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(54) **Titre : SYSTEME DE VOLET ROULANT**
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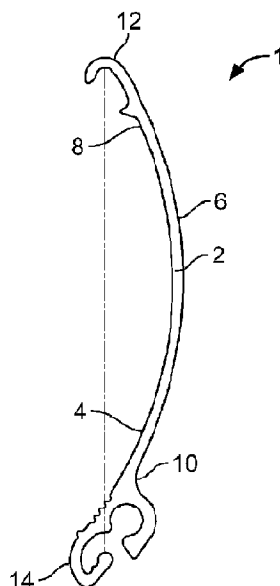


FIG. 1A

(57) **Abrégé/Abstract:**

A rolling shutter comprises first and second slats, each slat having inner and outer sides, a first edge with an engaging track, and a second edge with a receiving track. The receiving track comprises a lip member and a guard member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat. The engaging track of the first slat is received in the receiving track of the second slat to form an articulating hinge. The hinge has a vertical position with the maximum extension of the first and second slats, and the hinge is rotatable from the vertical position in a backward direction. In one embodiment, the engaging track is hook-shaped and comprises a bend that curves toward the inner side, and a rib positioned at the first edge that projects from the inner side.



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Abstract:

A rolling shutter comprises first and second slats, each slat having inner and outer sides, a first edge with an engaging track, and a second edge with a receiving track. The receiving track comprises a lip member and a guard member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat. The engaging track of the first slat is received in the receiving track of the second slat to form an articulating hinge. The hinge has a vertical position with the maximum extension of the first and second slats, and the hinge is rotatable from the vertical position in a backward direction. In one embodiment, the engaging track is hook-shaped and comprises a bend that curves toward the inner side, and a rib positioned at the first edge that projects from the inner side.

ROLLING SHUTTER SYSTEM

[0001] This application claims the benefit of U.S. Provisional Application No. 63/210,461, filed on June 14, 2021, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to rolling shutter systems and, in particular, to the configurations of the slats for a rolling shutter system.

[0003] Rolling shutter systems comprise a series of slats that are linked together to form an articulated curtain that covers an opening of a structure, such as a doorway or window. The slats typically span the width of the opening, and have an upper edge with a hook-shaped engaging track, and a lower edge with a receiving track that forms a pocket for receiving the engaging track of another slat. The slats are linked by the slidable engagement of the engaging track of a first slat in the receiving track of a second slat, to form a loosely articulated hinge between the slats. In an open position, the rolling shutter curtain is retracted or raised away from the opening by coiling or winding the slats about a spindle positioned at the top of the opening. In the closed position, the slats are unwound from the spindle and extended or lowered toward the bottom of the opening. An example of a shutter slat is described in U.S. Patent No. 9,074,411 to Miller et al., which is incorporated herein by reference.

[0004] Conventional rolling shutter slats are commonly designed to have engaging tracks and receiving tracks that fit closely to prevent intrusion into the hinge and to resist deflection of the extended rolling shutter curtain from external forces. However, the closely fitting design tends to accumulate debris, which becomes compacted over time and may interfere with the operation of the hinge. The narrow dimensional tolerances of the closely fitting design also

increases the difficulty in manufacturing the rolling shutter slats.

[0005] To better accommodate the introduction of debris, it would be desirable to design the rolling shutter slats with loosely articulated hinges that have an increased clearance and range of rotation. A loosely articulated hinge design would also increase the allowable dimensional tolerances and improve the manufacturability of the slats. However, such designs also increase the risk of inadvertent decoupling of the slats in the rolling shutter. Thus, it would be desirable to provide a loosely articulated hinge design without the problem of decoupling.

[0006] Rolling shutters are also commonly designed to reduce the profile of the retracted rolling shutter, by configuring the slats to be tightly nested when coiled about the spindle. The tight nesting of the slats increases the contact between slats and the risk of wear and cosmetic blemishes to the finish of the slats. Thus, it would be desirable to protect against inadvertent contact and wear between the slats, while maintaining the ability to tightly coil the rolling shutter in the retracted position.

SUMMARY OF THE INVENTION

[0007] In one embodiment, a rolling shutter comprises first and second slats, each slat having inner and outer sides, a first edge with an engaging track, and a second edge with a receiving track. The receiving track comprises a lip member and a guard member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat. The engaging track of the first slat is received in the receiving track of the second slat to form an articulating hinge. The hinge has a vertical position with the maximum extension of the first and second slats, and the hinge is rotatable in a backward direction with a maximum angle of backward rotation greater than 10° from the vertical position.

[0008] In another embodiment, a rolling shutter comprises first and second slats, each

slat having inner and outer sides, first and second edges, a hook-shaped engaging track positioned at the first edge, and a receiving track positioned at the second edge. The engaging track of each slat comprises a bend that curves toward the slat inner side, and a rib positioned at the first edge that projects from the inner side. The receiving track of each slat comprising a lip member and a guard member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat. The engaging track of the first slat is received in the receiving track of the second slat to form an articulating hinge. The hinge is rotatable in a forward direction, and the rib of the first slat contacts the lip member of the second slat to stop the forward rotation of the hinge.

[0009] In another embodiment, a rolling shutter comprises a plurality of slats. Each slat comprises a body with a body inner surface having a concave curve, a body outer surface having a convex curve, and first and second edges. A hook-shaped engaging track is positioned at the first edge, that comprises a first base adjacent to the first edge, and a first bend that curves toward the body inner surface. The first base has a first outer surface that extends along the same convex curve as the body outer surface. A receiving track is positioned at the second edge, that comprises a guard member and a lip member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat. The lip member comprises a second base adjacent to the second edge and a second bend that curves toward the body outer surface. The second base has an second outer surface that extends along the same concave curve as the body inner surface. A rib projects from the second outer surface. The guard member having a third outer surface. The rolling shutter has a retracted position that forms a coil comprising a plurality of windings of linked slats. Each winding has a winding outer surface formed by the body outer surfaces and the first and third outer surfaces of the slats in the

winding, and a winding inner surface formed by the body inner surfaces and second outer surfaces of the slats in the winding. The adjacent winding inner surfaces and winding outer surfaces in the coil are separated by the rib. In a further embodiment, the winding inner surfaces and winding outer surfaces in the coil have curvatures that are concentric.

[0010] In one embodiment, a rolling shutter system comprises a spindle and a plurality of coupled slats, including an initial slat coupled to the spindle and a base slat distal to the spindle. The plurality of slats have a retracted position and an extended position, where the slats are wound about the spindle in the retracted position. A retaining rail or guide track is configured to receive the slats in an extended position. In a further embodiment, the rolling shutter system further comprises an end retention device comprising: a retaining screw; a bushing positioned on the retaining screw; and a guide track configured to receive the retaining screw. At least one slat has a screw boss sized and shaped to receive the retaining screw, and the at least one slat is coupled to the guide track when the retaining screw is received in the guide track.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1A is a side section view of an embodiment of a rolling shutter slat, in a vertical position.

[0012] FIG. 1B is a detail, side section view of the engaging track of the slat of FIG. 1A.

[0013] FIG. 1C is a detail, side section view of the receiving track of the slat of FIG. 1A.

[0014] FIG. 2A is a side section view of two linked slats of FIG. 1A.

[0015] FIG. 2B is a detail, side section view of the hinge between the slats of FIG. 2A, showing the range of rotation.

[0016] FIG. 2C is a detail, side section view of the hinge between the slats of FIG. 2A, showing the vertical clearance.

- [0017] FIG. 3A is a side section view and detail side section view of two prior art linked slats.
- [0018] FIG. 3B is a side section view and detail side section view of another embodiment of two prior art linked slats.
- [0019] FIG. 4A is a side section view of two linked slats of FIG. 1A, showing the back rotation of the slats.
- [0020] FIG. 4B is a detail, side section view of the hinge between the slats of FIG. 4A, showing the vertical clearance at the tip of the engaging hook and the receiving track.
- [0021] FIG. 5A is a side section view of two linked slats of FIG. 1A, showing the forward rotation of the slats.
- [0022] FIG. 5B is a detail, side section view of the hinge between the slats of FIG. 5A.
- [0023] FIG. 6A is a side section view of a series of linked slats of FIG. 1A, that form single a winding of slats about a spindle.
- [0024] FIG. 6B is a detail, side section view of the hinge between two linked slats of FIG. 6A, showing the alignment of the slat surfaces.
- [0025] FIG. 6C is a side section view of a rolling shutter comprising a series of linked slats of FIG. 1A, that form multiple tightly nested windings of slats about a spindle.
- [0026] FIG. 6D is a detail, side section view of the rolling shutter of FIG. 6C.
- [0027] FIG. 7A is a side section view of an embodiment of a rolling shutter slat, dimensioned to be incorporated in a winding proximal to the spindle.
- [0028] FIG. 7B is a side section view of an embodiment of a slat, dimensioned to be incorporated in a winding distal to the spindle.
- [0029] FIG. 8A is a side section view of an embodiment of a starter slat for a rolling

shutter.

[0030] FIG. 8B is a side section view of an alternative embodiment of a starter slat for a rolling shutter.

[0031] FIG. 9 is a side section view of an embodiment of a spindle for a rolling shutter.

[0032] FIG. 10 is a side section view of an alternative embodiment of a spindle for a rolling shutter.

[0033] FIG. 11 is an accessory slat for a rolling shutter, comprising an embodiment of a finger pull.

[0034] FIG. 12 is a side section view of an embodiment of a cover for a guide track of a rolling shutter system.

[0035] FIG. 13 is a side section view of an accessory slat for a rolling shutter, comprising an embodiment of a slat coupler.

[0036] FIG. 14 is a side section view of an accessory slat for a rolling shutter, comprising an embodiment of a base slat.

[0037] FIG. 15 is a side section view of an accessory slat for a rolling shutter, comprising an alternative embodiment of a base slat.

[0038] FIG. 16 is a side section view of an accessory slat for a rolling shutter, comprising an embodiment of a housing for a base slat.

[0039] FIG. 17 is a side section view of an accessory slat for a rolling shutter, comprising an alternative embodiment of a base slat.

[0040] FIG. 18 is a side section view of an accessory slat for a rolling shutter, comprising an alternative embodiment of a base slat.

[0041] FIG. 19 is a side section view of an accessory slat for a rolling shutter, comprising

an embodiment of a lock slat and cover.

[0042] FIG. 20 is a side section view of an embodiment of an end retention device for a rolling shutter slat, comprising a retaining screw and bushing.

[0043] FIG. 21A is a side view of the end retention device of FIG. 20 installed in an embodiment of a rolling shutter slat.

[0044] FIG. 21B is a front view of the rolling shutter slat and end retention device of FIG. 21A, showing hidden lines.

[0045] FIG. 21C is a bottom section view of the rolling shutter slat and end retention device of FIG. 21A.

[0046] FIG. 22A is a top section view of an embodiment of a guide track and the end retention device of FIG. 20.

[0047] FIG. 22B is a top section view of an alternative embodiment of a guide track and the end retention device of FIG. 20.

[0048] FIG. 23A is a top section view of an alternative embodiment of a guide track and the end retention device of FIG. 20.

[0049] FIG. 23B is a top section view of an alternative embodiment of a guide track and the end retention device of FIG. 20.

[0050] FIG. 24 is a side section view of an embodiment of a rolling shutter mounted at the opening of a structure.

[0051] FIG. 25 is a side section view of an alternative embodiment of a rolling shutter mounted at the opening of a structure.

[0052] FIG. 26 is a front view of an embodiment of a rolling shutter installed at the opening of a structure.

[0053] FIG. 27 is a front view of an embodiment of multiple rolling shutters installed at the opening of a structure.

[0054] FIG. 28 is a top section view of the guide track and end retention device of FIG. 23B, installed on a building structure by a wall mount.

[0055] FIG. 29 is a top section view of the guide track and end retention device of FIG. 23B, installed on a building structure by a trap mount.

[0056] FIG. 30 is a top section view of two guide tracks and end retention devices of FIG. 23B, installed on a mullion by a face mount.

[0057] FIG. 31 is a top section view of two guide tracks and end retention devices of FIG. 23B, installed on a mullion by a trap mount.

DETAILED DESCRIPTION OF THE INVENTION

[0058] Referring to FIGs. 1A-1C, an embodiment of a slat 1 for a rolling shutter is shown. Slat 1 comprises a single-walled body 2 having a curvature with an inner side or surface 4 with a concave curve, and an outer side or surface 6 with a convex curve. Body 2 has a top edge 8 and a bottom edge 10. A hook-shaped engaging track 12 is positioned at edge 8, and a receiving track 14 is positioned at edge 10. Receiving track 14 is configured to receive the engaging track 12 of another slat, such that multiple slats may be linked together in head-to-tail fashion and extended to form a curtain that covers an opening in a structure.

[0059] FIG. 1A shows slat 1 in a vertical orientation or position, such as when the rolling shutter is in a closed position and the slats are extended to cover an opening. The centers of mass of engaging track 12 and receiving track 14 are vertically aligned. As shown in FIG. 1B, hook-shaped engaging track 12 is positioned at edge 8, and comprises a neck or base 12a adjacent to edge 8, and a bend 12b that extends to a tip 12c. In one embodiment, base 12a

extends along the same curvature as body 2, and bend 12b curves toward concave inner side 4 such that engaging track 12 does not project beyond the convex curve of outer side 6. In a preferred embodiment, engaging track base 12a has an outer surface 12e that extends along the same curve as convex outer surface 6 of body 2. In one embodiment, engaging track 12 includes a protrusion or rib 12d positioned at edge 8, that projects from concave inner side 4. Engaging track rib 12d limits the rotation of engaging track 12 in the receiving track 14 of another slat and prevents inadvertent disengagement of the slats, as described below.

