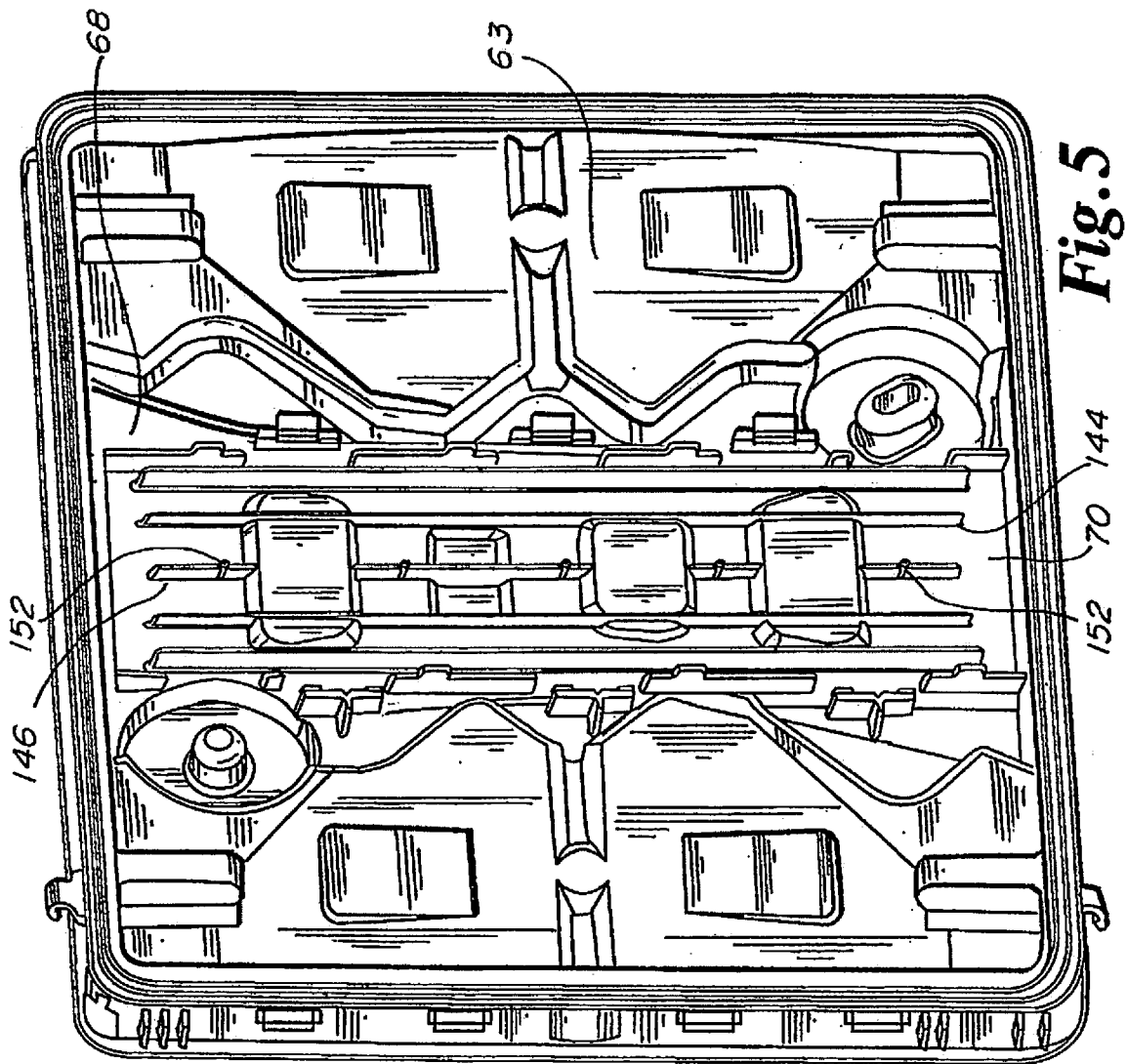
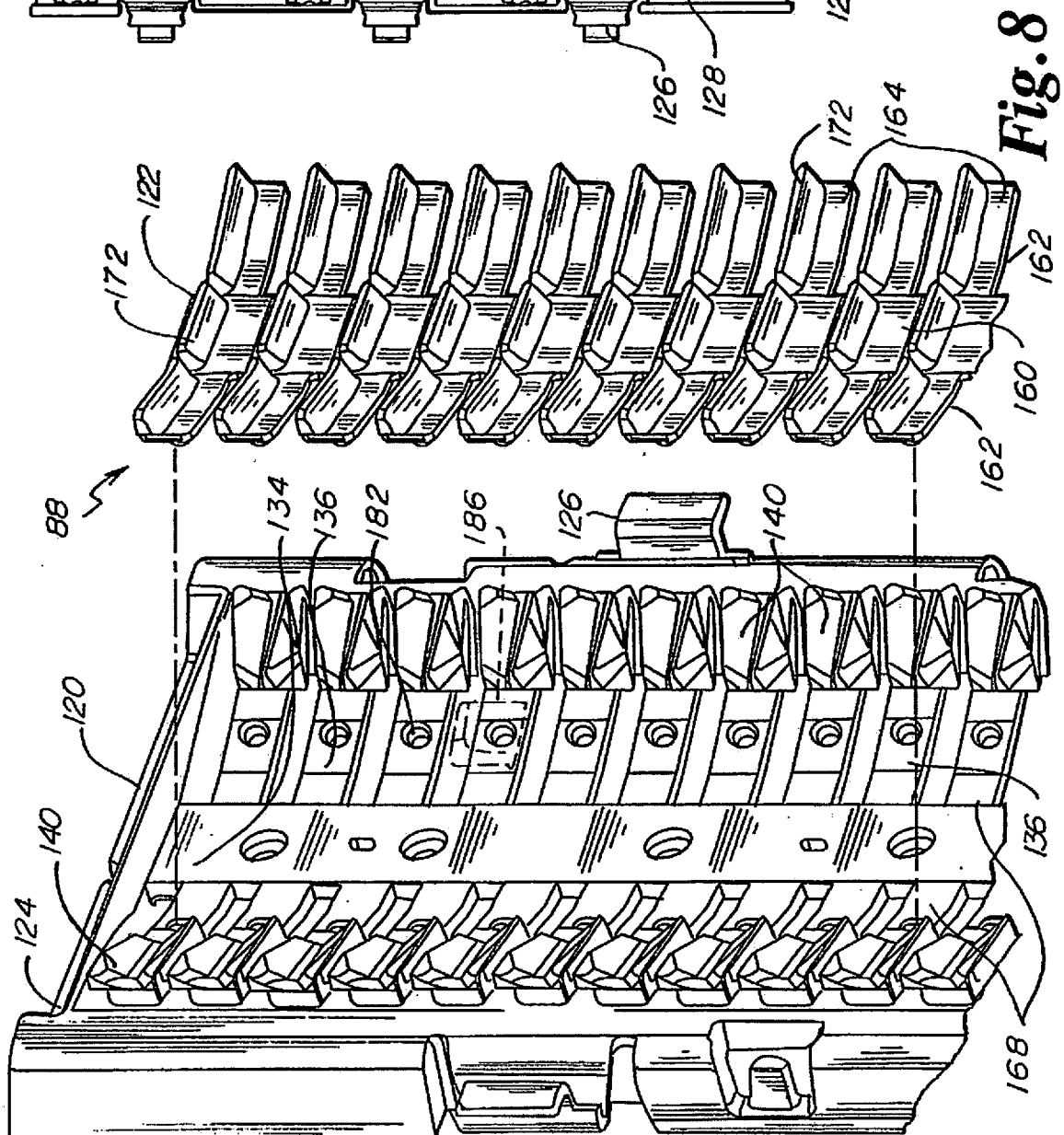
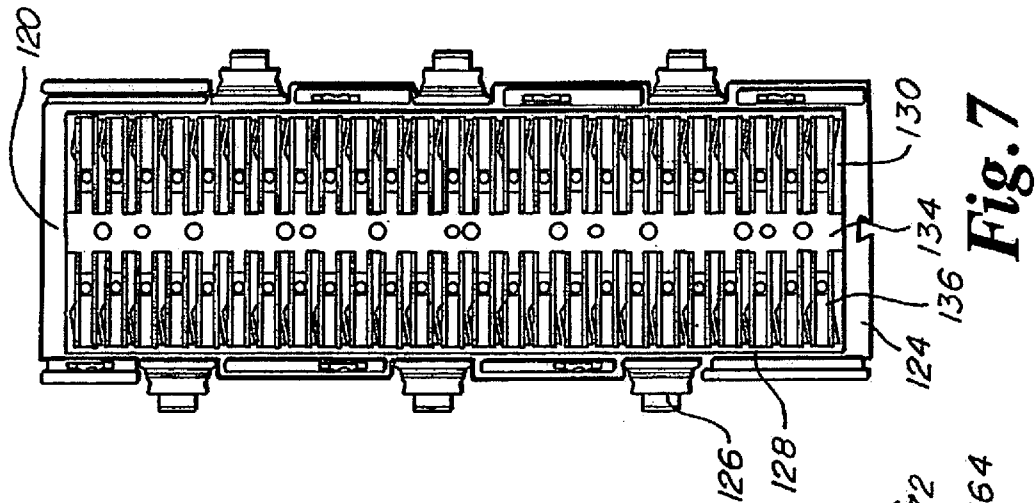