[0060] As shown in FIG. 1C, receiving track 14 is positioned at edge 10, and comprises a lip member 16 and guard member 18. Lip member 16 comprises a base 16a adjacent to edge 10, and a bend 16b that extends to a tip 16c. Receiving track bend 16b forms a pocket or articulation space 20 that is sized and shaped to receive the hook-shaped engaging track 12 of another slat. In one embodiment, base 16a extends along the same curvature as body 2, and bend 16b curves toward convex outer side 4 such that receiving track 14 does not project beyond the concave curve of inner side 6. In a preferred embodiment, lip member base 16a has an outer surface 16d that extends along the same curve as concave inner surface 4 of body 2. In one embodiment, lip member outer surface 16d includes a bump or protrusion 16g that reduces wear on the slats when the rolling shutter is in the retracted position, as described below.

[0061] Guard member 18 is spaced apart from lip member 16, and has a tip 18a that extends toward lip member tip 16c. Guard member tip 18a and lip member tip 16c are spaced apart to form an aperture 22, that opens to articulation space 20 and is sized and shaped to receive the hook-shaped engaging track 12 of another slat. Guard member 18 projects above the convex curve of slat outer side 4, and includes an outer surface 18b that is approximately concentric with the convex curve of outer side 4.

[0062] In one embodiment, receiving track 14 includes a receptacle 34 formed between guard member 16 and lip member 18. Receptacle 34 is separate from articulation space 20, and is sized and shaped to receive an end retention device, as described below. In a preferred embodiment, a rib 36 is formed on the inner surface 16e of lip member 16, that separates articulation space 20 and receptacle 34.

[0063] FIGs. 2A-2C show an embodiment of two slats 1a and 1b that are linked together in a vertical position, with the maximum extension of the two linked slats. Engaging track 12 of slat 1a is received in the receiving track 14 of slat 1b to form an articulating hinge 24 between the two slats. During articulation of hinge 24, bend inner surface 12f of engaging track 12 bears on lip member tip 16c of receiving track 14. In one embodiment, inner surface 12f and tip 16c are configured with complementary rounded surfaces that facilitate articulation of hinge 24 and rotation of slats 1a and 1b, to increase the ease of operation and product life of the slats.

[0064] As shown in FIGs. 2B and 2C, hinge 24 is designed to provide engaging track 12 with an increased range of rotation and vertical clearance “A” within receiving track 14 in comparison to conventional rolling shutter slats. The increased range of rotation and vertical clearance accommodates the introduction of debris into articulation space 20, reduces the compression and buildup of debris, and facilitates the self-cleaning of debris from the articulation space. The increased range of rotation and vertical clearance also increases the allowable dimensional tolerances of manufacturing, and improves manufacturability of the slats.

[0065] Conventional rolling shutters are typically designed to resist deflection from exterior forces when in the closed (vertical) position, by restricting the backward rotation of the hinge between slats and limiting the clearance of the engaging track within the hinge. As used herein, backward or back rotation means the rotation of two linked slats such that the (convex)

outer side 6 of the first slat rotates toward the (convex) outer side 6 of the second slat -- e.g., the counterclockwise rotation of slat 1a relative to slat 1b as shown in FIG. 2A. Examples of prior art rolling shutters are disclosed in U.S. Patent No. 8,944,137 to Miller (FIG. 3A), and U.S. Patent No. 9,074,411 to Miller et al. (FIG. 3B), which are incorporated herein by reference. FIG. 3A shows prior art linked slats 52a and 52b that have a hinge 50 designed to have a maximum back rotation of only about 2° from vertical (i.e. counterclockwise rotation of slat 52a relative to slat 52b). Receiving track guard member tip 56a angles sharply toward lip member 58 and is configured to generally conform to the outer surface 54a of guard member 54, to limit rotation of slat 52a and restrict the back rotation of hinge 50. FIG. 3B shows prior art linked slats 51a and 51b that have a hinge 50 designed to limit back rotation to only about 10° from vertical. Receiving track guard member tip 57a similarly angles sharply toward lip member 59 to contact the outer surface 55a of guard member 55, limit rotation of slat 53a, and restrict the back rotation of the hinge 51.

[0066] Guard members 56 and 57 are also configured to respectively restrict the vertical movement of engaging tracks 54 and 55, which may contribute to the compression of debris or other material within hinges 50 and 51. In the vertical position, hinges 50 and 51 have minimal vertical clearance. Furthermore, engaging tracks 54 and 55 respectively pivot on inner surfaces 60 and 61 of receiving track lip members 58 and 59. This configuration may cause debris introduced into hinges 50 and 51 to be scraped and compacted at the bottom of the receiving track inner surfaces 60 and 61. Over time, the buildup of debris may impair the rotation of the slats and function of the hinge.

[0067] In one embodiment, the inventive slats are configured to allow back rotation of the hinge substantially beyond vertical. FIGs. 4A and 4B show the back rotation of hinge 24

between linked slats 1a and 1b. Guard member tip 18a has a rounder profile with a convex surface in comparison to the generally concave profile of conventional guard member tips 56a and 57a, such that aperture 22 allows a greater range of rotation of engaging track 12 in the aperture. In a preferred embodiment, the surface of guard member tip 18a has a convex curve “C” with a radius of about 0.25 inches. In contrast to the prior art, slat 1a may rotate backward substantially past vertical before guard member tip 18a contacts engaging track 12. In one embodiment, guard member 18 is configured such that hinge 24 has a maximum angle of back rotation “B” that is greater than 10° , and preferably at least about 15° . In one embodiment, hinge 24 has a maximum angle of back rotation that is about 18° from vertical (complementary angle between convex outer surfaces 6 of about 162°).

[0068] The rounder profile of guard member tip 18a also contributes to increased vertical clearance of hinge 24. In one embodiment, when hinge 24 is in the vertical position with linked slats 1a and 1b in the vertical orientation, engaging track 12 is vertically displaceable within aperture 22 of receiving track 14 by a height “A” (FIG. 2C). Hinge 24 has a vertical clearance “A” of at least about 0.025 inches, and more preferably about 0.0287 inches.

[0069] The back rotation and vertical clearance of hinge 24 allow the hinge to accommodate the introduction of debris, and contributes to self-cleaning of debris from the hinge. As engaging track 12 rotates to the vertical position in receiving track articulation space 20, engaging track tip 12c scrapes the inner surface 16e of the articulation space. As best shown in FIG. 4B, the back rotation of engaging track 12 past vertical, creates an interior space 20a within engaging track bend inner surface 12f, between engaging track tip 12c and receiving track tip 16c. Debris introduced into hinge 24 is not compressed, but is pushed into space 20a. The vertical clearance of hinge 24 (vertical displacement of engaging track 12) allows the collected

debris to be ejected from space 20a and escape from the hinge.

[0070] Compression of debris may also be reduced by configuring hinge 24 such that the engaging track does not pivot on the inner wall of the receiving track. FIG. 4C shows an embodiment of hinge 24 in the vertical position. Engaging track bend inner surface 12f pivots on receiving track tip 16c. Engaging track tip 12c is separated from the bottom of receiving track inner surface 16e by a vertical clearance “D”. The separation reduces the likelihood that debris will become trapped and compacted within receiving track articulation space 20. In one embodiment, hinge 24 has a vertical clearance “D” of at least about 0.025 inches, preferably between about 0.025 to about 0.03 inches, and more preferably about 0.0265 inches.

[0071] In some configurations, the rounder profile of guard member tip 18a and the increased vertical clearance of hinge 24 may permit the overrotation and inadvertent disengagement or decoupling of the slats. In one embodiment, hinge 24 is configured to prevent overrotation and decoupling of the linked slats. FIGs. 5A and 5B show an embodiment of linked slats 1a and 1b with an engaging track rib 12d spaced apart from engaging track tip 12c, that limits the forward rotation of hinge 24. As used herein, forward rotation means the rotation of two linked slats such that the (concave) inner side 4 of the first slat rotates toward the (concave) inner side 4 of the second slat -- e.g., the clockwise rotation of slat 1a relative to slat 1b as shown in FIG. 2A. A portion of receiving track 14 comprising lip member segment 16f between tip 16c and bend 16b, is captured in engaging track 12 between engaging track tip 12c and rib 12d. The maximum height “E” of lip member segment 16f between tip 16c and bend 16b, is greater than the maximum height “F” between engaging track tip 12c and rib 12d. As slat 1a rotates forward, engaging track rib 12d of slat 1a contacts receiving track lip member 16 (preferably bend 16b) of slat 1b to stop the forward rotation of the slat 1a.

[0072] In general, overrotation is desirable to increase the allowable dimensional tolerances of manufacturing and improve manufacturability of the rolling shutter slats. Preferably, height “E” is only slightly or marginally greater than height “F”, to increase the degree of articulation (overrotation) while preventing decoupling. In one embodiment, slats 1a and 1b form a hinge 24 with a maximum angle of forward rotation “G” (FIG. 5A) of between about 70° to about 80° from vertical, and preferably about 76° from vertical (i.e. complementary angle of 104° between concave inner surfaces 4). In another embodiment, the maximum height “E” of lip member segment 16f between tip 16c and bend 16b is about 0.219 inches, and the maximum height “F” between engaging track tip 12c and rib 12d is about 0.216 inches.

[0073] The use of engaging track rib 12d to prevent overrotation provides advantages over conventional slat designs, including consistency in the design of hinge 24. As described below, rolling shutters commonly comprise slats with different heights (i.e. the maximum vertical height of slat 1 between engaging track 12 and receiving track 14) and radii of curvature. In conventional rolling shutter slat designs without an engaging track rib 12d, the geometries of the engaging track and/or receiving track are configured to prevent overrotation and decoupling of the hinge. These geometries are not uniform across all slats, but must be modified to reflect the different heights and radii of curvature of the slats. In contrast to conventional slat designs, overrotation is restricted by engaging track rib 12d, which allows slats with different heights and radii of curvature to be configured with engaging tracks 12 and receiving tracks 14 that have consistent geometries, and allows hinges 24 to be formed even between slats 1a and 1b that have substantially different heights and radii of curvature. Engaging track rib 12d similarly facilitates the use of accessory slats that may only be available in a single configuration, such as finger pull slats and utility slats described below. In addition, the restriction of overrotation by engaging

track rib 12d reduces the dependence on guard member 18 to prevent decoupling of hinge 24, which permits reduction of the guard member to provide greater vertical clearance within the hinge.

[0074] A rolling shutter curtain is formed of a series of slats 1 that are linked in head-to-tail fashion to form a chain, with the engaging track 12 of a successive slat engaged in the receiving track 14 of the preceding slat in the chain. In the closed position, the slats 1 are extended (vertically) to cover the opening of a host structure. In the open position, the slats 1 are retracted (raised) from the opening by coiling or winding the linked slats about a spindle. The retracted rolling shutter typically comprises multiple windings of slats 1 that substantially encircle the spindle. The windings of slats are preferably tightly nested to minimize the space required by the retracted rolling shutter.

[0075] FIG. 6A shows an embodiment of a single winding, comprising five slats 1a-1e wound about a spindle 26. Adjacent slats in the winding (e.g., 1a and 1b) have a standard forward rotation angle of about 69° from vertical. In one embodiment, each winding comprises the same number of slats, which permits the alignment of slats in successive windings to facilitate tight nesting.

[0076] Tight nesting may be further improved by configuring the slats to form windings with concentric surfaces. In the embodiment of FIGs. 6A and 6B, the slats form a winding with concentric outer and inner surfaces “H” and “I”. Guard member outer surface 18b of slat 1b and engaging track base outer surface 12e of slat 1a are aligned and extend along the same curve as convex body outer surface 6 of slat 1a, to form a combined winding outer surface “H”. Similarly, lip member base outer surface 16d of slat 1b extends along the same curve as body concave inner surface 4 of slat 1b, to form a combined winding inner surface “I”. In a preferred

embodiment, the curves of winding outer and inner surfaces H and I are approximately concentric (i.e. share a center point located on the longitudinal axis of spindle 26) to improve tight nesting of adjacent windings when the rolling shutter is in the retracted position. In one embodiment, lip member segment 16f has an outer surface that is also concentric with inner and outer surfaces D and E, to facilitate the alignment of engaging track base outer surface 12e with guard member outer surface 18b.

[0077] The tightly nested configuration of the retracted rolling shutter increases the risk of wear caused by contact between the slats of adjacent windings. In one embodiment, a wear rib or bump 16g is positioned on the inner surface of slat 1 (i.e surfaces 4 and 16d), to reduce contact between the slats in the retracted position. Wear bump 16g is preferably located at a position that has a high probability of contact with a slat of the adjacent (previous) winding, such as the region of hinge 24. In one embodiment, wear bump 16g is positioned on lip member outer surface 16d. Wear bump 16g creates separation between the slats of adjacent windings, by reducing the face-to-face contact between slats to the minimal area of the wear bump, which reduces inadvertent damage to the surface finish of the slats and increases product life.

[0078] FIGs. 6C and 6D show a rolling shutter in the retracted position, wound or coiled about spindle 26 in a tightly nested configuration. The rolling shutter coil includes a winding comprising five slats 1a-1e, with slat 1a overlapped by slat 1f in the successive winding. A wear bump 16g is positioned on lip member 16 at outer surface 16d of each slat, to separate the adjacent (overlapping) slats of successive windings. As shown in FIG. 6D, wear bump 16g of slat 1e reduces the face-to-face contact between the adjacent winding inner and outer surfaces in the coil -- e.g., between slat 1f body inner surface 4 and lip member outer surface 16d (inner surface "I"), and slat 1e body outer surface 6 (outer surface "H").

[0079] Wear bump 16g also increases the allowable dimensional tolerances of manufacturing and improves manufacturability of the rolling shutter slats. For example, the separation between slats created by wear bump 16g accommodates variations in the concentricity of adjacent windings. Conversely, the concentricity of the slats can be adjusted by simply changing the size of wear bump 16, rather than redesigning the slat dimensions and curvature.

[0080] Those of skill in the art will appreciate that the circumference of each successive winding of slats will increase the further from the spindle. Therefore, the height of the slats must increase in each successive winding to accommodate the increasing circumference and maintain the same number of slats in each winding -- i.e. the maximum vertical height of slat 1 between engaging track 12 and receiving track 14 generally increases the further from the spindle. The radius of curvature of the slats also must increase in each successive winding to maintain the concentricity of the windings. In a one embodiment, the height and radius of curvature of the slats in a rolling shutter curtain increases monotonically the further from the spindle.

[0081] An initial starter slat of the rolling shutter curtain is coupled to the spindle. FIGs. 8A and 9 shown an embodiment of a spindle 26 and a corresponding starter slat 28. Spindle 26 is generally cylindrical, with an outer surface 26a. Starter slat 28 is a partial slat with a similar configuration to slat 1, comprising a body 2 having a curvature with a concave inner surface 4 and a convex outer surface 6. Starter slat 28 has a top and bottom edges 8 and 9, with a receiving track 14 positioned at bottom edge 10. However, starter slat 28 does not include an engaging track at top edge 8. The curvature of starter slat body 2 (and preferably the curve of concave inner surface 4) conforms to the curvature of spindle outer surface 26a. Starter slat 28 may be coupled to spindle 26 using various fasteners as are known in the art. For example, starter slat 28 may be attached to spindle 26 using screws.

[0082] The starter slat and spindle may also be configured to be coupled without a fastener. FIGs. 8b and 10 show an embodiment of a spindle 32 and complementary starter slat 29. Starter slat inner surface 4 has a flange 30 positioned at edge 8, and spindle 32 has one or more complementary channels 32a that are sized and shaped to receive flange 30. In a preferred embodiment, flange 30 is generally L-shaped, having a stem 30a and leg 30b. Channel 32a is sized and shaped for hook-in or snap-fit insertion of L-shaped flange 30 into the channel to couple starter slat 29 to spindle 32. In one embodiment, spindle 32 may include one or more channels 32b that are a mirror image of channel 32a, to allow starter slat 28 to be coupled to the spindle in the opposite orientation to coupling to channel 32a. Starter slat 29 is coupled to spindle 32 with receiving track 14 extending around the spindle in the counterclockwise direction when flange 30 is received in channel 32a, and extending in the clockwise direction when flange 30 is received in channel 32b.

[0083] In a preferred embodiment, the rolling shutter has a spindle 26 with an outer diameter of about 3.325 inches, and comprises a series slats having monotonically increasing heights (i.e. maximum height between engaging track 12 and receiving track 14) selected from the progression: 2.3118, 2.4618, 2.6180, 2.7787, 2.9446, 3.1170, 3.2699, 3.4265, 3.5877, 3.7543, 3.9275, and 4.0971 inches. Sequential slats in the series have a maximum difference in slat height of about 6% (i.e. between sequential slat heights of 2.3118 and 2.4618 inches). The difference between non-sequential slat heights ranges from a minimum of about 8.5% (3.7543 to 4.0971 inches) to a maximum of about 43.5% (2.3118 to 4.0971 inches). FIGs. 7A and 7B show a comparison of a slat in an initial winding proximal to the spindle having a height of about 2.3118 inches, and a slat in a terminal winding distal to the spindle having a height of about 4.0971 inches. In an alternative embodiment, the rolling shutter has a spindle 32 comprising a

snap-in drive tube (e.g., FIG. 5) with an outer diameter of about 3.315 inches.

[084] As discussed above, rib 12d enables the formation of hinges 24 between slats having substantially different heights and radii of curvature. In the aforementioned embodiment of a progression of slat heights, hinge 24 may be formed between non-sequential slats having a difference in slat height of at least about 7%. In another embodiment, hinge 24 is formed between non-sequential slats having a difference in slat height ranging between about 9% to about 45%.

[0085] To accommodate different spindle diameters, the quantity of identical slats present in the initial layer (winding) of slats can be altered from the standard value. In this arrangement, a certain quantity of slats equal to or less than a standard value can be used before progressing through the standard slat groups to achieve a nested configuration. Further, any subset of the standard slat groups can be used. In one embodiment, this alternate slat configuration may be used in the manufacture of shutters that exceed the mechanical limits of the standard spindles.

[0086] To optimize the slat profile sequence for a standard enclosure size, a subset of the curtain may be designed to utilize a nested configuration before transitioning to a standard non-nested configuration. This subset of nested curtain groups can be adjusted to be optimized for geometry, cost, manufacturability, or shutter strength in the field. In particular, the slat configuration can be optimized for different security levels at different points in the curtain.

[0087] The rolling shutter system may also comprise one or more accessory slats, such as a finger pull slat, coupler, base slat, and/or utility slat that are incorporated in the series of slats 1. Referring to FIGs. 11-19, embodiments of the slats, accessory slats and slat couplers of a rolling shutter system are shown. In one embodiment, the rolling shutter system includes a finger pull

slat to facilitate manual operation of the rolling shutter. An example of a finger pull slat 100 is shown in FIG. 11, that has a similar configuration to slat 1, including a single-walled body 102 having a curvature with an inner side or surface 104 having a concave curve, and an outer side or surface 106 with a convex curve. Slat 100 further comprises a projection 108 formed in body 102 that provides a handle for manually raising or lowering the rolling shutter. In one embodiment, projection 108 is formed as a generally U-shaped channel in body 102 that has an opening 108a on outer side 106, and that projects from inner side 104 to create a handle surface 108b. In a preferred embodiment, the base 108c of the U-shaped channel has a curvature that is concentric with the curvature of body 102, to facilitate tight winding of the rolling shutter in the retracted position. An operator may either grasp handle 108b from the inside of the rolling shutter, or insert their fingers into opening 108a from outside the rolling shutter. Those of skill in the art will appreciate that projection 108 may be formed with the reverse configuration -- i.e. with an opening on inner side 104 and a handle projecting from outer side 106.

[0088] In one embodiment, the rolling shutter system includes a coupler slat for adapting a rolling shutter to incorporate multiple different slat designs. Rolling shutter slats may be designed to emphasize different features which are reflected in the configuration and geometries of the engaging tracks and receiving tracks, such as tight nesting of the coiled shutter, or hinges with improved water resistance. FIG. 13 shows an embodiment of a coupler 12 for linking two slats having different designs. Coupler 120 comprises an engaging track 122 configured for a first slat design, and a receiving track 124 configured for a second slat design. In a preferred embodiment, coupler 120 does not include a body separating engaging track 122 and receiving track 124, to minimize the profile of the coupler in the rolling shutter and the separation between the two different slats.

[0089] In one embodiment, the rolling shutter system may include a base slat that is positioned at the end of the series of linked slats to contact the bottom of the opening in a host structure, when the rolling shutter is in the closed position. The base slat may include a seal and/or may be shaped to conform to the bottom of the opening to prevent gaps that would allow infiltration or the insertion of a pry tool. The base slat may also include a locking device for securing the rolling shutter in the closed position and prevent it from being raised from the bottom of the opening.

[0090] FIGs. 14-18 show base slats configured for a variety of different applications. FIGs. 14, 15 show embodiments of a large base slat 130 and small base slat 140. Large base slat 130 is generally configured for use in rolling shutter applications for building structures such as a doorway or window. Small base slat 140 is generally configured for use in smaller structures and furnishings, such as security cabinets, counters, and display cases. Base slats 130, 140 have double-walled bodies 132, 142 with an engaging track 134, 144 at a top end, and a channel 136, 146 formed at the bottom end. Channel 136, 146 are configured to receive a gasket or seal to allow the bottom end of base slats 130, 140 to better conform to the bottom of the opening of the host structure. In one embodiment, base slats 130, 140 may include a receptacle 138, 148 that may serve as a screw boss for an end retention device (as described below), or may be configured to receive a simple end plug or bushing (not shown) as are known in the art.

[0091] FIG. 16 shows a housing 152 which is coupled to a base slat 154, to provide additional strength and stiffness. Housing 152 has a generally rectangular cross-section that is sized and shaped to conform to base slat 154, which may have a standard configuration such as base slat 130 (FIG. 14). Housing may be coupled to base slat 154 by one or more fasteners as are known in the art, such as screws or bolts.

[0092] FIG. 17 shows a base slat 160 having a body 162 with an internal space 164 that is configured to receive additional functionality, such as a rolling shutter locking device (not shown). Base slat 160 has a top end with a removable coupler 166 that comprises an engaging track, and a removable bottom 168. Coupler 166 may be provided with different engaging track configurations to allow base slat 160 to be adapted for use with different rolling shutter designs. Bottom 168 is removable to provide convenient access to internal space 164 for installation of a locking device or other feature.

[0093] FIG. 18 shows a base slat 170 that has a body 172, with a channel 174 that is configured to receive a removable handle (not shown) to facilitate manual raising or lowering of the rolling shutter. In one embodiment, channel 174 is C-shaped and configured for snap-fit insertion of a handle.

[0094] In one embodiment, the rolling shutter system may include a utility slat with an interior space that can be modified to add functionality to the rolling shutter, such as a locking system or a reinforcing bar for the rolling shutter. An example of a utility slat 200 is shown in FIG. 19, that comprises a body 202 and a cover 204. Utility slat body 202 forms a generally U-shaped channel that comprises a base 206, and walls 208 and 210 that define an interior space 212. The ends 208a and 210a of walls 208 and 210 define the opening into interior space 212. Cover 204 is secured to body 202 to cover the opening and enclose interior space 212.

[0095] In one embodiment, cover 204 has edges 204a and 204b, with a height between edges 204a and 204b that is sufficient to cover the opening between ends 208a and 210a. Ends 208a and 210a are configured to respectively receive edges 204a and 204b and secure cover 204 to body 202. In one embodiment, cover 204 is removably secured to body 202. In a preferred embodiment, edges 204a and 204b are secured to ends 208a and 210a by snap fit insertion.

[0096] Utility slat 200 is preferably designed to be seamlessly incorporated in the rolling shutter at various positions in the sequence of slats. Utility slat 200 has an engaging track 214 and a receiving track 216 that are similar to or otherwise compatible with engaging track 12 and receiving track 14 of slat 1. In one embodiment, an engaging track 214 and a receiving track 216 are positioned at opposite ends 206a and 206b of base 206. In a preferred embodiment, engaging track 214 and receiving track 216 are respectively positioned on walls 208 and 210, and may form at least part of walls 208 and/or 210. In one embodiment, utility slat cover 204 has the same convex outer profile as outer side or surface 6 of slat 1, when the rolling shutter is in the extended or closed position.

[0097] Utility slat interior space 212 may be sized and shaped to receive a variety of different features, such as a cut-resistant bar or other device to increase the security of the rolling shutter. In one embodiment, a locking device is received in interior space 212 to secure the rolling shutter in a closed or partially closed position. One or more flanges 218 may project into interior space 212 from base 206, cover 204, and/or walls 208 and 210 to position and support the locking device or other feature within the interior space.

[0098] The rolling shutter may include an end retention system that comprises a retaining rail or guide track positioned at the sides of the opening in the host structure. The guide track is configured to receive the ends of the slats and secure the slats in position to cover the opening of the structure. An end retention device is secured to the ends of the slats, and is received in the guide track to align and prevent disengagement of the slat ends from the guide track. The ends of the slats may be configured with a receptacle for receiving an end retention device, such as a fastener with a washer that is retained within a channel of the guide track. Examples of end retention systems are described in U.S. Patent Nos. 8,616,261 and 8,925,617 to Miller, which are

incorporated herein by reference.

[0099] FIGs. 20 and 21 show an embodiment of a slat and an end retention device. Slat 300 has a body 302, an engaging track 304, and a receiving track 306. Receiving track 306 is similar to receiving track 14 of slat 1, and includes a receptacle 308 for receiving the end retention device that is similar to receptacle 34 (FIG. 1C).

[0100] The end retention device comprises a first end that secures the end retention device to a slat, and a second end that engages a guide track. In one embodiment, the end retention device is a retaining screw 310 with first and second ends 310a and 310b. End 310a includes a threaded portion 310c for securing the retaining screw to slat 300. A retaining screw head or flange 312 is positioned at end 310b, for engaging a guide track. In a preferred embodiment, end 310b includes an unthreaded portion 310d adjacent to flange 312.

[0101] In one embodiment, the end retention device further includes a bushing 314 that comprises a cylindrical body 316 with first and second ends 316a and 316b, and a bore 316c that is sized and shaped to receive retaining screw 310. A bushing head or flange 318 is positioned at the first end 316a of body 316. The end retention device is assembled by inserting retaining screw 310 through bore 316c and positioning bushing 314 at end 310b. Bushing end 316b is positioned proximal or adjacent to retaining screw flange 312, such that bushing flange 318 and the retaining screw flange are spaced apart by body 316. In a preferred embodiment, bushing 314 is positioned over the unthreaded portion 310d of retaining screw 310.

[0102] Retaining screw end 310a is received in slat receptacle 308, to couple the end retention device to the ends 320 and/or 322 of slat 300. In one embodiment, receptacle 308 of slat 300 is sized and shaped to provide a screw boss for retaining screw threaded portion 310c, to secure the end retention device to the slat. Retaining screw flange 312 (and spaced apart bushing

flange 318) projects from slat ends 320 and 322, to engage the guide track of an end retention system.

[0103] Under load conditions, the end retention device experiences high stresses at the point of engagement with the slat. In one embodiment, the unthreaded portion 310d of retaining screw 310 includes a section 310e adjacent to threaded portion 310c, that has a diameter that is approximately the diameter of the screw boss (receptacle 308). Retaining screw 310 is configured such that unthreaded section 310e becomes embedded within receptacle 308 and slat end 320 (or 322), to provide a stronger connection than if this transition occurred over a threaded portion of the screw, as shown in FIGs. 21B and 21C.