Fig. 3







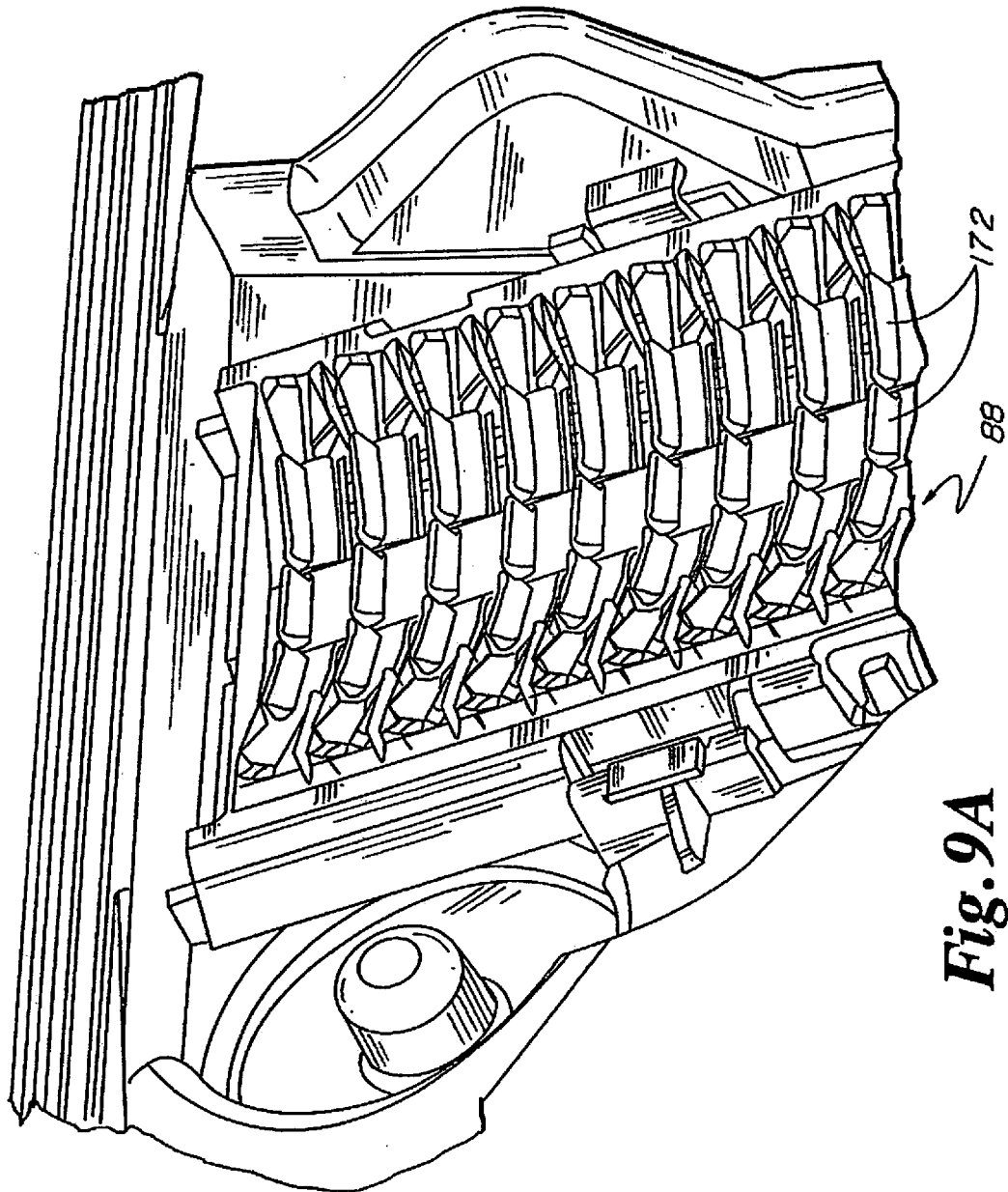
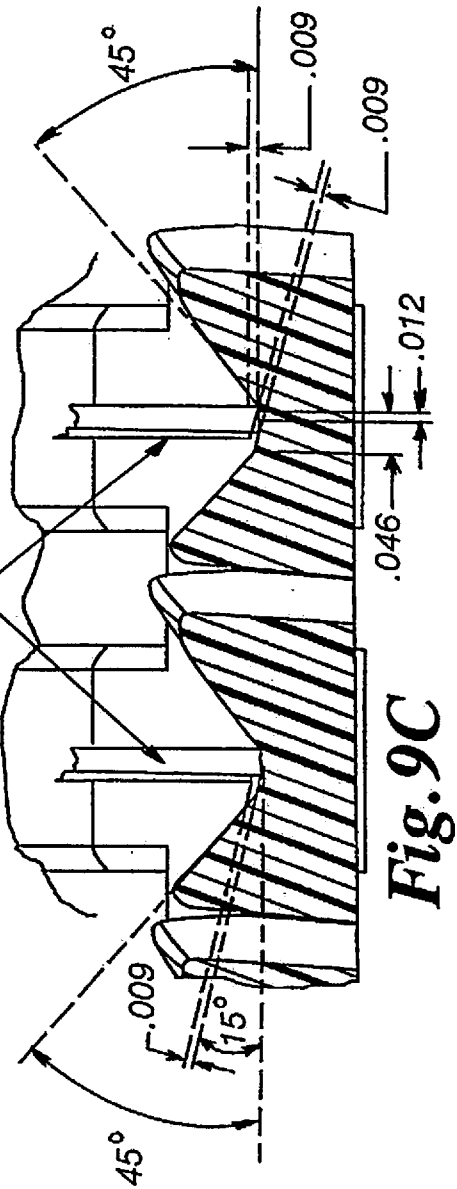
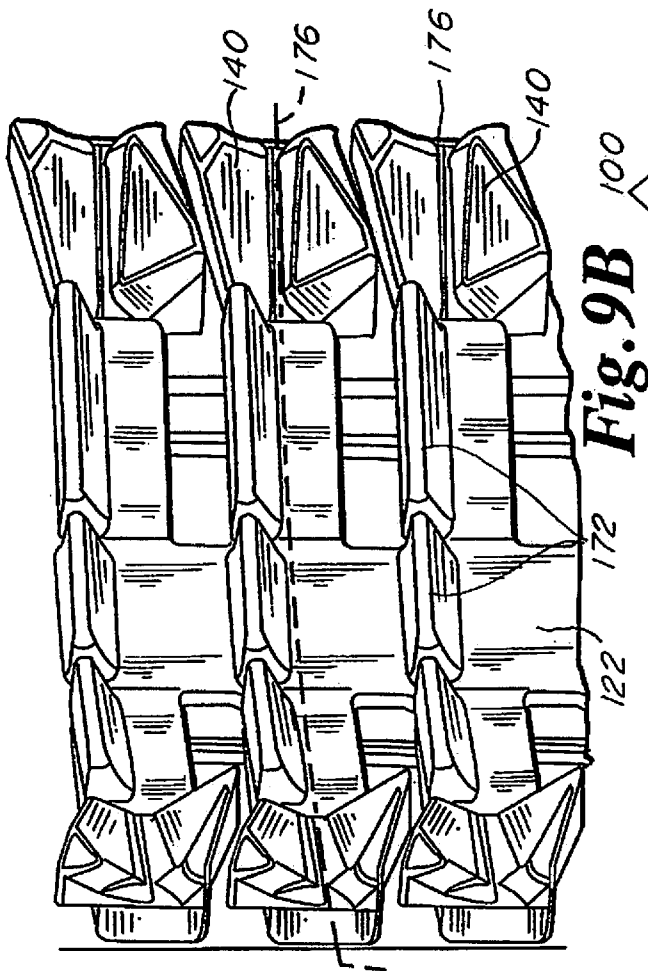
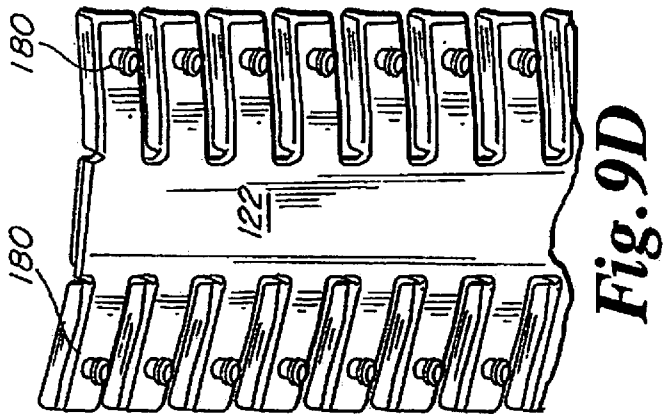
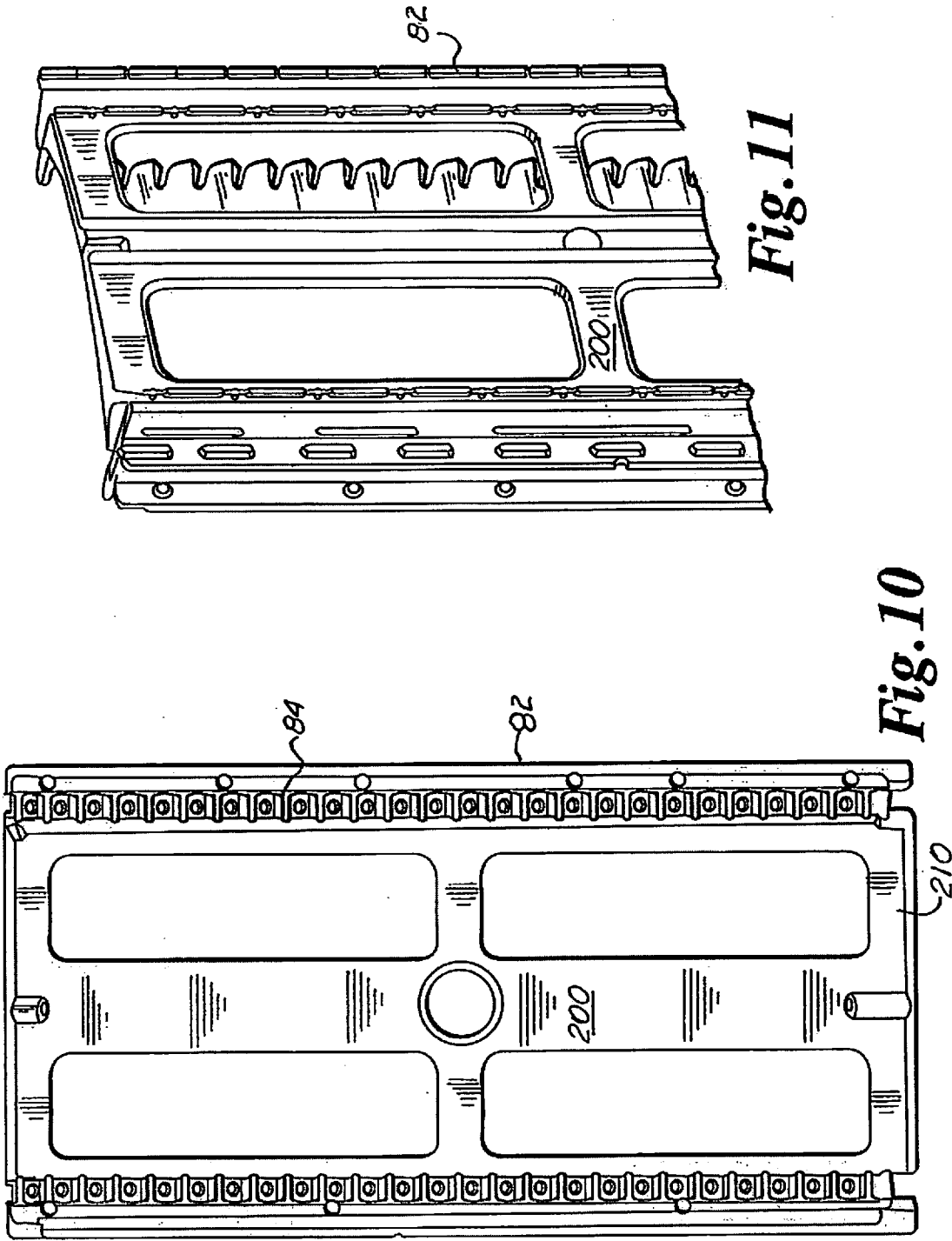


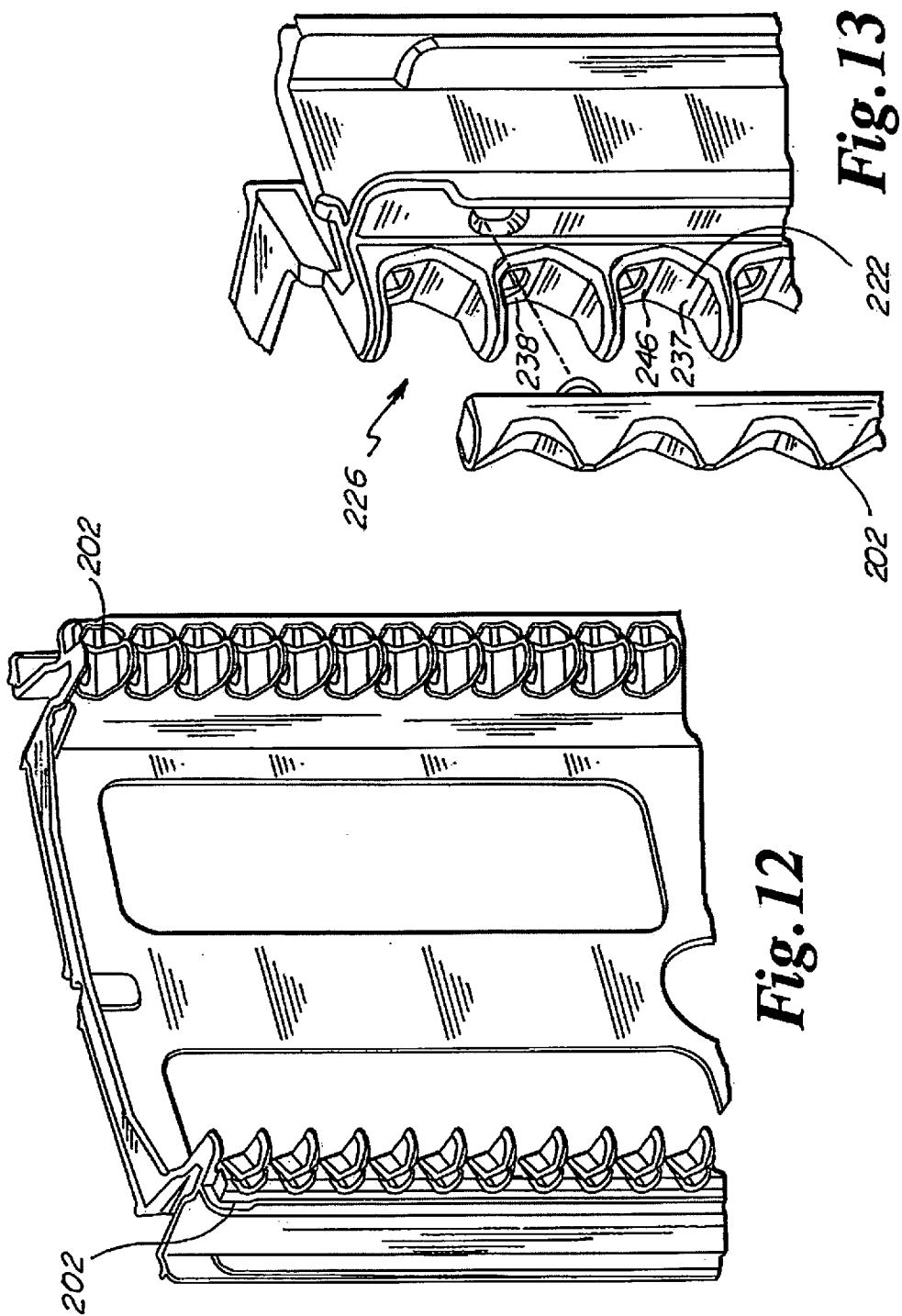
Fig. 9A

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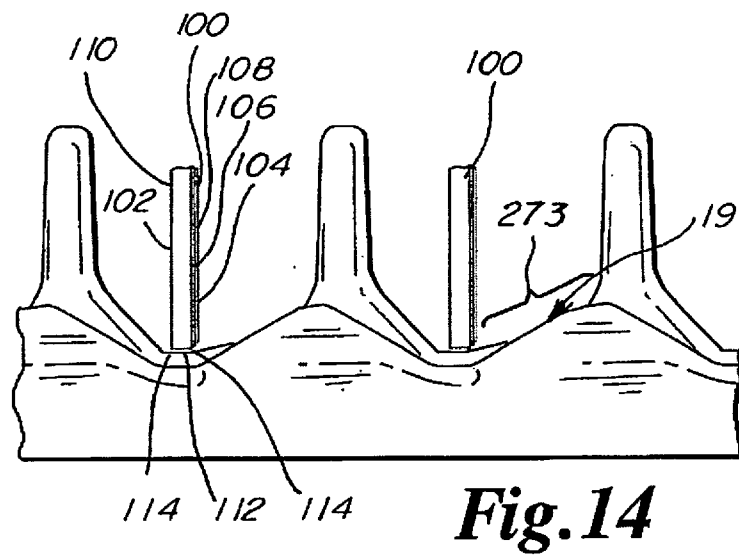
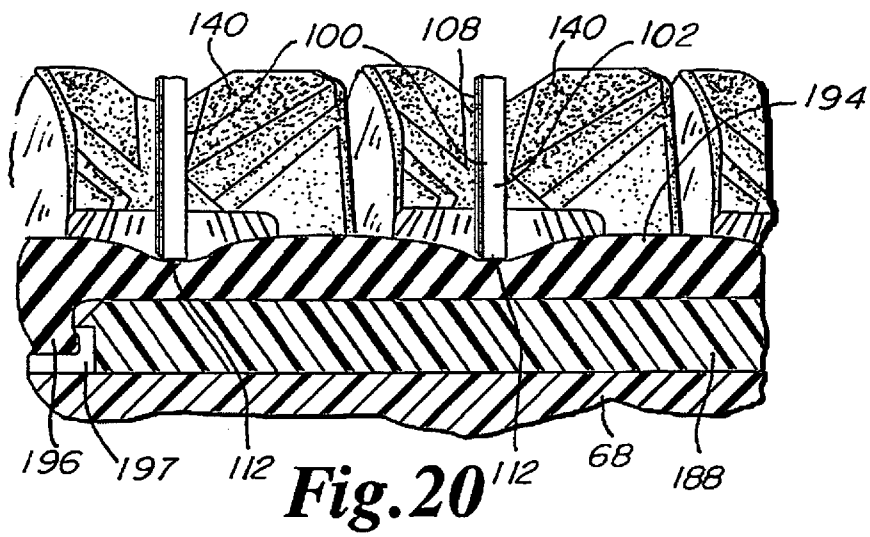




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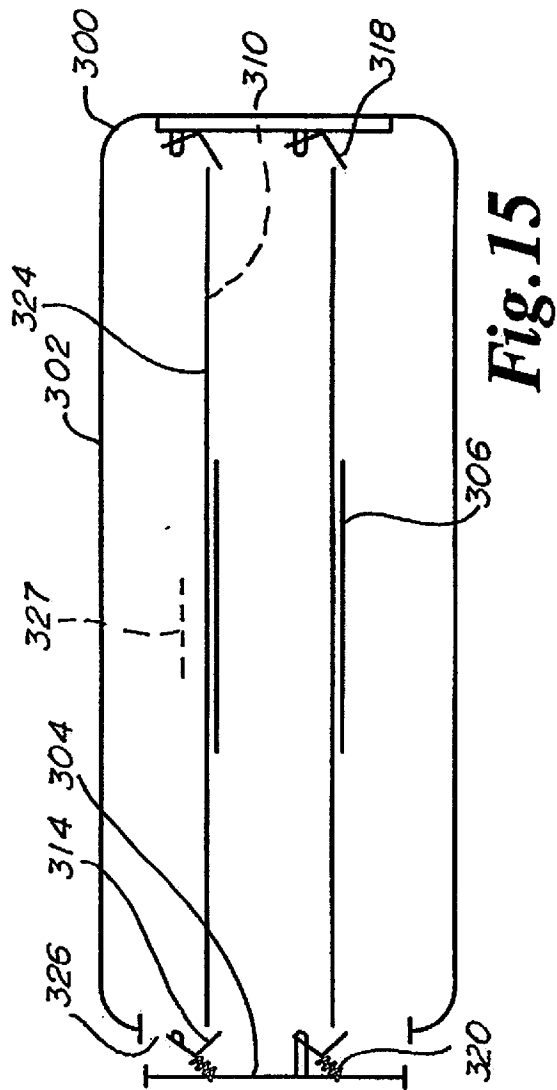


Fig. 15

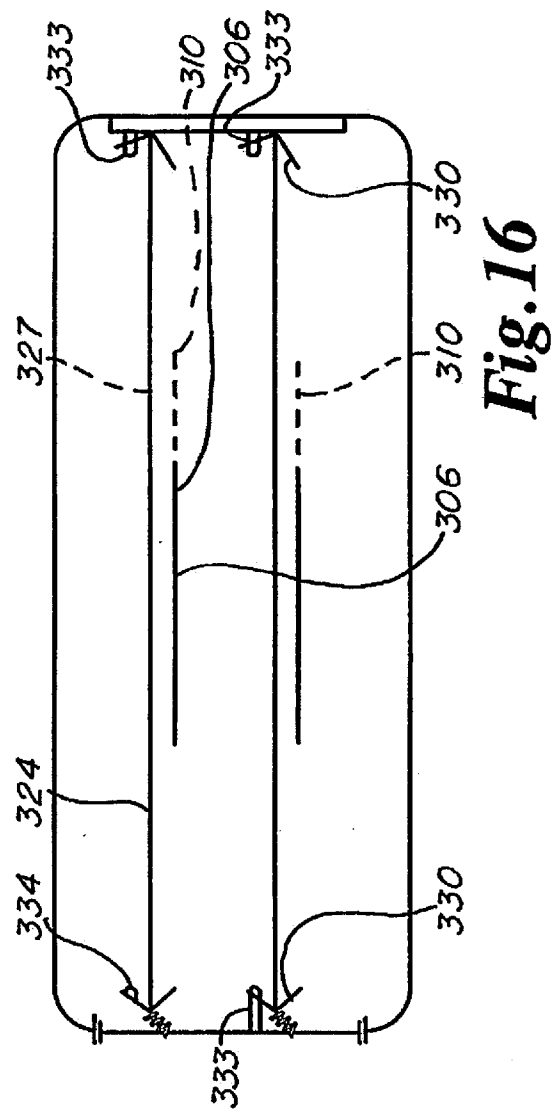


Fig. 16

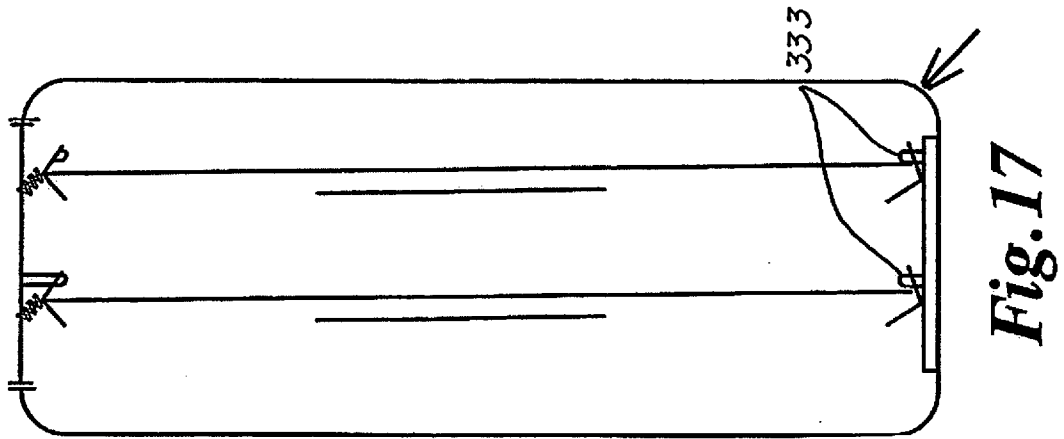
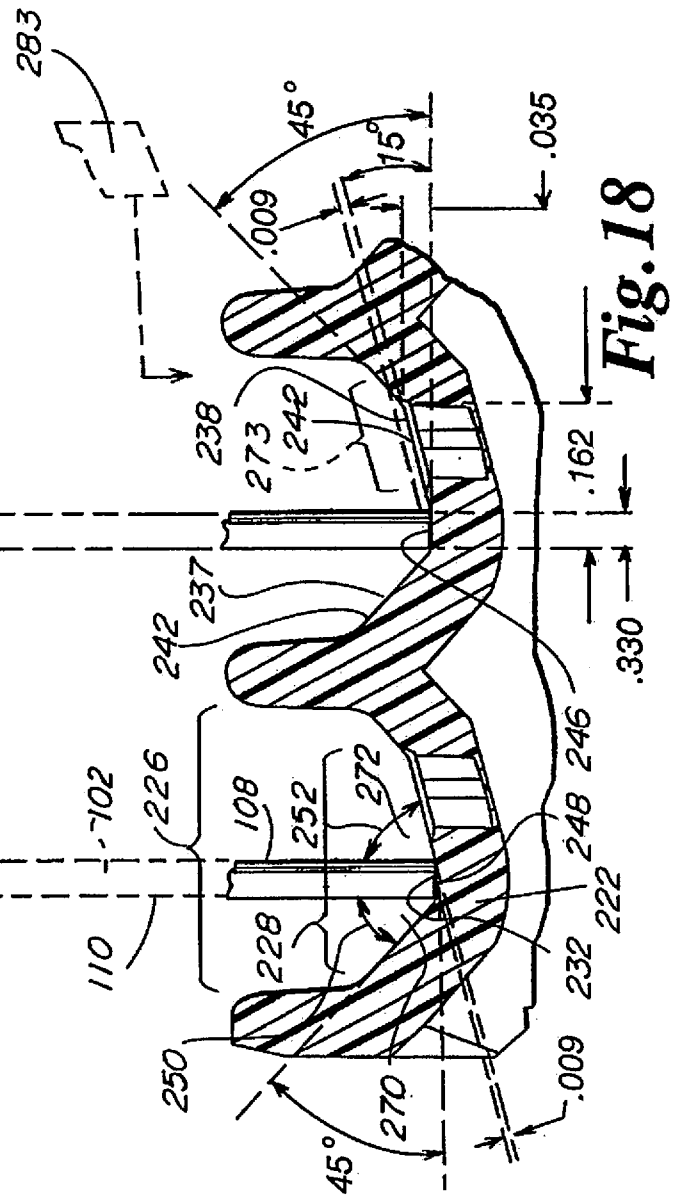
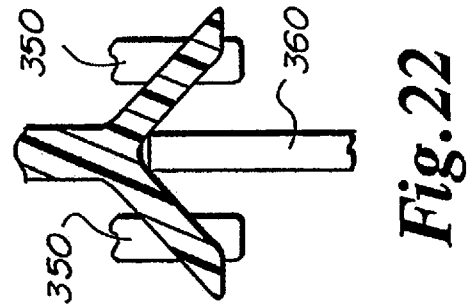
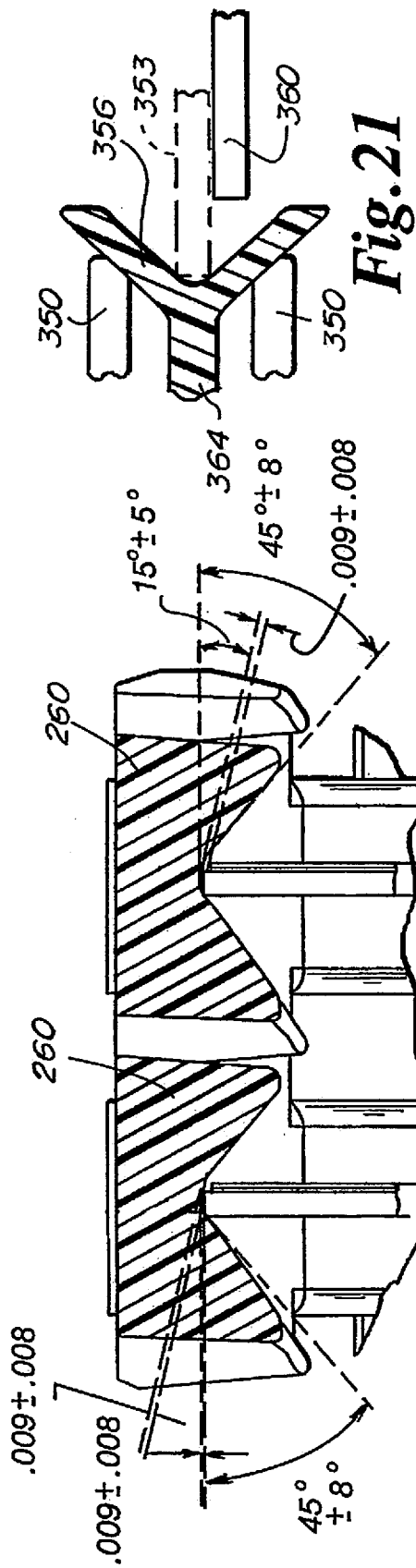
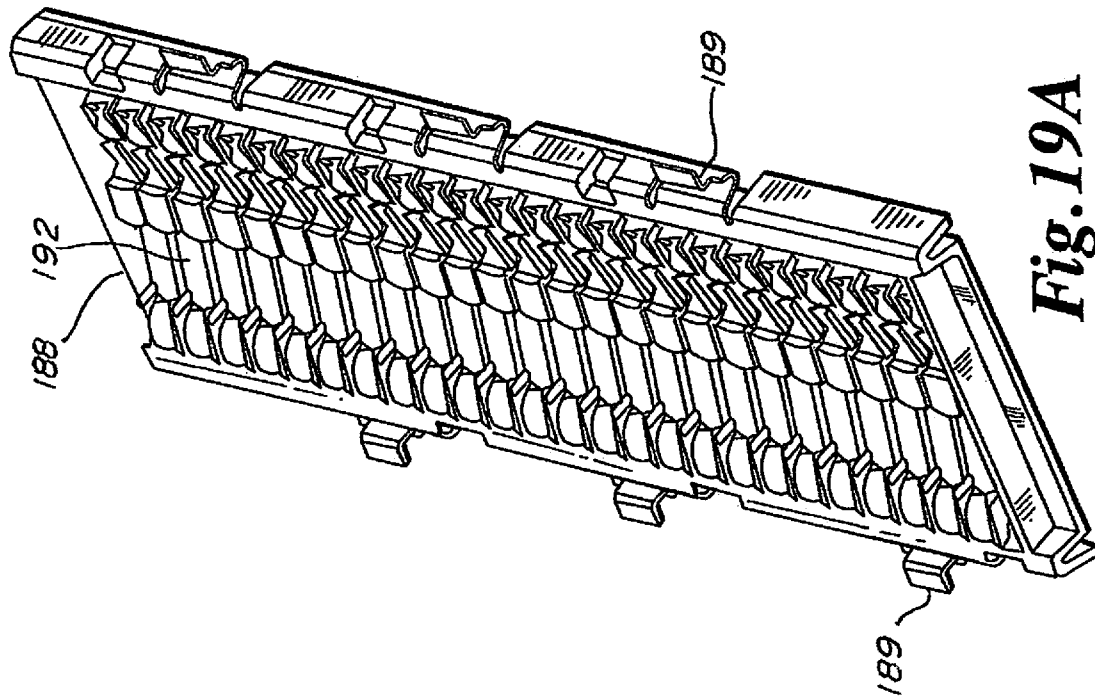