[0104] FIG. 22A shows an embodiment of a guide track 400, that comprises a U-shaped channel 402 formed by a base 404 and walls 406. Channel 402 is sized and shaped to receive a slat end 320 or 322 coupled to an end retention device, to retain and guide the longitudinal movement of the slat within the channel. In one embodiment, flanges 408 project from walls 406 into channel 402, to form a guide slot 410 that is sized and shaped to receive bushing body 316. The movement of bushing body 316 in slot 410 guides the longitudinal movement of the end retention device (retaining screw 310 and bushing 314) and slat 300 within guide track channel 402. Retaining screw flange 312 has a larger width or diameter than the width of guide slot 410, such that the retaining screw flange is captured by the guide slot and is prevented from being withdrawn from channel 402. Bushing flange 318 also has a larger width or diameter than guide slot 410, such that the transverse movement of the end retention device in guide track 400 is limited by the length of bushing body 316 between the retaining screw flange and bushing flange.

[0105] In the embodiment of FIG. 22A, flanges 408 have different heights, such that slot

410 is positioned off-center within channel 402, and the end retention device and slat 300 are positioned closer to one of walls 406 of guide track 400. FIG. 22B shows an alternative embodiment of a guide track 450 with a similar structure to guide track 400, that comprises a channel 452 defined by base 454 and walls 456. Flanges 458 project from walls 456 into channel 452, to form a guide slot 460 that is sized and shaped to receive bushing body 316 and capture retaining screw flange 312. Guide slot flanges 458 project from walls 456 at approximately the same height, such that guide slot 460 is equidistant from walls 456 and is centered within channel 452.

[0106] In yet another embodiment, the guide track may include a stop within the channel that limits the transverse movement of the end retention device and slat 300 into the guide track channel. FIG. 23A shows a guide track 500 with a similar structure to guide track 400, that comprises a channel 502 defined by base 504 and walls 506. Flanges 508 project from walls 506 into channel 502, to form a guide slot 510 that is sized and shaped to receive bushing body 316 and capture retaining screw flange 312. A stop comprising one or more stop flanges 512 is formed within channel 502, between base 504 and guide slot flanges 508. Stop flanges 512 are positioned to contact retaining screw flange 312 as the end retention device and slat 300 move transversely into guide track channel 502.

[0107] Similarly to guide track 400, guide slot flanges 508 project from walls 506 at different heights, such that guide slot 510 is positioned off-center within channel 502, and the end retention device and slat 300 are positioned closer to one of walls 506 of guide track 500. In one embodiment, each stop flange 512 projects from wall 506 at about the same height as the guide slot flange 508 projecting from the same wall.

[0108] FIG. 23B shows an alternative embodiment of a guide track 550 with a similar

structure to guide track 500, that comprises a channel 552 defined by base 554 and walls 556. Flanges 558 project from walls 556 into channel 552, to form a guide slot 560 that is sized and shaped to receive bushing body 316 and capture retaining screw flange 312. A stop comprising one or more stop flanges 562 is formed within channel 552, between base 554 and guide slot flanges 558. Stop flanges 512 are positioned to contact retaining screw flange 312 as the end retention device and slat 300 move transversely into guide track channel 502.

[0109] Guide slot flanges 558 project from walls 556 at approximately the same height, such that guide slot 560 is equidistant from walls 556 and is centered within channel 552. In one embodiment, each stop flange 562 projects from wall 556 at about the same height, and preferably project from wall 556 at about the same height as guide slot flanges 558.

[0110] The guide track may also include a stop within the channel, to prevent the rolling shutter from being inadvertently raised out of the guide track -- e.g., when the rolling shutter is retracted to the open position. For example, a spring may be positioned in the channel at the top of the guide track to provide a resilient stop (not shown). A slat in the rolling shutter (e.g., a base slat) may include a stop bar (not shown) projecting into the channel and aligned to engage the channel stop and prevent inadvertent removal of the rolling shutter from the guide track. In one embodiment, one or more flanges that project within the channel may be configured to form or receive a guide channel stop. For example, flanges 458 and base 454 may form a receptacle 457 (FIG. 22B) within channel 452 that is sized and shaped to receive a stop, such as a spring (not shown). Similarly, flanges 562 and base 554 may form a receptacle 563 (FIG. 23B) within channel 552 that is sized and shape to receive a stop.

[0111] In one embodiment, the rolling shutter system includes a base slat with an end retention system to increase the security provided in a closed or extended position. Base slat end

retention increases resistance to pry and prevents the disengagement of lock bars from guide rails. In a preferred embodiment, the base slat incorporates the same guide track and end retention system as the rolling shutter slats. For example, the base slat may include a receptacle for receiving an end retention device, such as such as a receptacle 34 or 308 that serves as a screw boss for an end retention device, such as retaining screw 310 and bushing 314.

[0112] FIGs. 24-31 show various aspects of the installation of a rolling shutter system at the opening of a host structure. In one embodiment, the rolling shutter system includes a frame comprising one or more guide tracks positioned at the periphery of the opening in the host structure. The rolling shutter is commonly secured to the top of the opening and the guide tracks are positioned at either side of the opening. As the rolling shutter is lowered to cover the opening, the guide tracks retain and guide the ends of the slats as they are extended toward the bottom of the opening and into the closed position.

[0113] FIG. 24 shows an embodiment of a rolling shutter system 600 installed by a wall mount at the opening 602 of a host structure, such as for a window 601. Opening 602 has a top 604, a bottom 606, and a wall 608. Rolling shutter system 600 comprises multiple linked slats 610 that form the rolling shutter. Slats 610 are coupled to a spindle 612 and covered by a housing 614 that is sized and shaped to receive and store the rolling shutter in a retracted (wound) position. Housing 614 may be secured to wall 608 at the top of opening 602, using one or fasteners 616 such as screws, bolts, nails, or other fasteners known in the art. In a preferred embodiment, fastener 616 is a concrete or masonry anchor, such as a Tapcon®. The ends of slats 610 are captured in one or more guide tracks 618, that align and secure the slats in position to cover the opening. The rolling shutter may include a base slat 620, which may also have ends that are received in guide tracks 618.

[0114] FIG. 25 shows an alternate embodiment of a rolling shutter system 650 installed by a trap mount. The opening of a host structure 652 has a top 654, a bottom 656, and a side wall 658. Rolling shutter system 650 comprises multiple linked slats 660 that form the rolling shutter. The slats are coupled to a spindle 662 and covered by a housing 664 that is sized and shaped to receive and store the rolling shutter in a retracted (wound) position. Housing 664 may be secured to top 654 of opening 652, using one or fasteners 666. The ends of slats 660 are captured in guide tracks 668, that align and secure the slats in position to cover the opening. Guide tracks 668 are secured to side wall 658 by a trap mount. A post 672 is secured to side wall 658, and guide tracks 668 (and housing 664) are secured to post 672 using one or more fasteners, such as fasteners 666. The rolling shutter may include a base slat 670, which may also have ends that are received in guide tracks 668.

[0115] FIG. 26 shows an embodiment of a rolling shutter system 700, comprising a single rolling shutter installed over the opening of a host structure having side walls 702. A rolling shutter curtain comprises multiple slats 704 that span the width of the opening between side walls 702. The ends of slats 704 are received in guide tracks 706 that are positioned at the sides of the opening and secured to side walls 702. In a retracted position, slats 704 are stored in a housing 708 positioned at the top of the opening.

[0116] FIG. 27 shows an alternative embodiment of a rolling shutter system 750, where multiple rolling shutter curtains are positioned side-by-side to span the width of an opening in a host structure. Each rolling shutter curtain comprises multiple slats 752, guide tracks 754 and a housing 756. Adjacent rolling shutter curtains have housings 756 positioned side-by-side and secured to the top 758 of the opening. Between adjacent rolling shutters, two guide tracks 754a and 754b are positioned back-to-back to receive the ends of slats 752 of their respective rolling

shutter curtains. In one embodiment, guide tracks 754a and 754b are secured to a vertical support internal to the opening (not shown), such as an internal mullion.

[0117] Referring to FIGs. 28-31, embodiments for securing a guide track 800 at the opening of a host structure, such as to a side wall 802. In the embodiment of FIG. 28, guide track 800 is mounted to wall 802 by a wall mount. Guide track 800 comprises a U-shaped channel 804 formed by a base 806 and walls 808. An end retention device (retaining screw 310 and bushing 314) is received in channel 802 to couple the end of a slat (not shown) to guide track 800. A flange 814 extends from base 804 for receiving a fastener 816 to secure guide track 800 to wall 802. For example, fastener 816 may be an anchor that extends through flange 814 and into wall 802.

[0118] In one embodiment, flange 814 forms a channel that is sized and shaped to enclose the head 816a of fastener 816. As shown in FIG. 28, an arm 818 extends from flange 814, opposite from guide track base 804. Flange 814, arm 818, and guide track base 804 form a U-shaped channel 820 that receives fastener head 816a. A cover may be positioned at the opening of channel 820 to conceal fastener head 816a, such as snap fit cover 110 (FIG. 12).

[0119] In the embodiment of FIG. 29, guide track 800 is secured to wall 802 by a trap mount. An intermediate member 822 is fastened to opening wall face 802 by a fastener 824, such as an anchor. Member 822 may be a vertical post, such as a square or rectangular tube. Guide track 800 is secured to member 822 transverse or at right angles to wall face 802, to receive the rolling shutter slats (not shown) that extend across the opening. In one embodiment, guide track 800 is secured to member 822 by a fastener 816 that extends through flange 814 and into member 822, such as a metal screw.

[0120] In the embodiment of FIG. 30, two guide tracks 800a and 800b are secured to an

internal mullion 826 by a face mount. Guide tracks 800a and 800b are positioned adjacent to each other in a back-to-back orientation on the same face of mullion 826. Each guide track 800a and 800b is secured to mullion 826 in a similar manner as the wall mount shown in FIG. 28. A fastener 816 (e.g., metal screw) extends through flange 814 and into mullion 826.

[0121] In the embodiment of FIG. 31, two guide tracks 800a and 800b are secured to an internal mullion 826 by a trap mount. Guide tracks 800a and 800b are respectively secured to different faces of mullion 826 through separate intermediate members 822a and 822b, in a similar manner as the trap mount shown in FIG. 29. In one embodiment, members 822a and 822b are respectively secured to opposite faces 826a and 826b of mullion 826 by fasteners 824 (e.g., metal screws). Guide tracks 800a and 800b are respectively secured to members 822a and 822b transverse or at right angles to mullion faces 802 by fasteners 816 (e.g., metal screws). The installed guide tracks 800a and 800b are oriented back-to-back and extend parallel to each other to receive the rolling shutter slats (not shown) that extend across the opening.

[0122] While particular embodiments of the present disclosure have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the present disclosure. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this disclosure.

What is claimed is:

1. A rolling shutter, comprising:

first and second slats, each slat having inner and outer sides, a first edge with an engaging track, and a second edge with a receiving track comprising a lip member and a guard member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat;

wherein the engaging track of the first slat is received in the receiving track of the second slat to form an articulating hinge; and

wherein the hinge has a vertical position with the maximum extension of the first and second slats; and the hinge is rotatable in a backward direction with a maximum angle of backward rotation greater than 10° from the vertical position.

2. The rolling shutter of claim 1, wherein the hinge has a maximum angle of backward rotation of at least about 15° from the vertical position.

3. The rolling shutter of claim 1, wherein the hinge has a maximum angle of backward rotation of about 18° from the vertical position.

4. The rolling shutter of claim 1 wherein the hinge in the vertical position has an engaging track of the first slat that is vertically displaceable in the receiving track of the second slat.

5. The rolling shutter of claim 4, wherein the hinge in the vertical position has an engaging track of the first slat that is vertically displaceable in the receiving track of the second slat by at least about 0.025 inches.

6. The rolling shutter of claim 1, wherein the hinge has a maximum angle of backward rotation of at least about 15° from the vertical position, and wherein the hinge in the vertical position has an engaging track of the first slat with a range of vertical displacement in the

receiving track of the second slat of at least about 0.025 inches.

7. The rolling shutter of claim 1, wherein the guard member has a convex tip surface, and the engaging track contacts the convex tip surface at the maximum angle of backward rotation of the hinge.

8. The rolling shutter of claim 7, wherein the guard member convex tip surface has a curve with a radius of about 0.25 inches.

9. The rolling shutter of claim 1, wherein the engaging track is hook-shaped and comprises a bend that curves toward the inner side, and a rib positioned at the first edge that projects from the inner side; and

wherein the hinge is rotatable from the vertical position in the forward direction, and the rib of the first slat contacts the lip member of the second slat to stop the forward rotation of the hinge.

10. The rolling shutter of claim 1, wherein the hinge is rotatable from the vertical position in the forward direction, and wherein the hinge has a maximum angle of forward rotation of between about 70° to about 80° from the vertical position.

11. The rolling shutter of claim 10, wherein the hinge is rotatable from the vertical position in the forward direction, and wherein the hinge has a maximum angle of forward rotation of about 76° from the vertical position.

12. A rolling shutter, comprising:

first and second slats, each slat having a body with inner and outer sides, and first and second edges, an hook-shaped engaging track positioned at the first edge of the body, and a receiving track positioned at the second edge of the body;

the engaging track of each slat comprising a bend that curves toward the slat inner side,

and a rib positioned at the first edge that projects from the inner side;

the receiving track of each slat comprising a lip member and a guard member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat;

wherein the engaging track of the first slat is received in the receiving track of the second slat to form an articulating hinge;

wherein the hinge is rotatable in a forward direction, and wherein the rib of the first slat contacts the lip member of the second slat to stop the forward rotation of the hinge.