Fig. 17





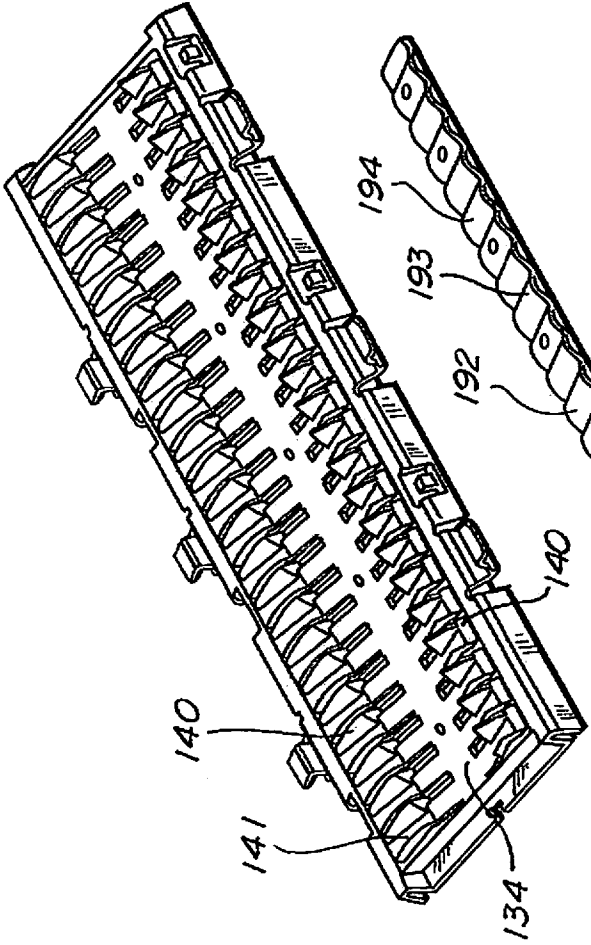


Fig. 19B

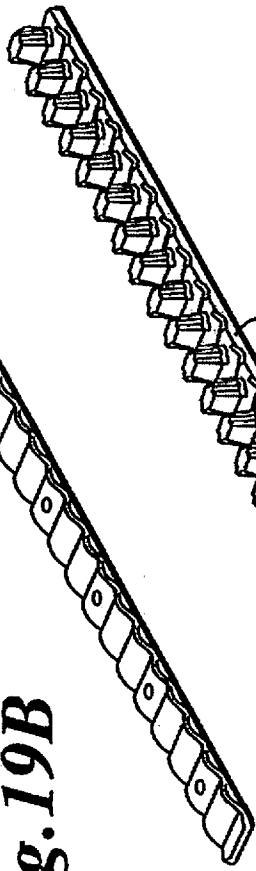


Fig. 19C

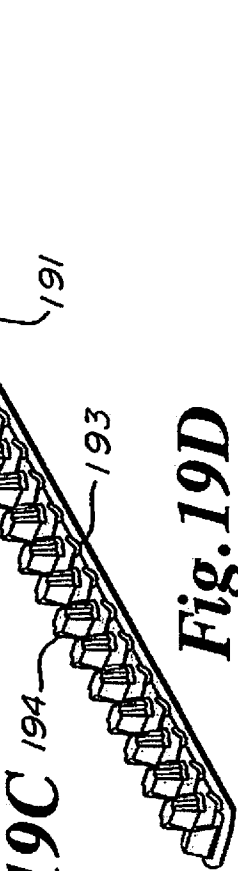


Fig. 19D

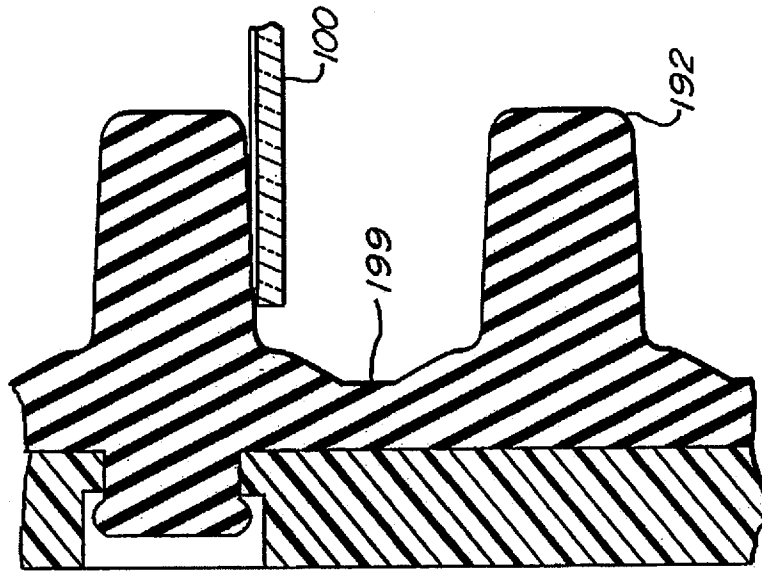


Fig. 19F

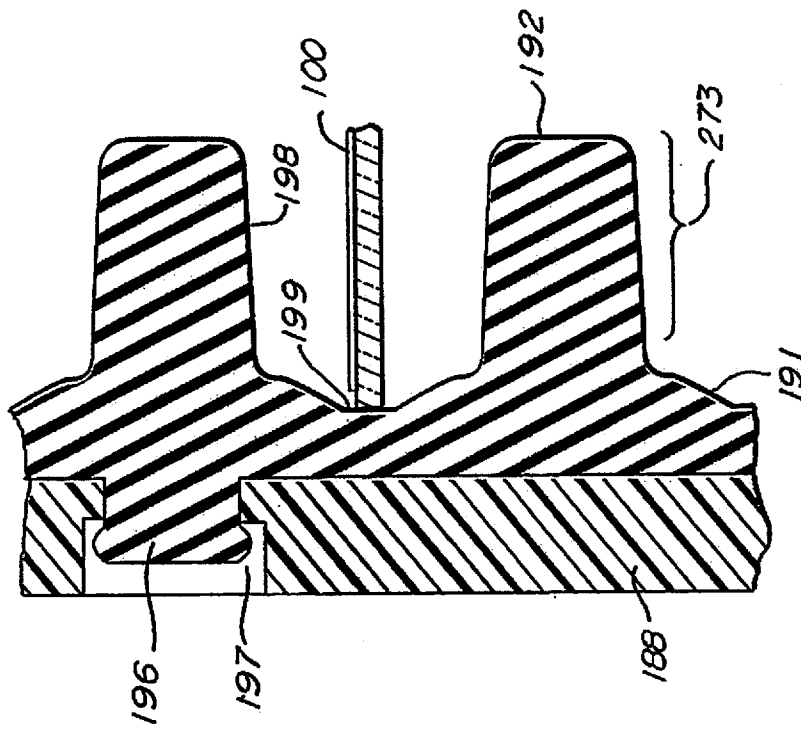


Fig. 19E

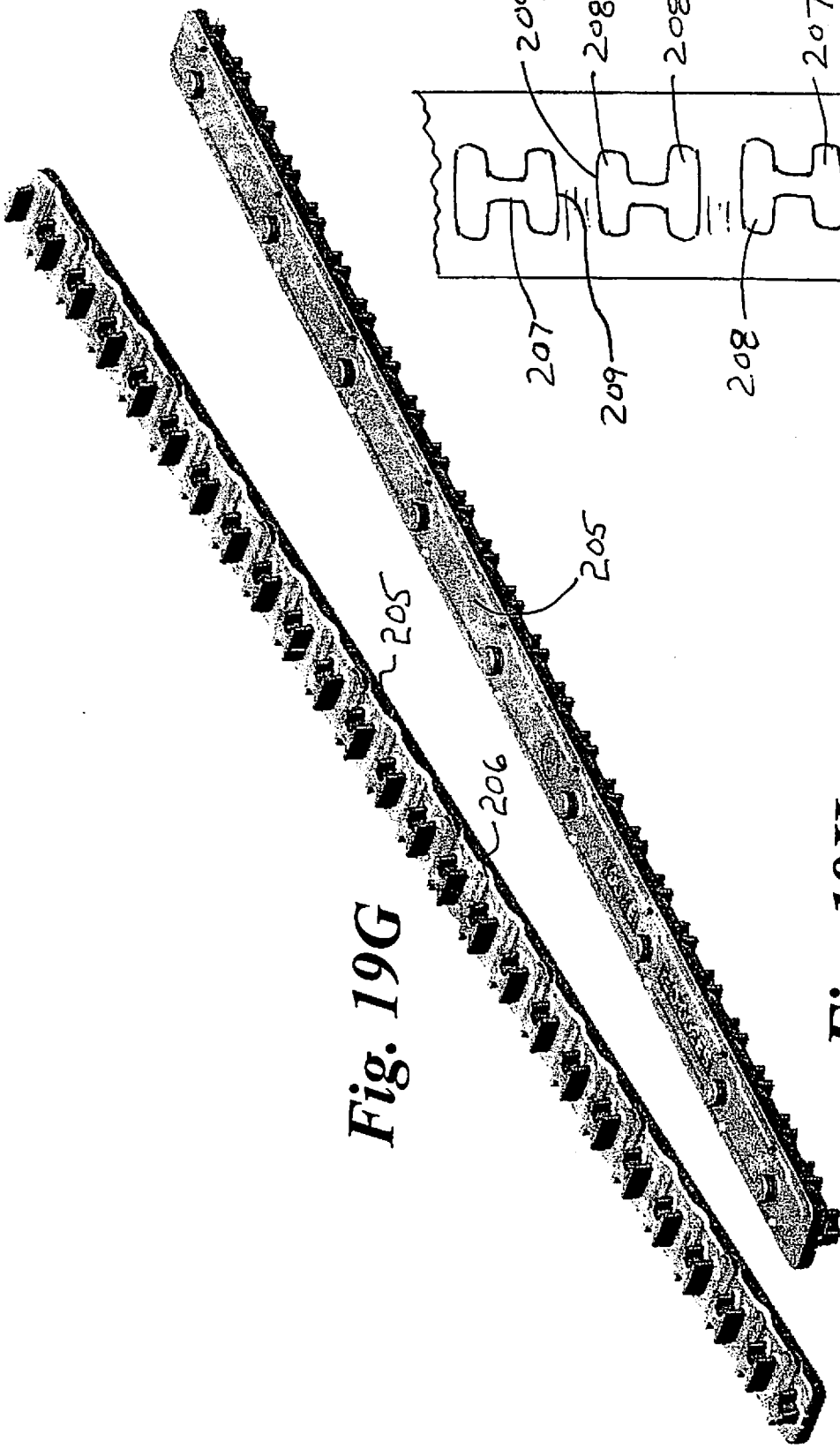


Fig. 19G

Fig. 19H

Fig. 19I

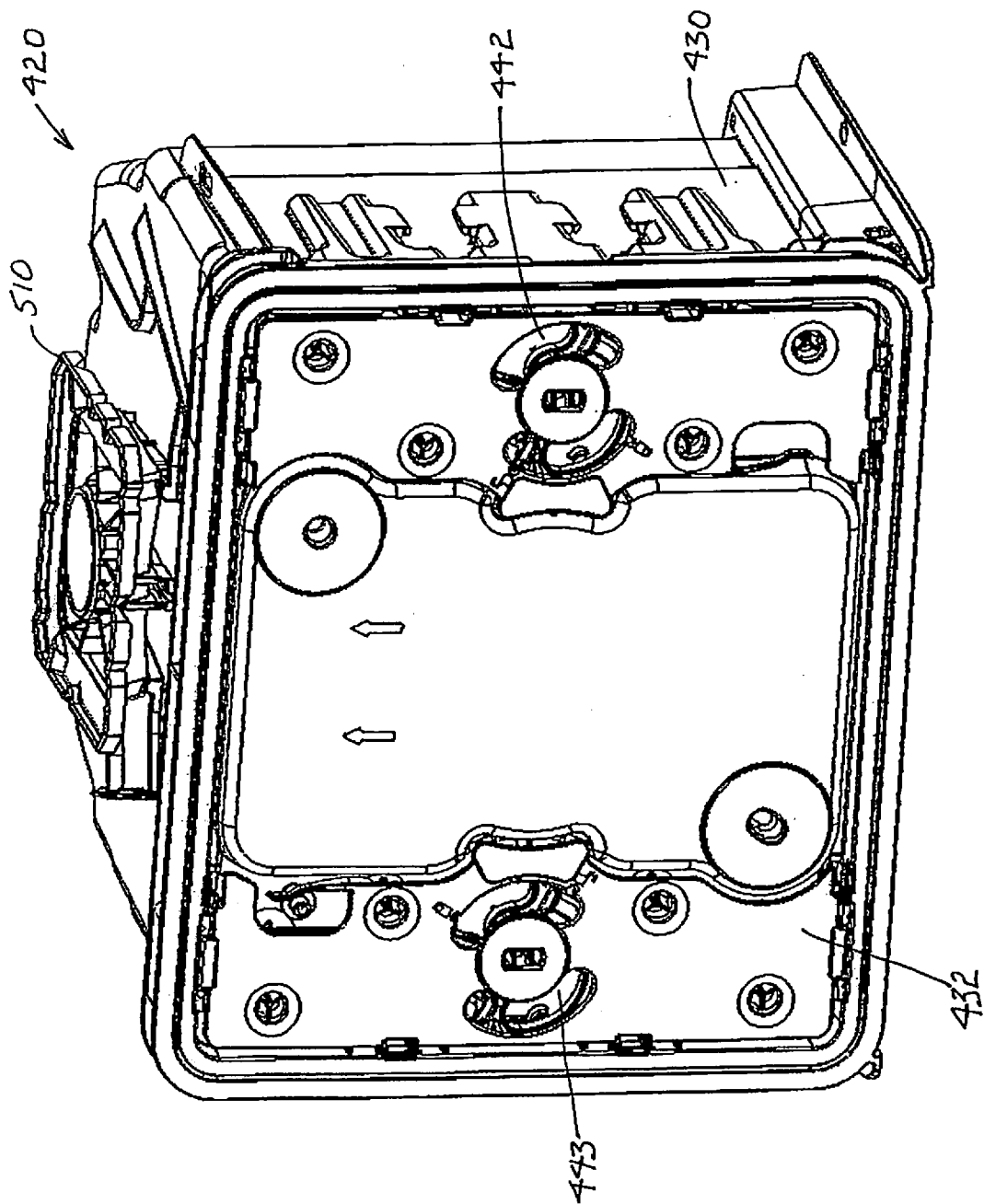


Fig. 23

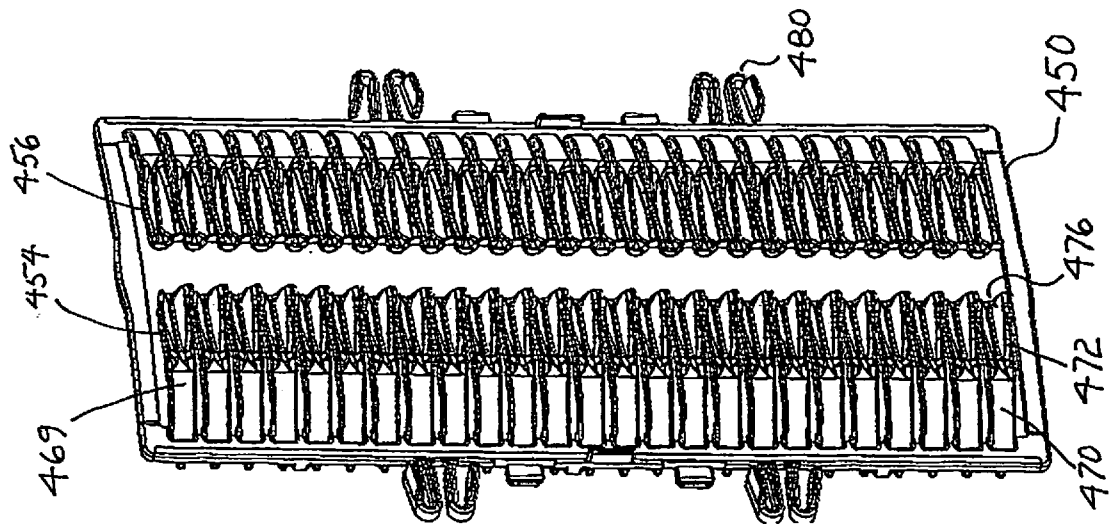


Fig. 25