13. The rolling shutter of claim 12, wherein the hinge has a vertical position with the maximum extension of the first and second slats; and wherein the hinge has a maximum angle of forward rotation of between about 70° to 80° from the vertical position.

14. The rolling shutter of claim 12, wherein the hinge has a vertical position with the maximum extension of the first and second slats; and wherein the hinge has a maximum angle of forward rotation of about 76° from the vertical position.

15. The rolling shutter of claim 12, wherein the hinge has a vertical position with the maximum extension of the first and second slats; and wherein the hinge in the vertical position has a vertical clearance between the engaging track of the first slat and the receiving track of the second slat.

16. The rolling shutter of claim 15, wherein the hinge has a vertical clearance of at least about 0.025 inches.

17. The rolling shutter of claim 12, wherein each slat has a maximum slat height between the engaging track and receiving track; and wherein the first and second slats have a difference in maximum slat height of at least about 7%.

18. The rolling shutter of claim 17, wherein the hinge has a vertical position with the maximum extension of the first and second slats; and wherein the hinge has a maximum angle of forward rotation of between about 70° to 80° from the vertical position, and a vertical clearance between the engaging track of the first slat and the receiving track of the second slat of at least about 0.025 inches.

19. The rolling shutter of claim 12, wherein each slat has a maximum slat height between the engaging track and receiving track; and wherein the first and second slats have a difference in maximum slat height ranging between about 9% to about 45%.

20. A rolling shutter, comprising:

a plurality of linked slats, each slat comprising:

a body with a body inner surface having a concave curve, a body outer surface having a convex curve, and first and second edges;

a hook-shaped engaging track at the first edge, comprising a first base adjacent to the first edge, and a first bend that curves toward the body inner surface, wherein the first base has a first outer surface that extends along the same convex curve as the body outer surface; and

a receiving track at the second edge, comprising a guard member and a lip member that are spaced apart to form an aperture that is sized and shaped to receive the engaging track of another slat, the lip member comprising a second base adjacent to the second edge and a second bend that curves toward the body outer surface, the second base having a second outer surface that extends along the same concave curve as the body inner surface, a rib projecting from the second outer surface, and the guard member having a third outer surface;

wherein the rolling shutter has a retracted position that forms a coil comprising a plurality of windings of linked slats, each winding having a winding outer surface formed by the body

outer surfaces and the first and third outer surfaces of the slats in the winding, and a winding inner surface formed by the body inner surfaces and second outer surfaces of the slats in the winding; and

wherein the adjacent winding inner surfaces and winding outer surfaces in the coil are separated by the rib.

21. The rolling shutter of claim 20, wherein the winding inner surfaces and winding outer surfaces in the coil have curvatures that are concentric.

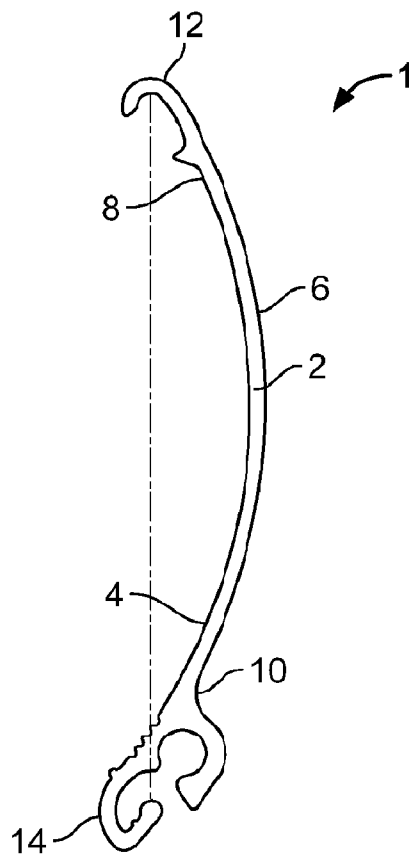


FIG. 1A

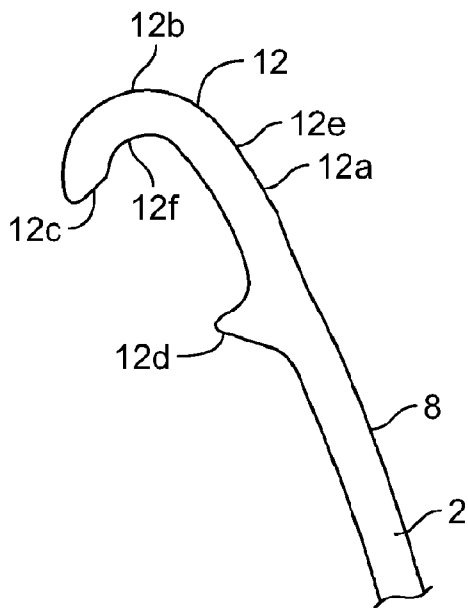


FIG. 1B

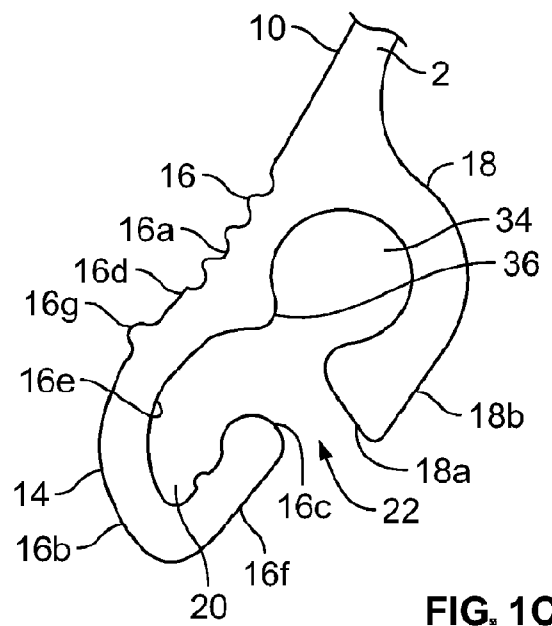


FIG. 1C

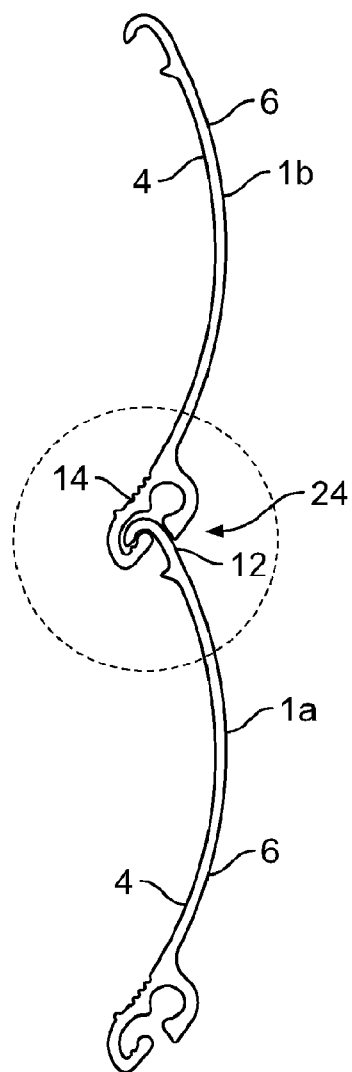


FIG. 2A

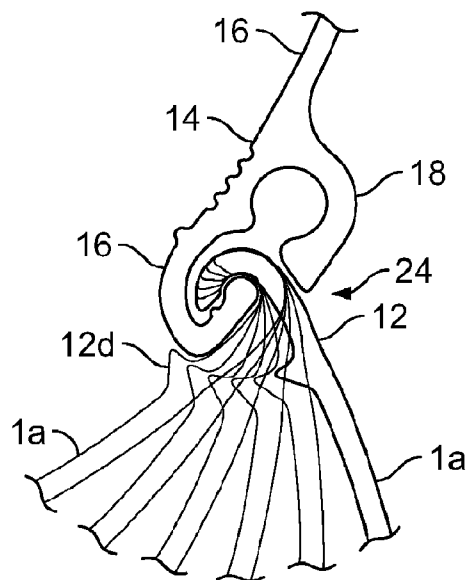


FIG. 2B

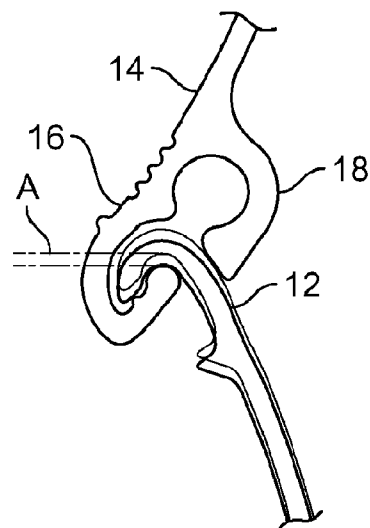


FIG. 2C

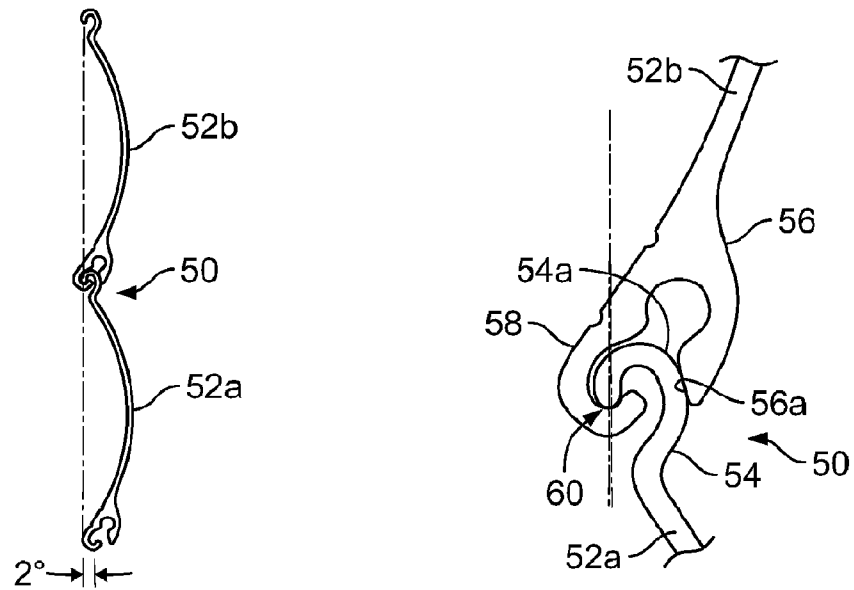


FIG. 3A
(Prior Art)

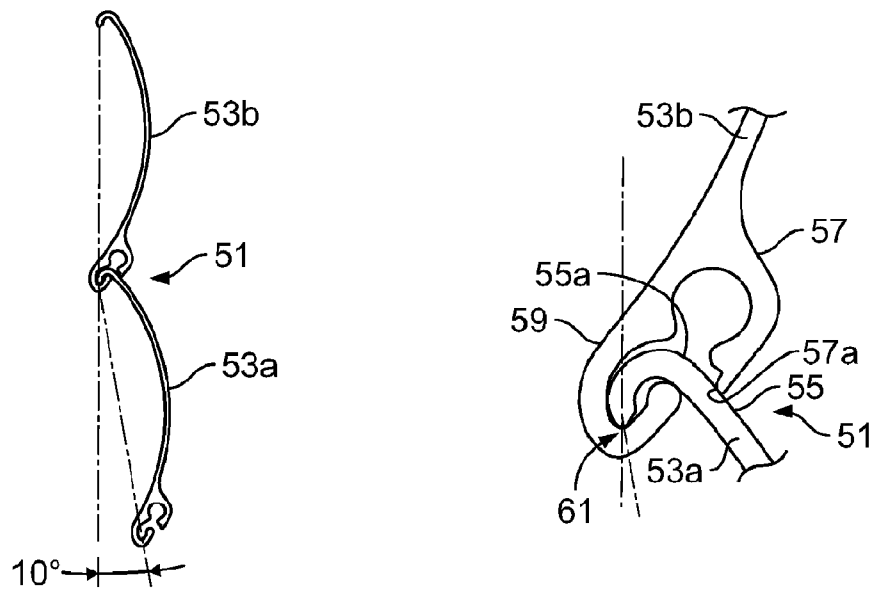


FIG. 3B
(Prior Art)