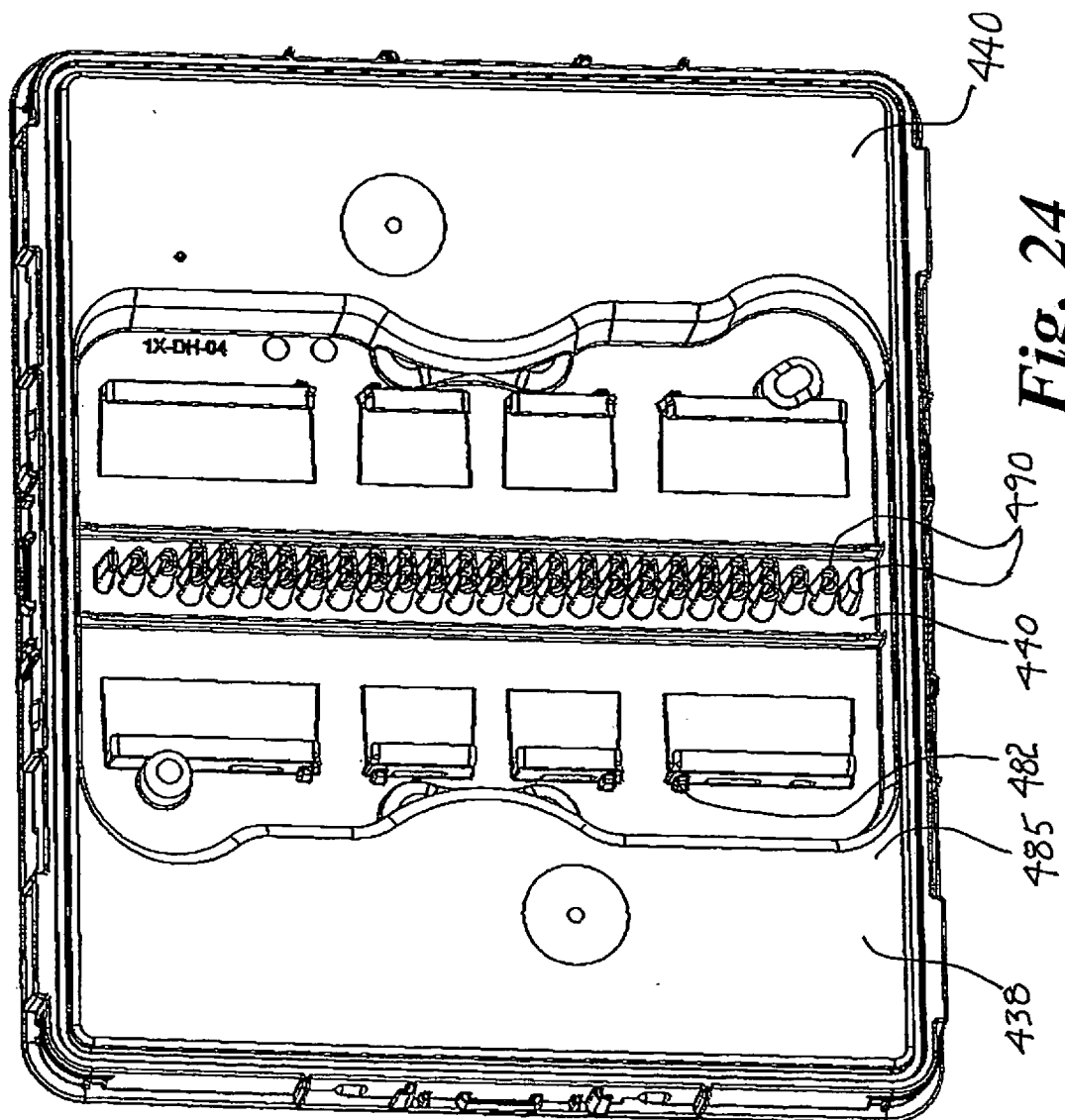
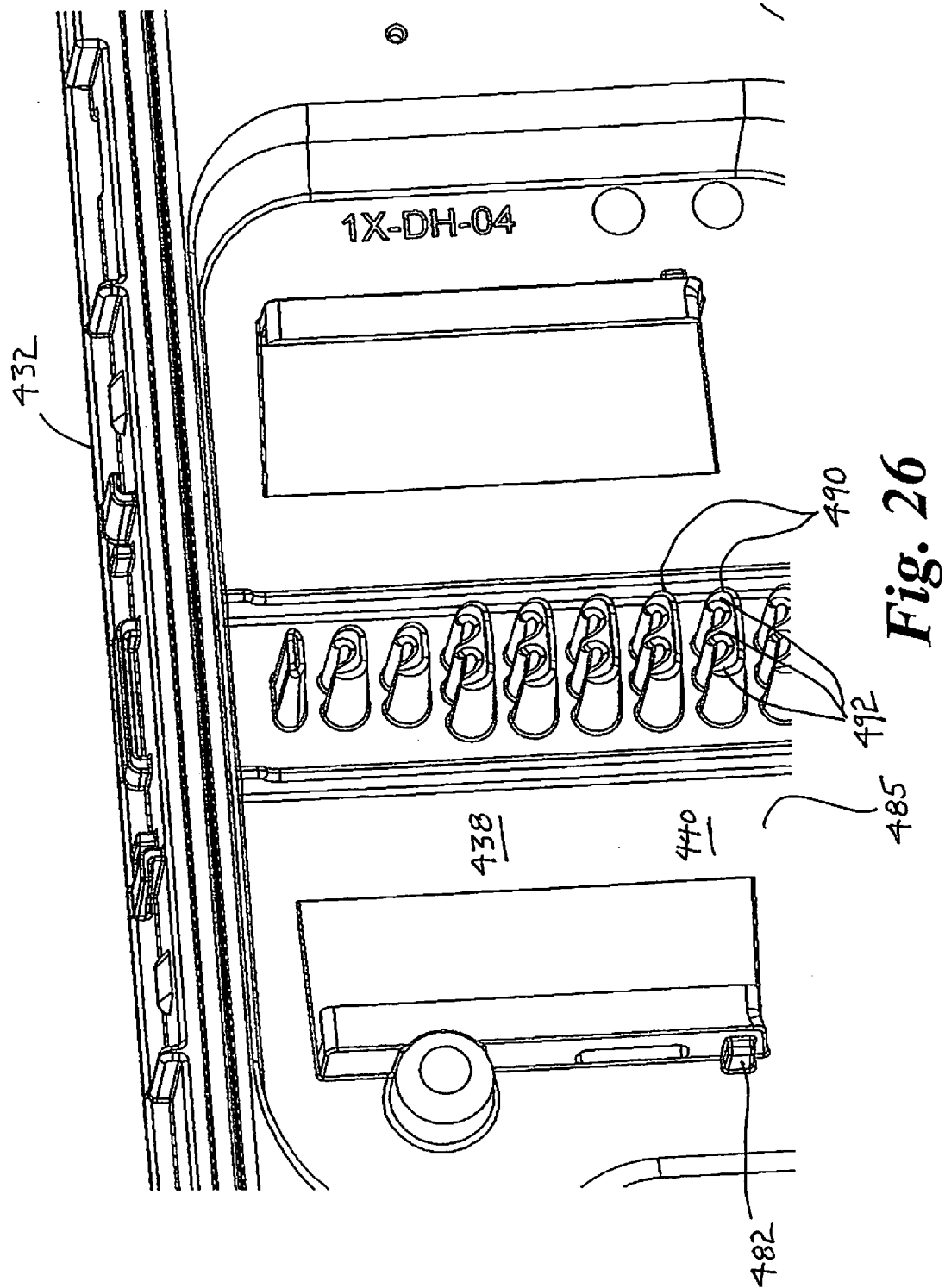
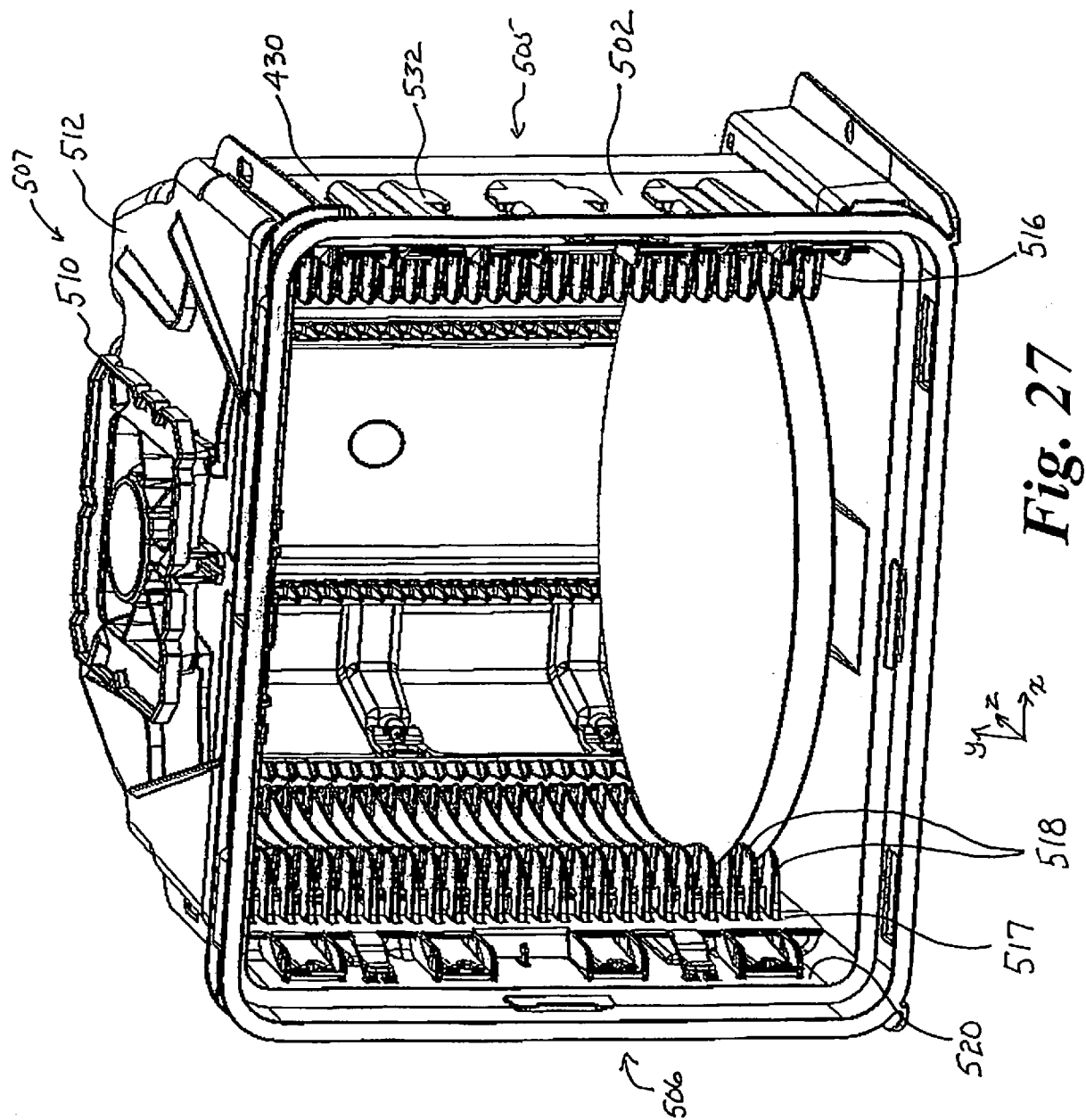


Fig. 24





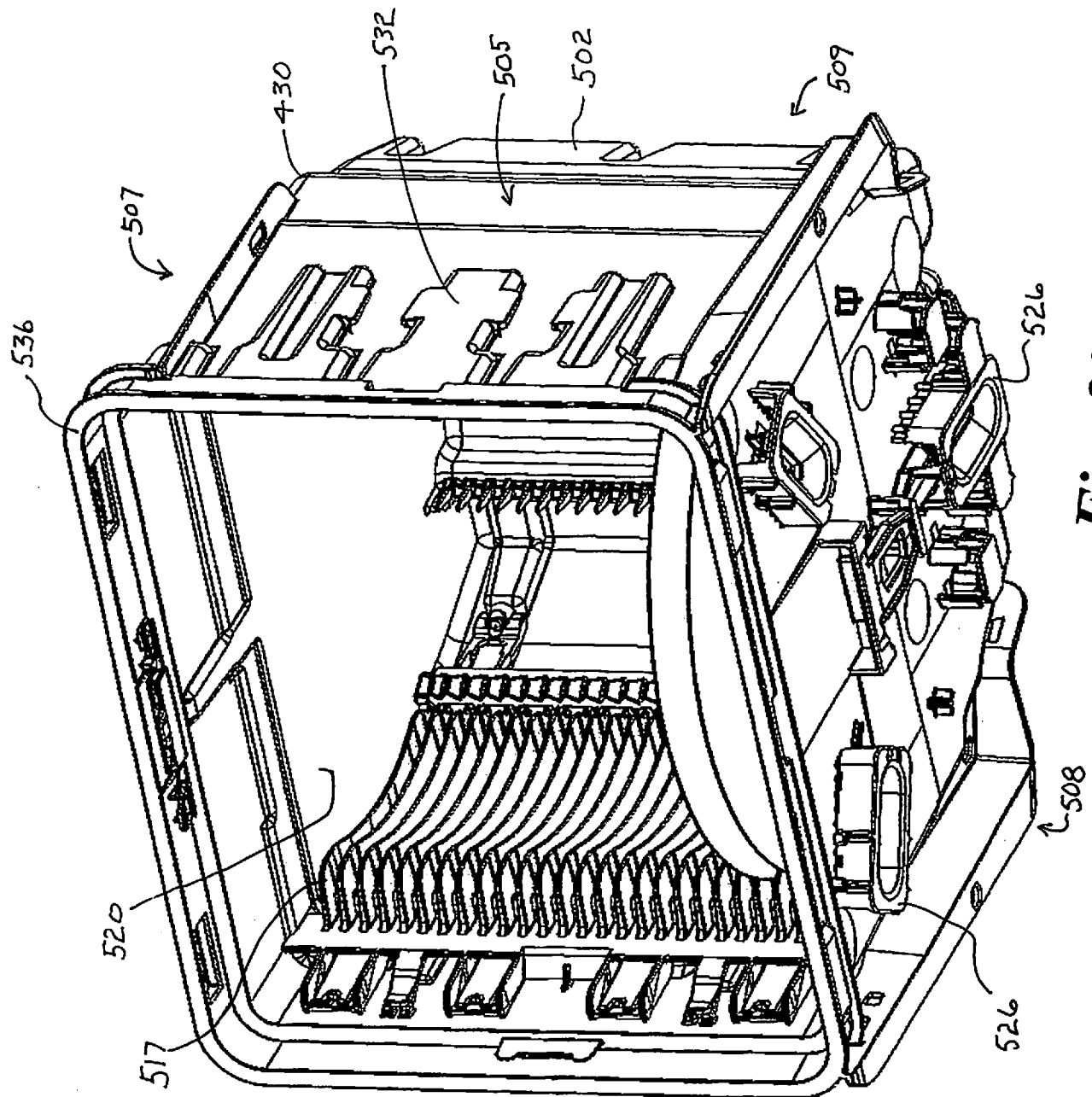
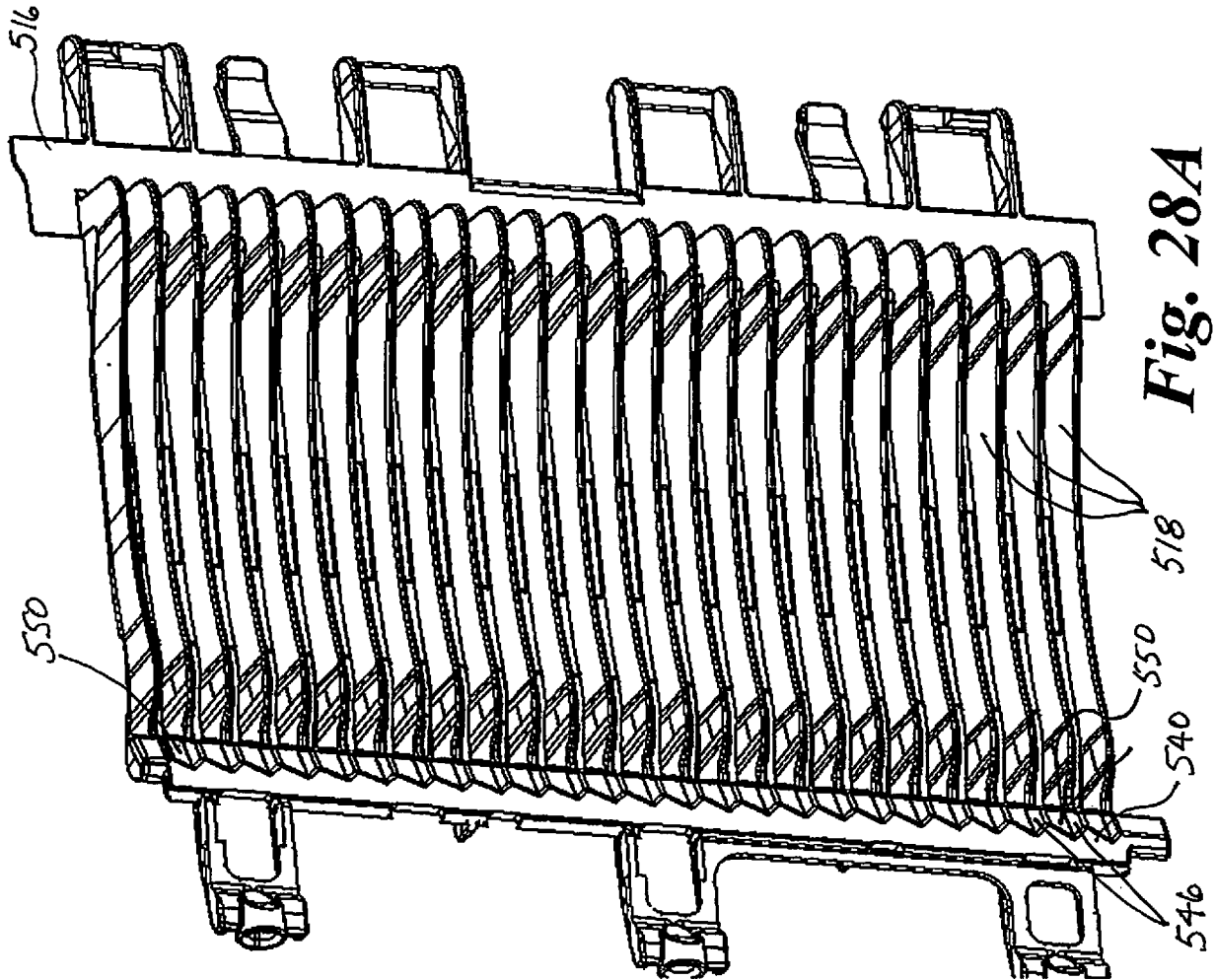