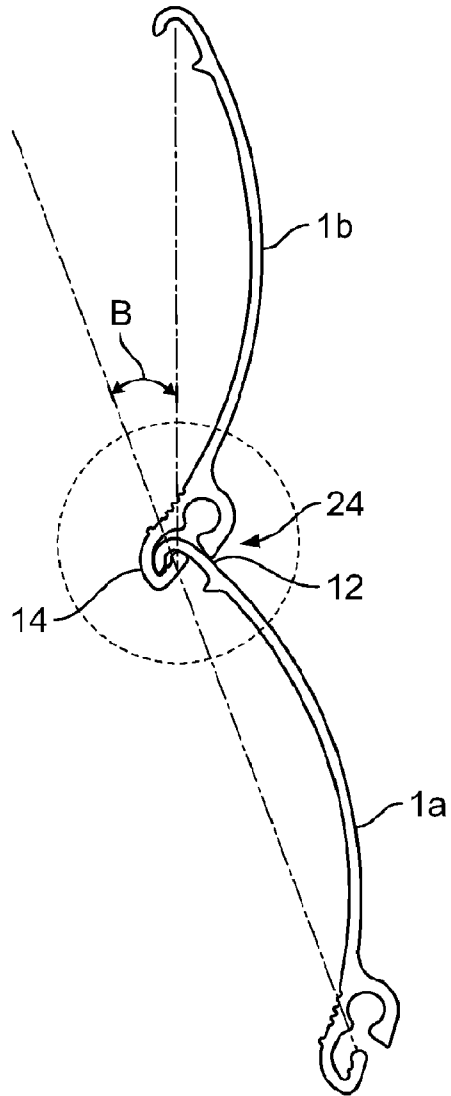


FIG. 4A

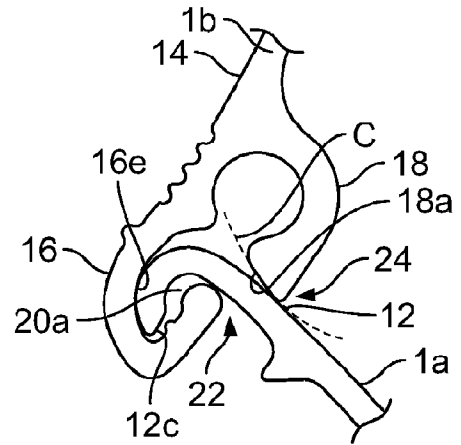


FIG. 4B

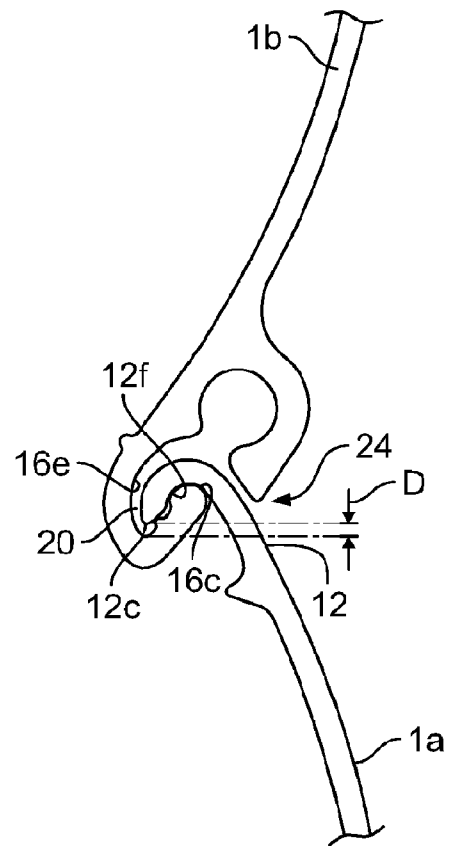


FIG. 4C

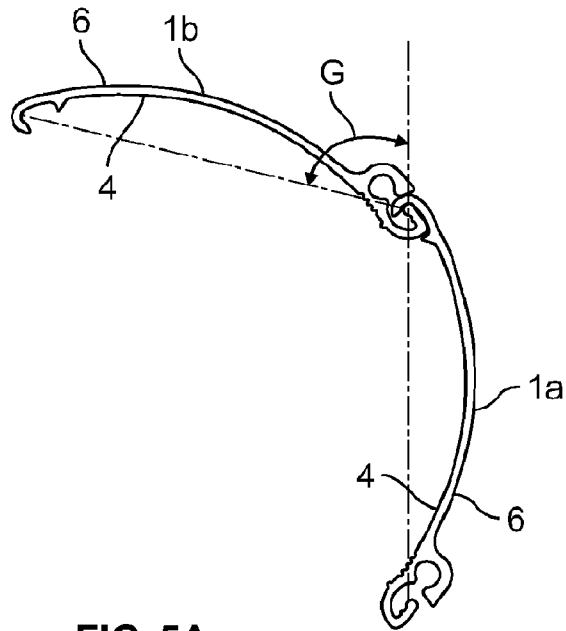


FIG. 5A

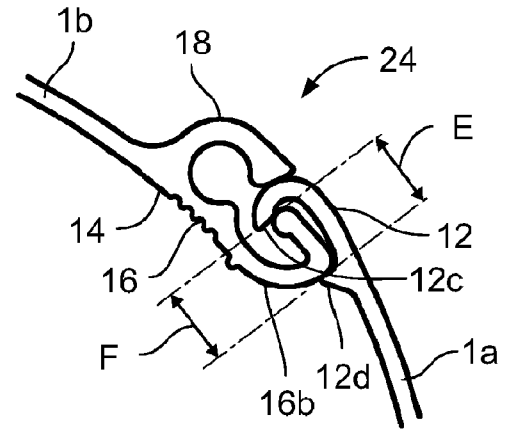


FIG. 5B

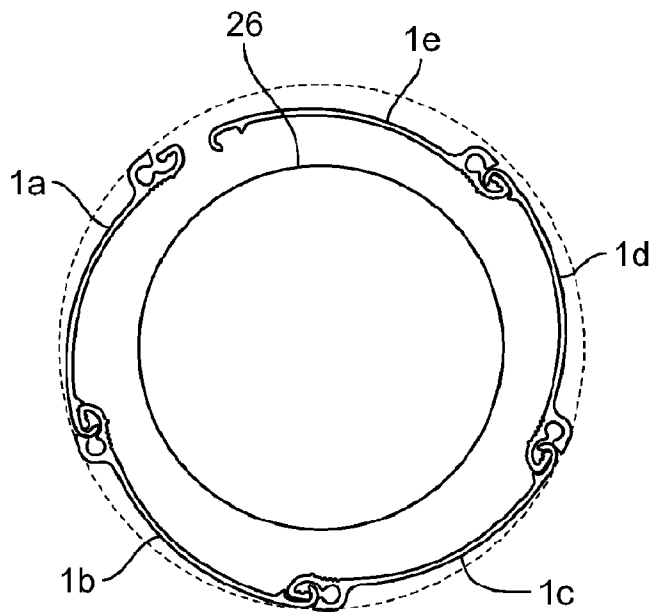


FIG. 6A

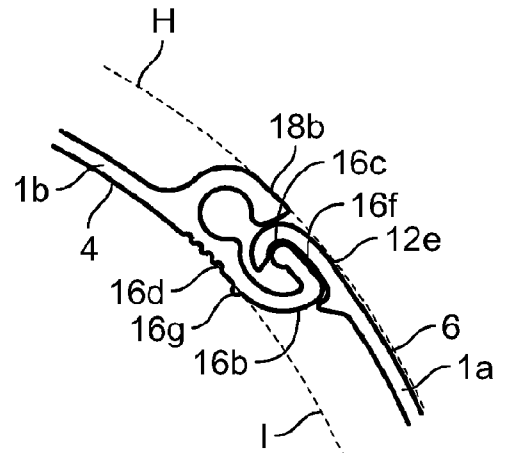


FIG. 6B

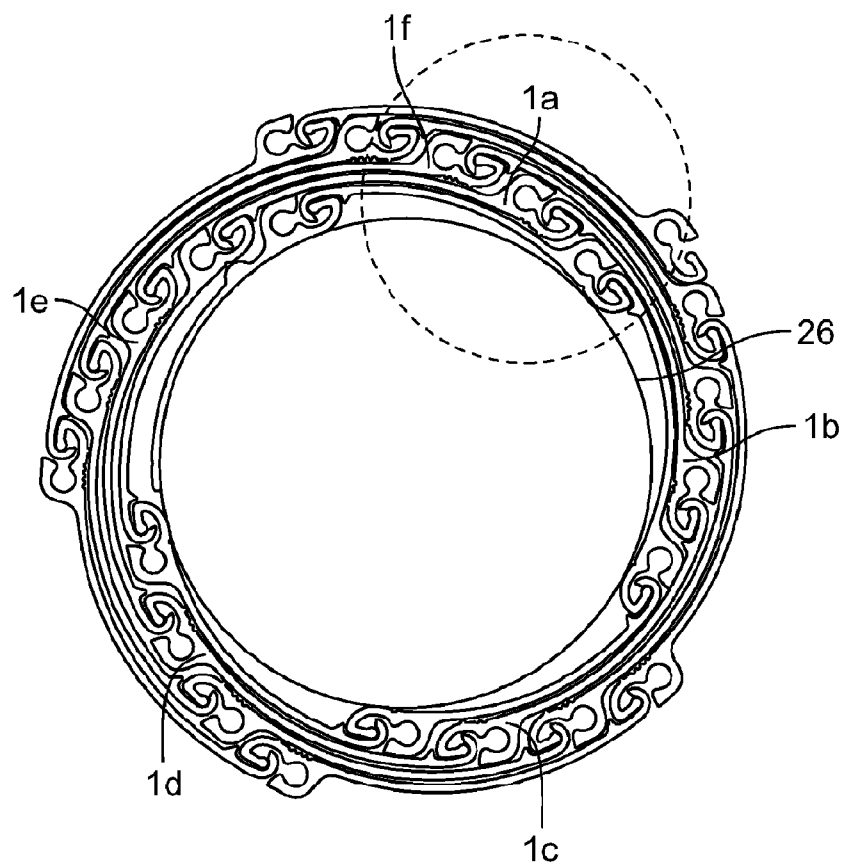


FIG. 6C

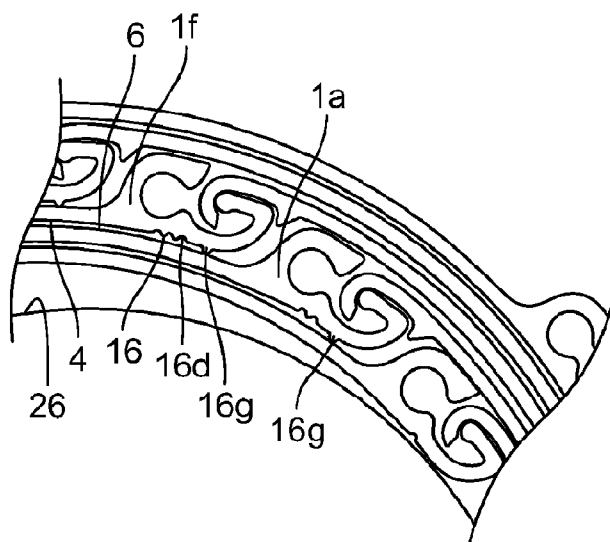
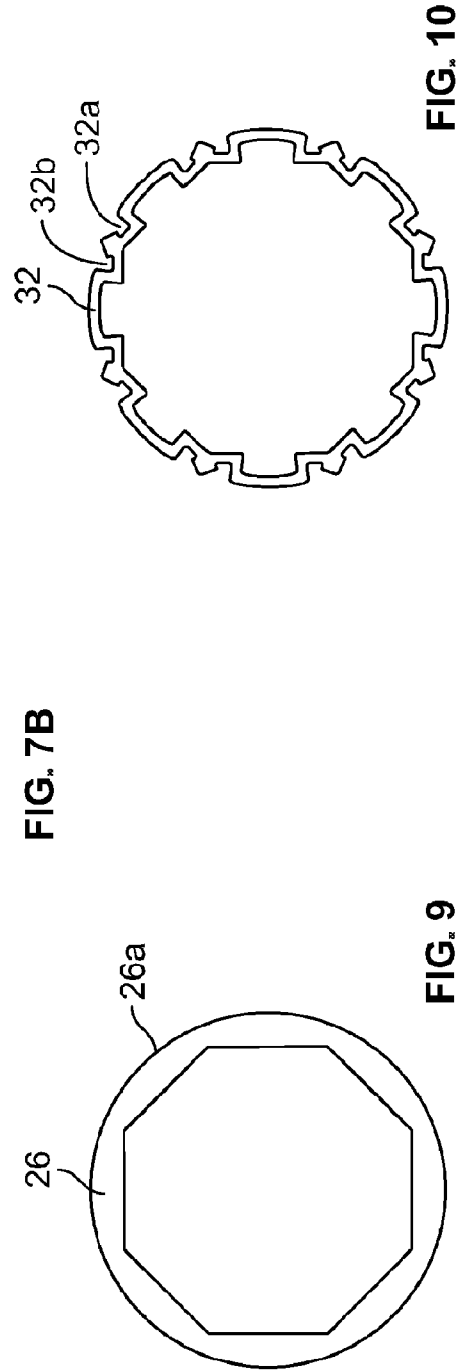
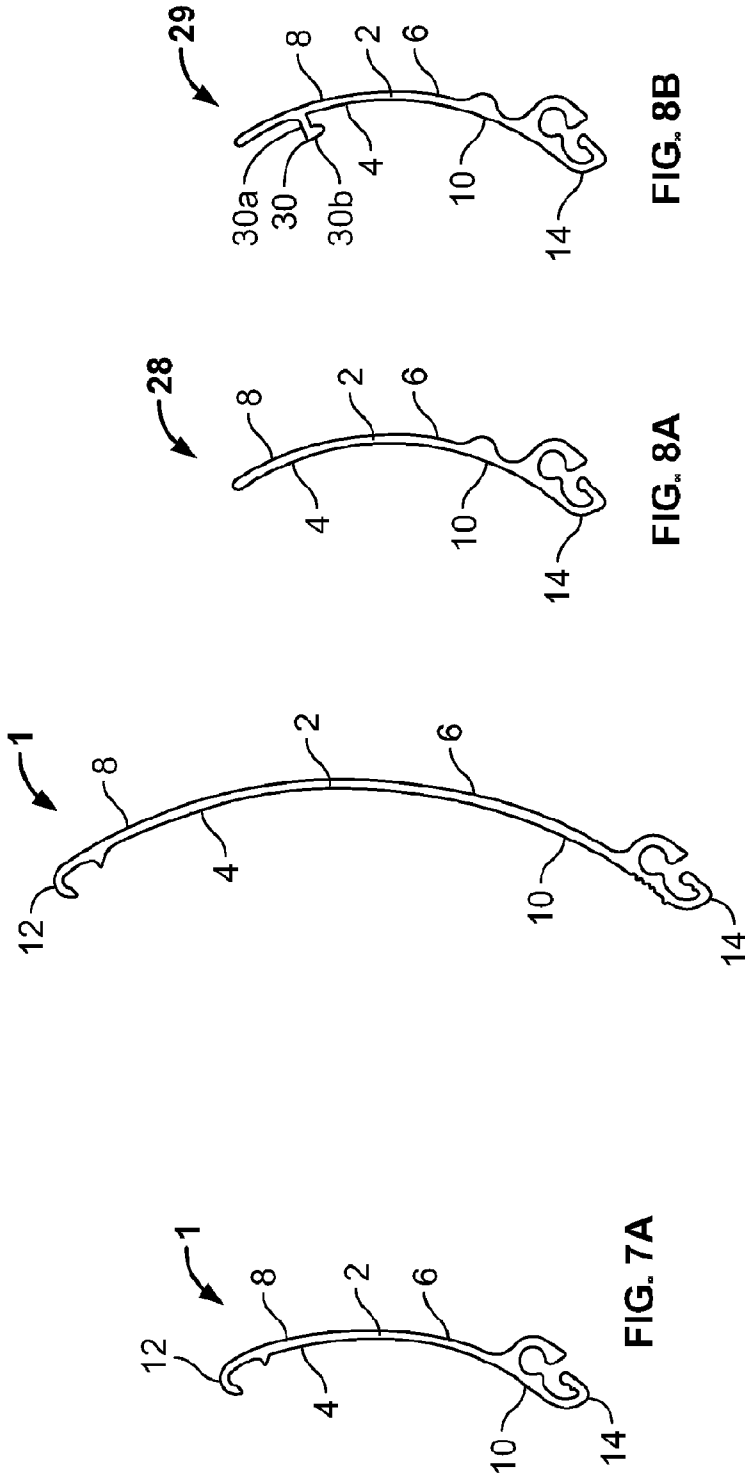