Fig. 28



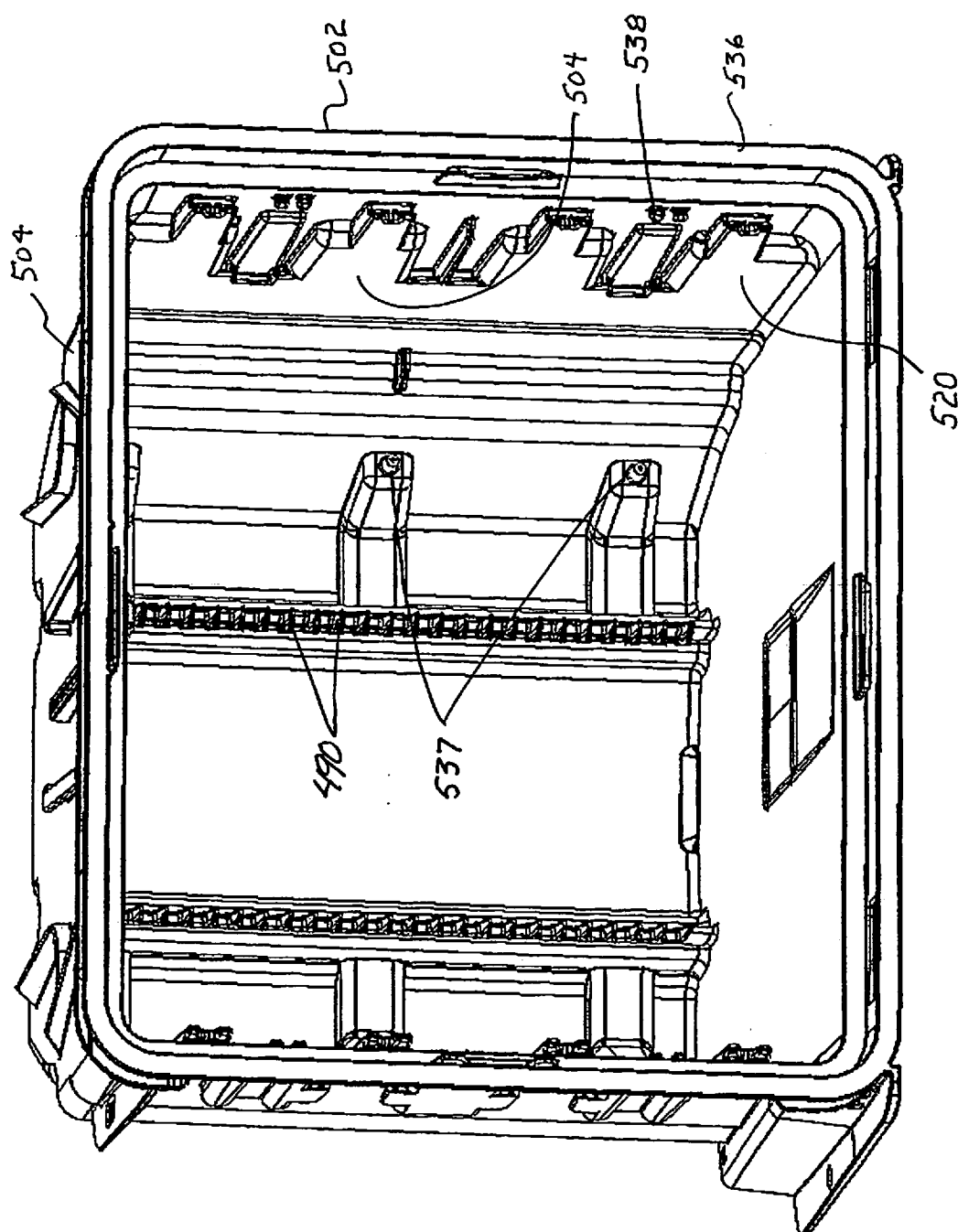


Fig. 29

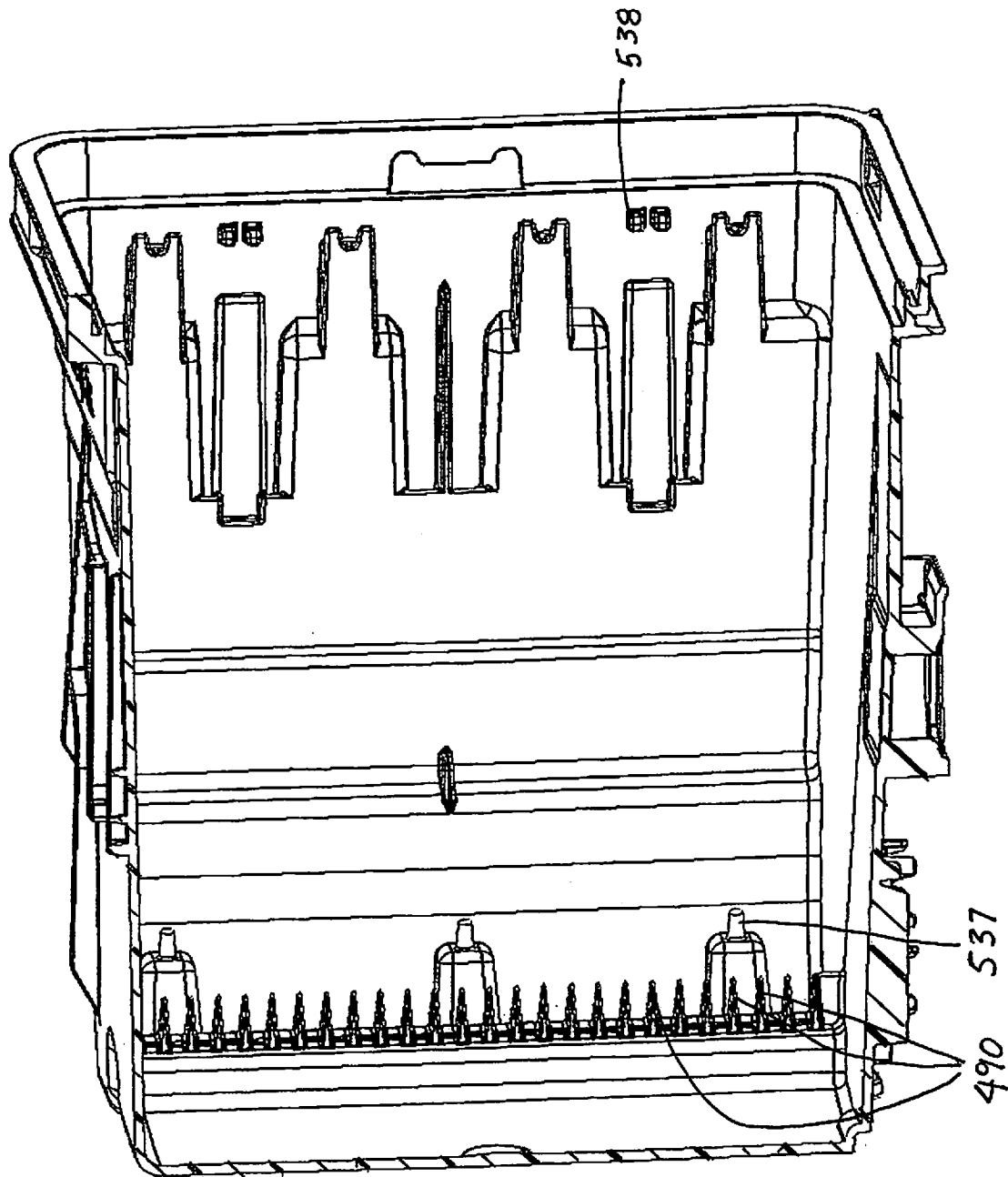
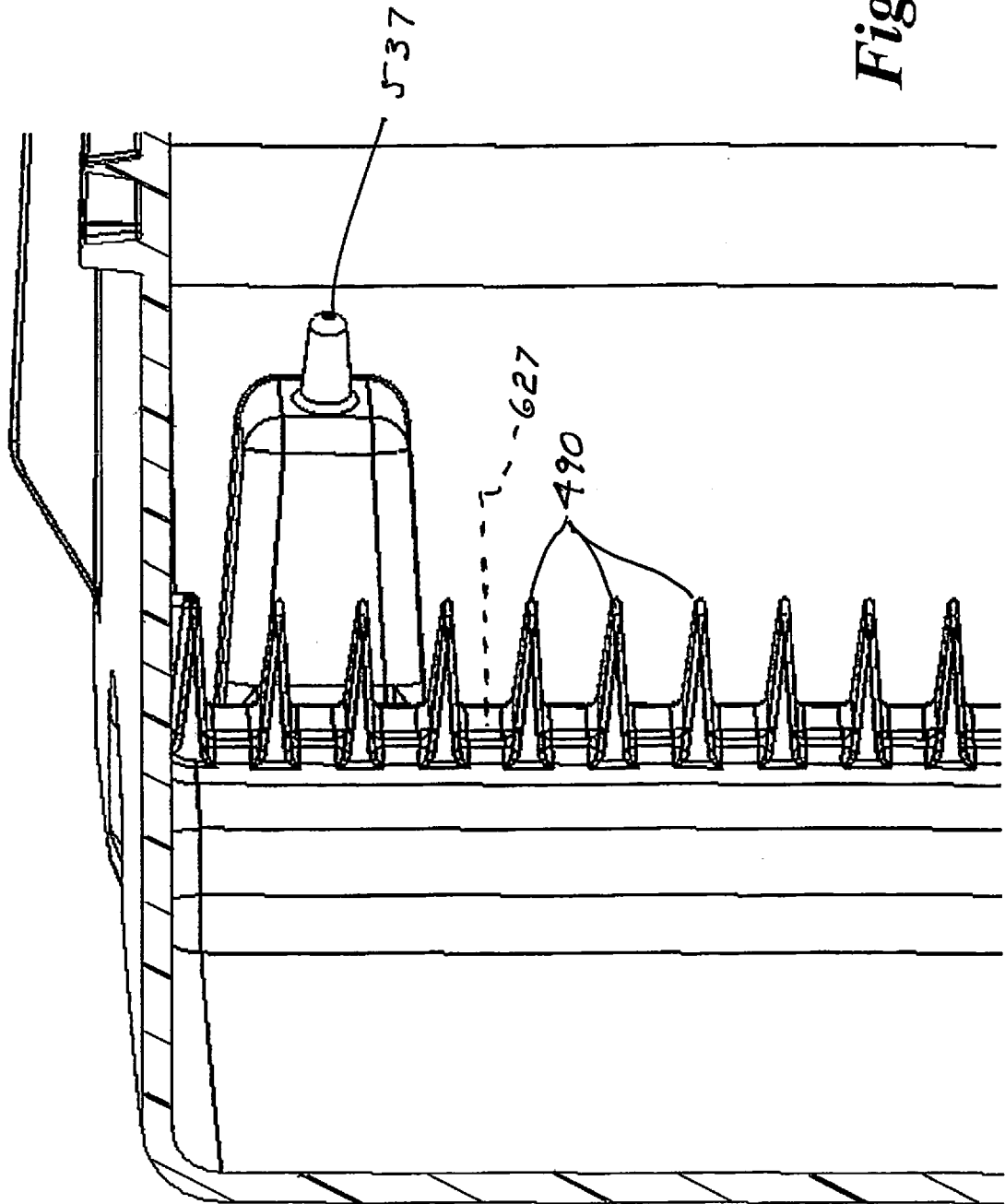
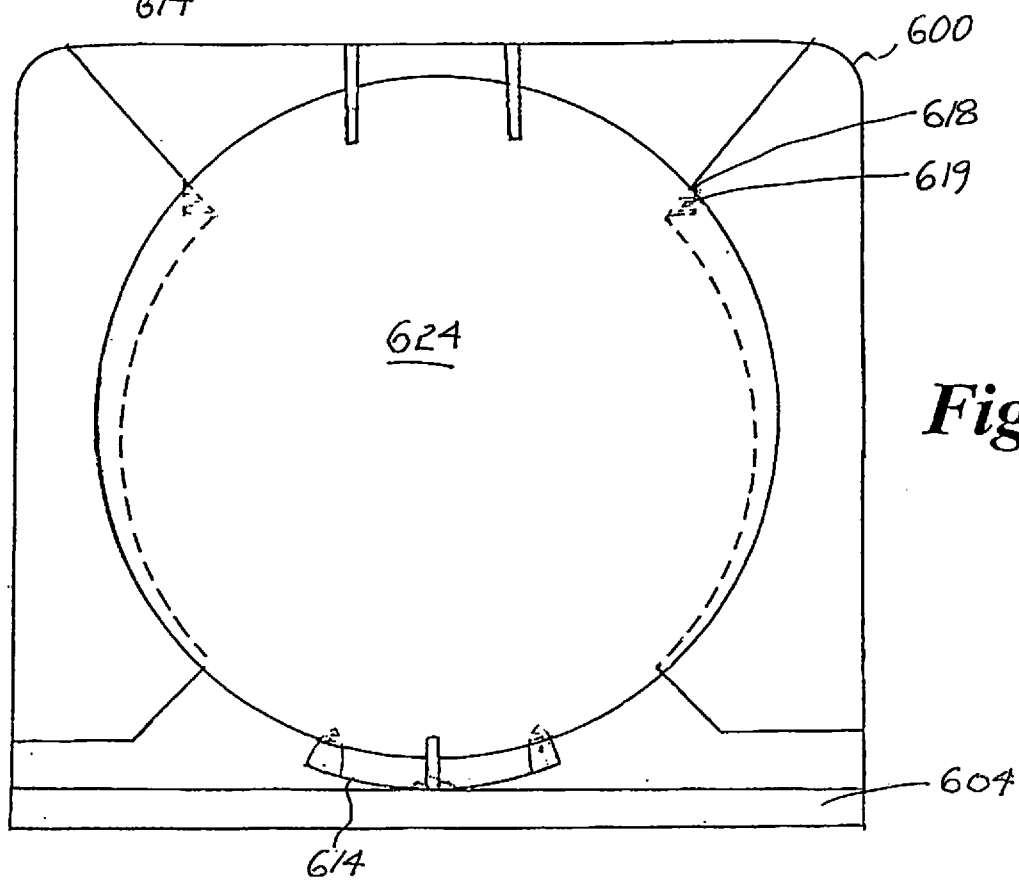
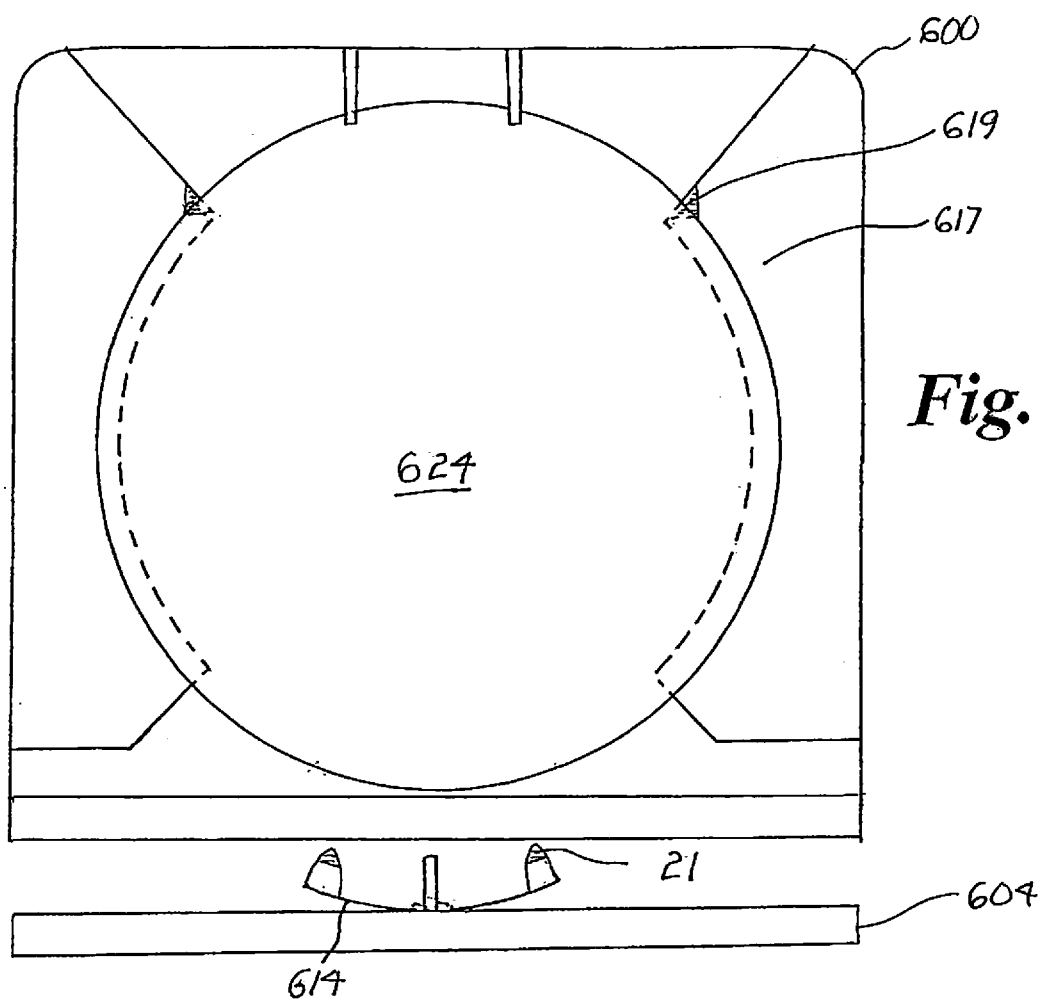


Fig. 30

Fig. 31





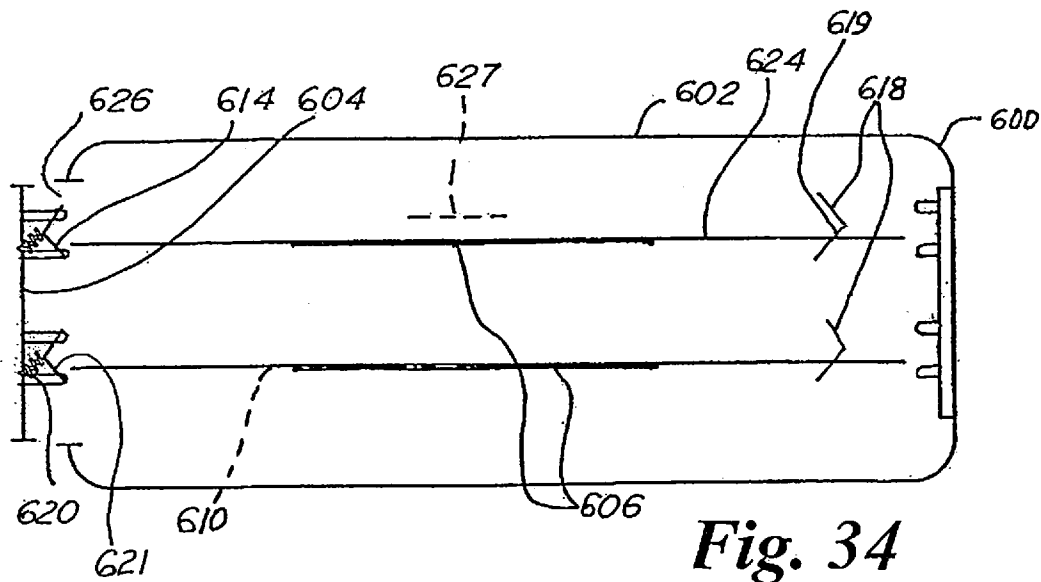


Fig. 34

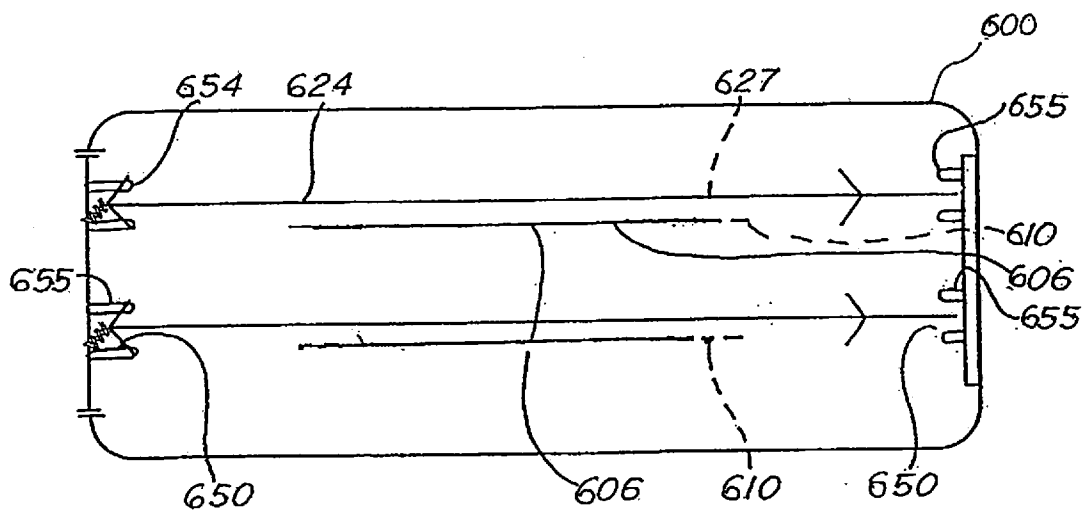


Fig. 35

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/024213**A. CLASSIFICATION OF SUBJECT MATTER****H01L 21/673(2006.01)i, H01L 21/677(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L 21/673; B65D 85/48; B65D 85/86; B65D 81/02; H01L 21/677

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: wafer container, door, primary wafer support, secondary wafer cushion, polymer, and projection

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011-0000817 A1 (HOSOI et al.) 06 January 2011 See paragraphs [0031]-[0036], [0043]-[0051], [0061]-[0062] and figures 1-13.	3, 10, 17-18
Y		1-2, 4-9, 11-16
Y	JP 2011-131940 A (HOYA CORP.) 07 July 2011 See paragraphs [0022]-[0024], claim 1, and figures 1-3.	1-2, 8-9
Y	JP 2010-199189 A (SHIN ETSU POLYMER CO., LTD.) 09 September 2010 See paragraphs [0020]-[0030] and figure 1.	4-7, 11-16
A	US 2003-0221985 A1 (YAJIMA et al.) 04 December 2003 See claims 1-9 and figures 1-7.	1-18
A	EP 1133437 B1 (ENTEGRIS, INC.) 14 May 2014 See claims 1, 3 and figures 1-5, 9-10B.	1-18

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 June 2016 (29.06.2016)

Date of mailing of the international search report

29 June 2016 (29.06.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Dal Kyong

Telephone No. +82-42-481-8440



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/024213

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