FIG. 6D



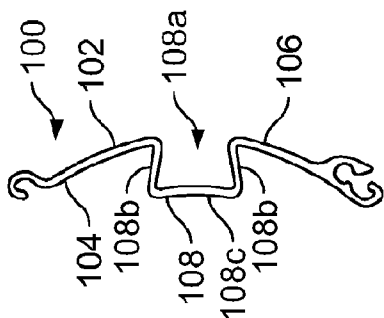


FIG. 11

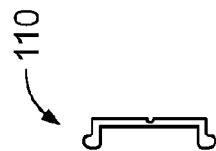


FIG. 12

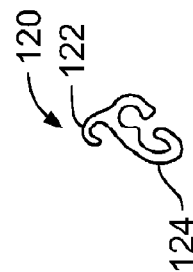


FIG. 13

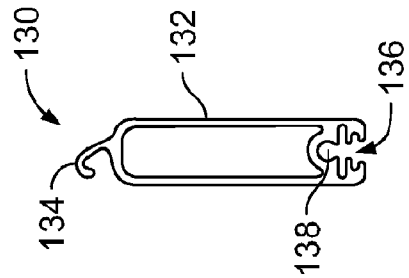


FIG. 14

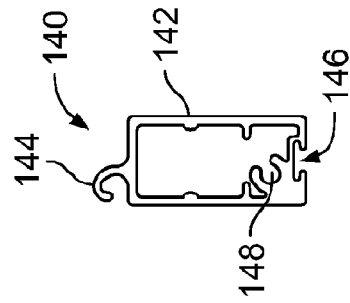


FIG. 15

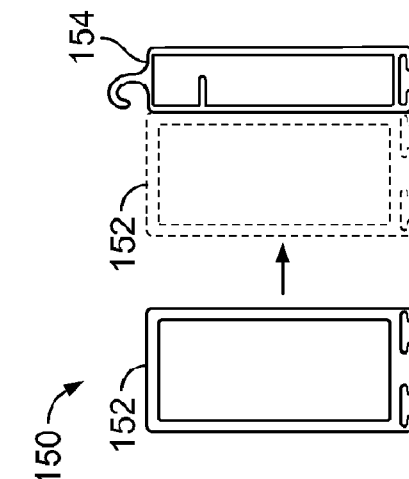


FIG. 16

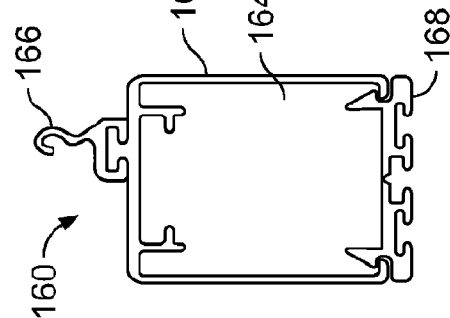


FIG. 17

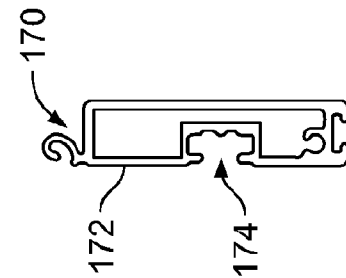


FIG. 18

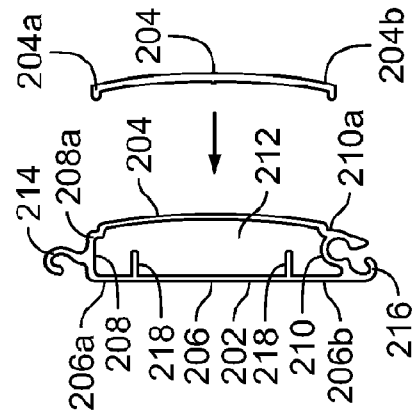
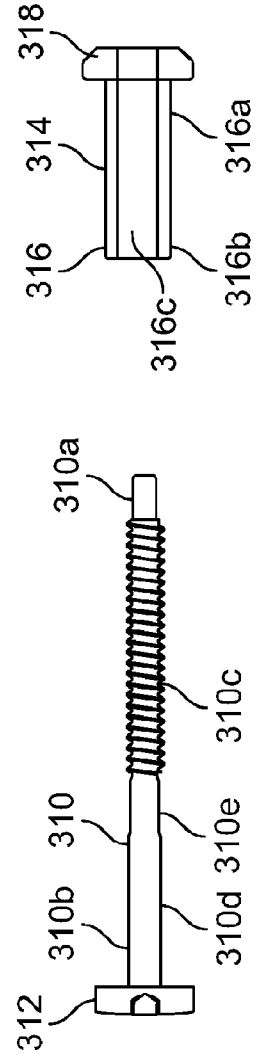
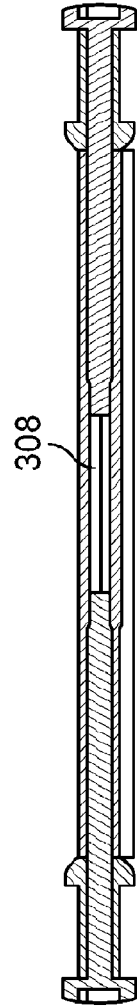
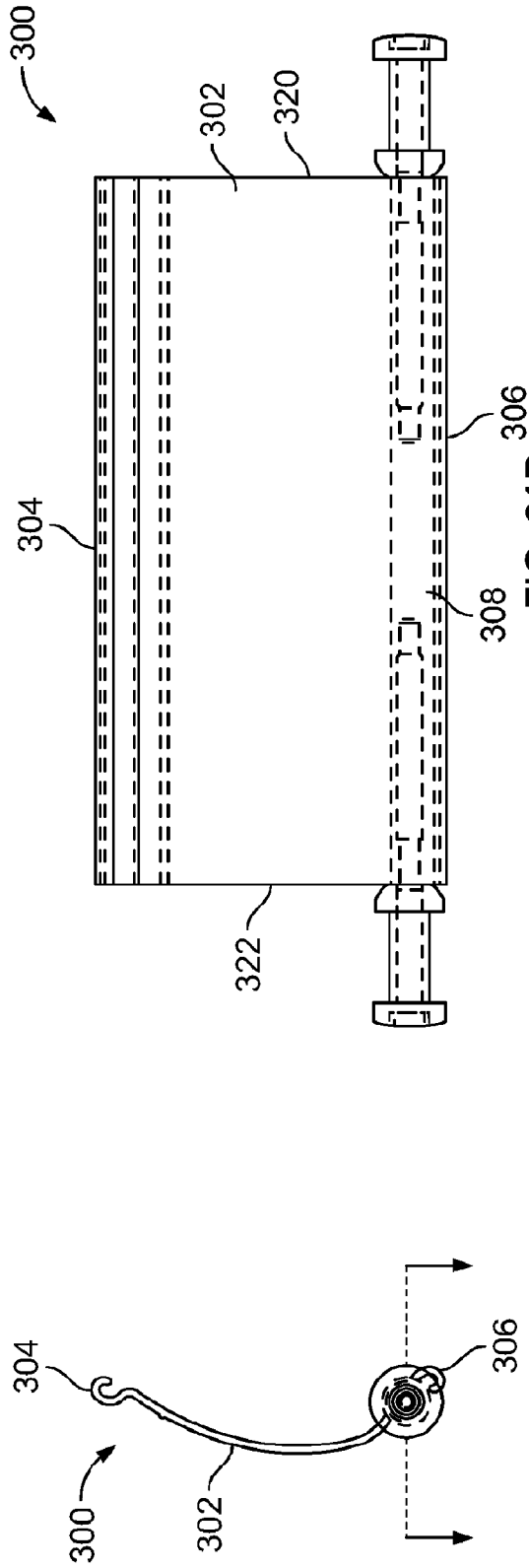
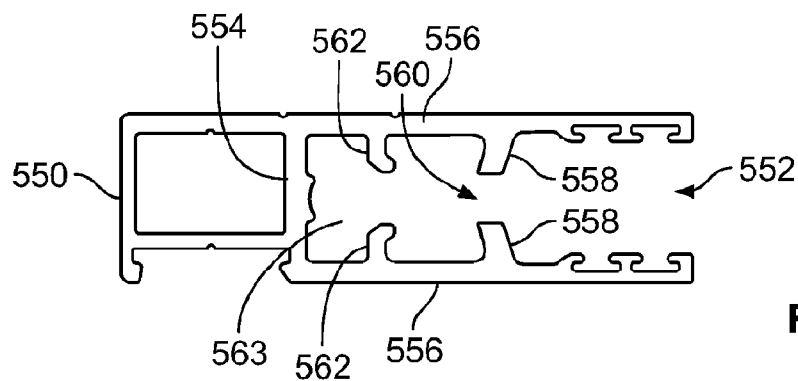
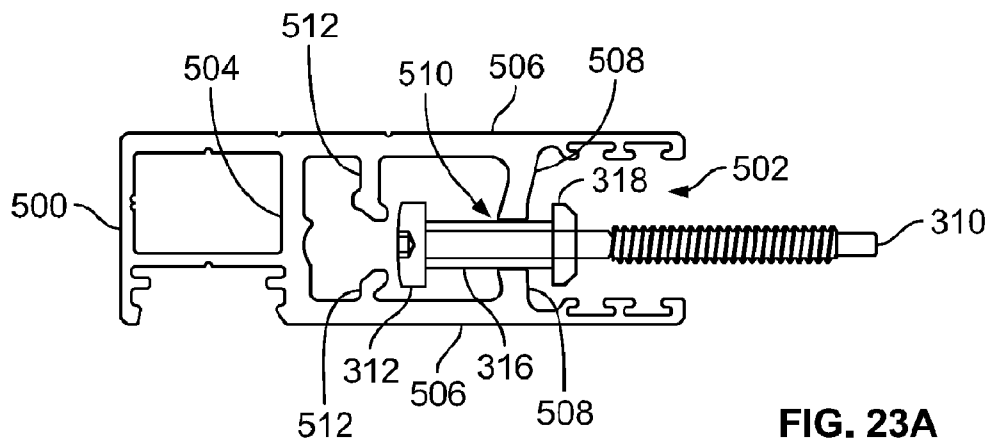
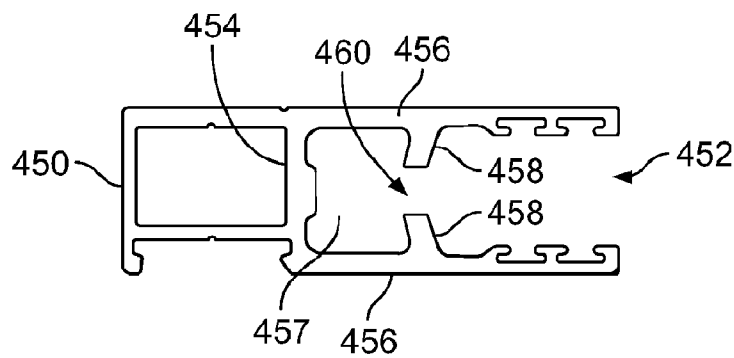
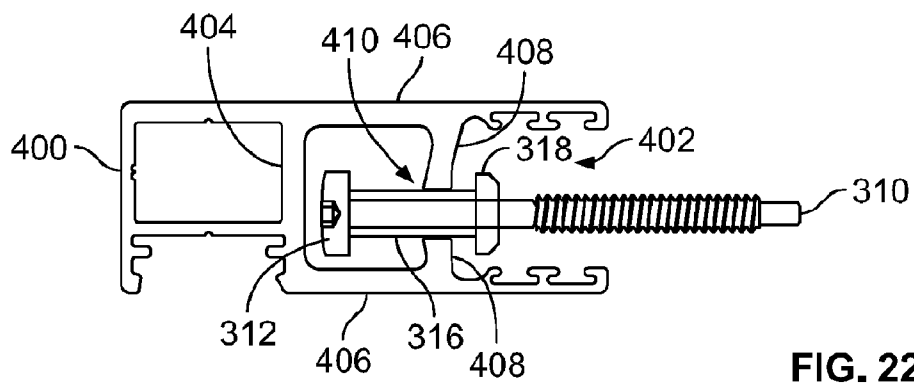


FIG. 19





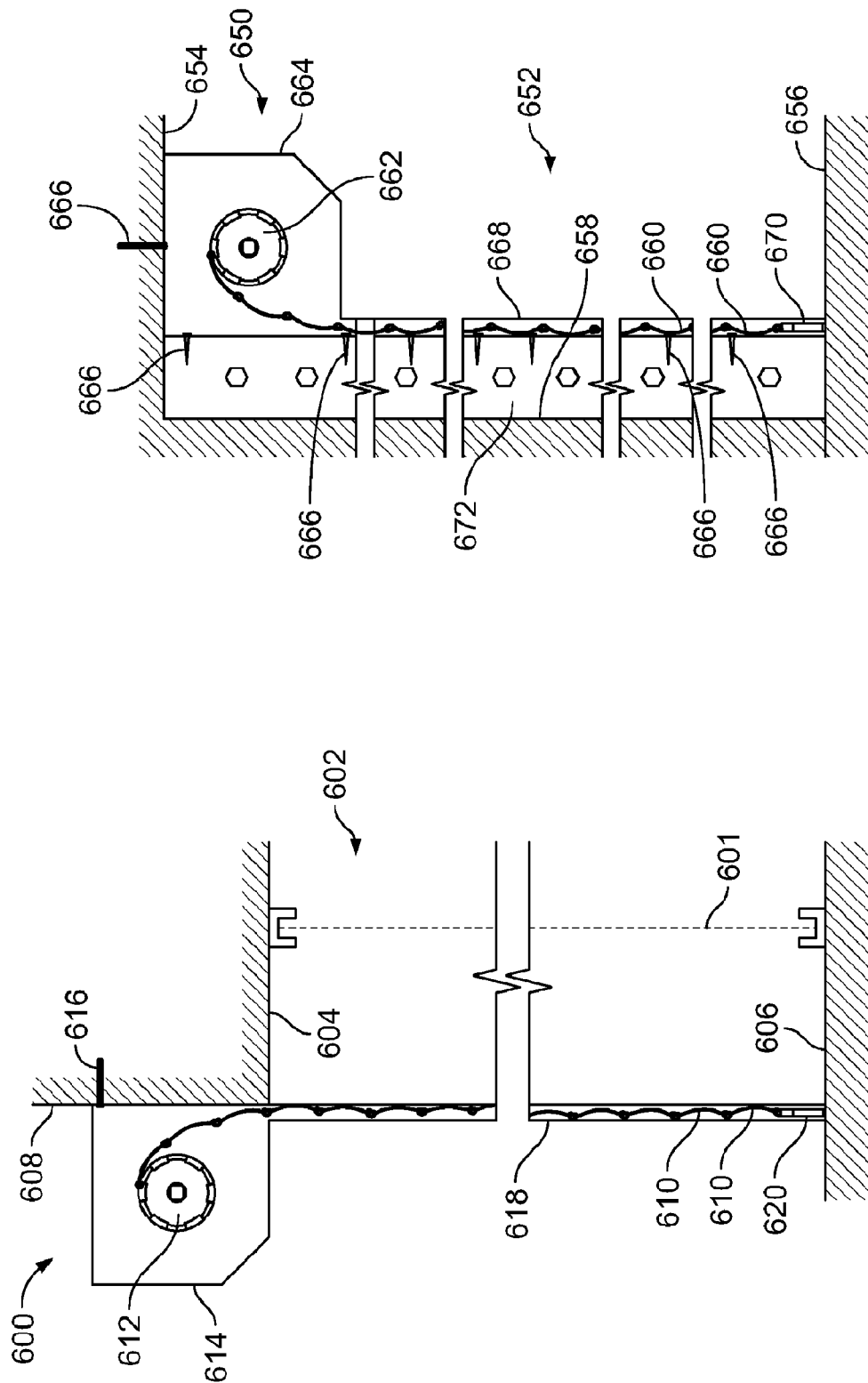


FIG. 25

FIG. 24

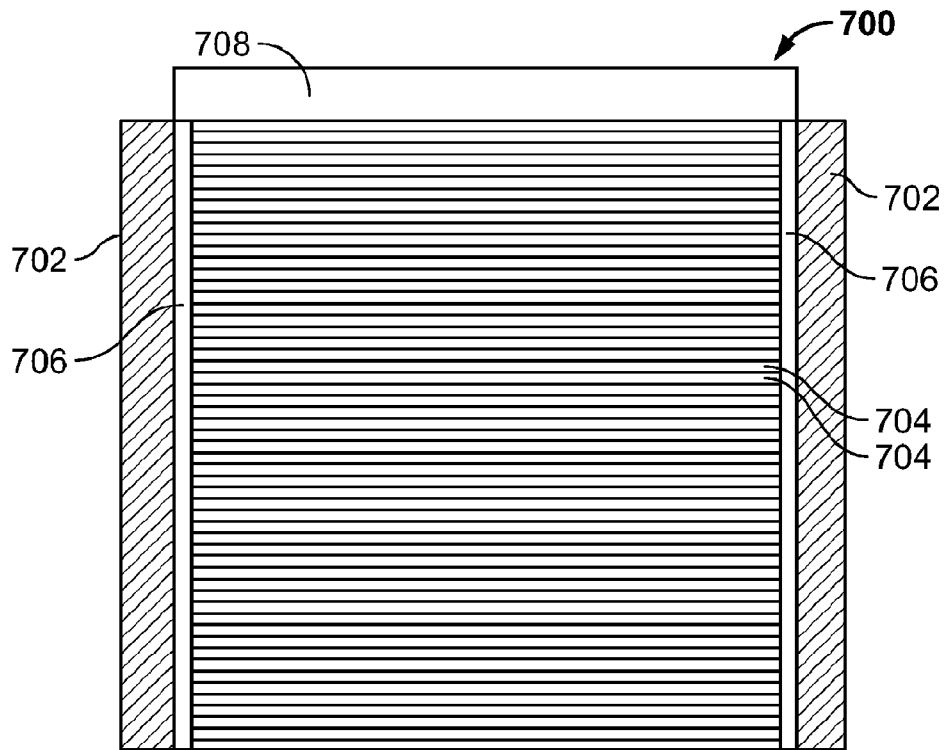


FIG. 26

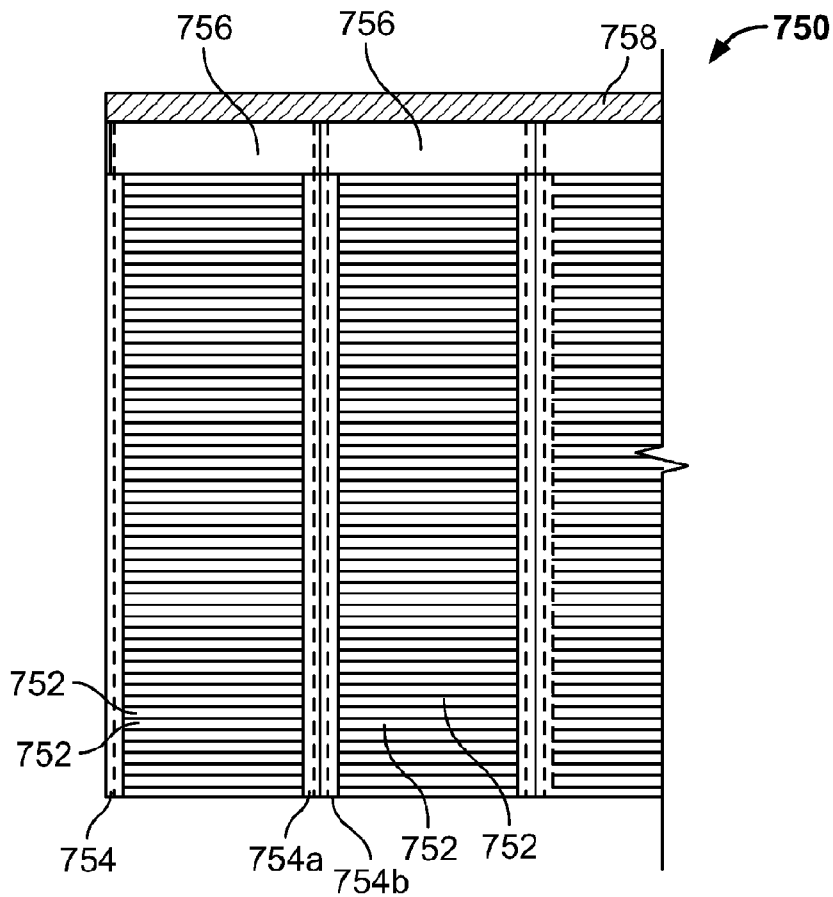


FIG. 27

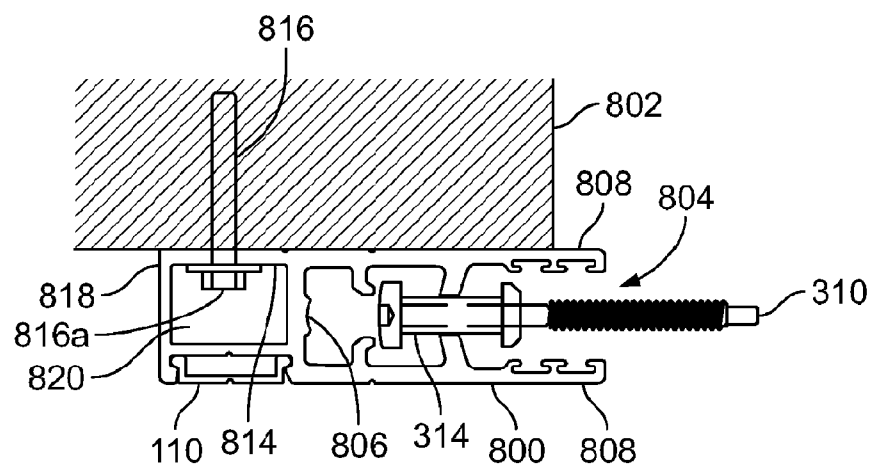


FIG. 28

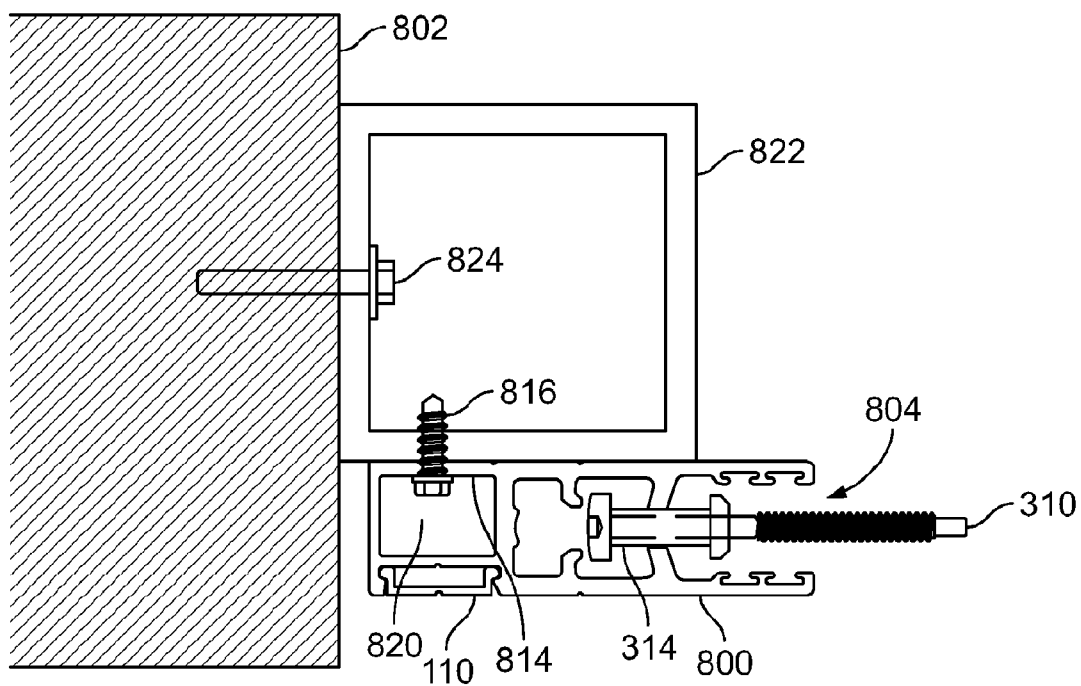


FIG. 29

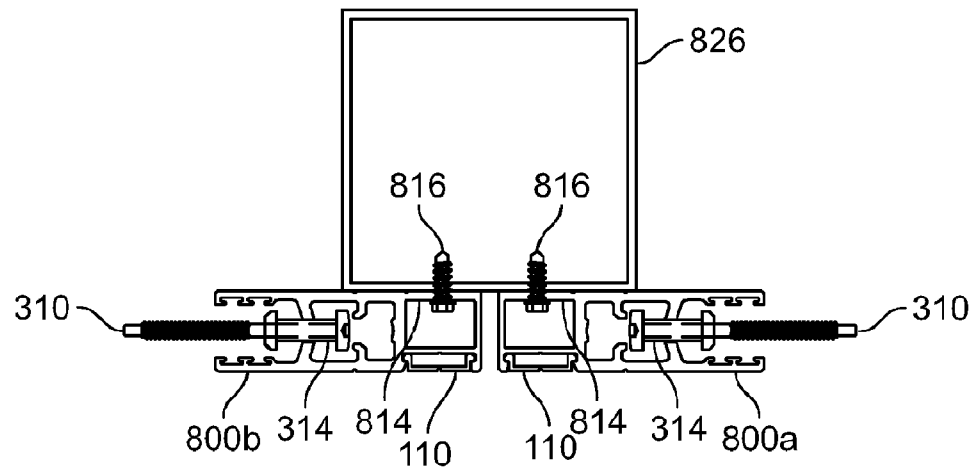


FIG. 30

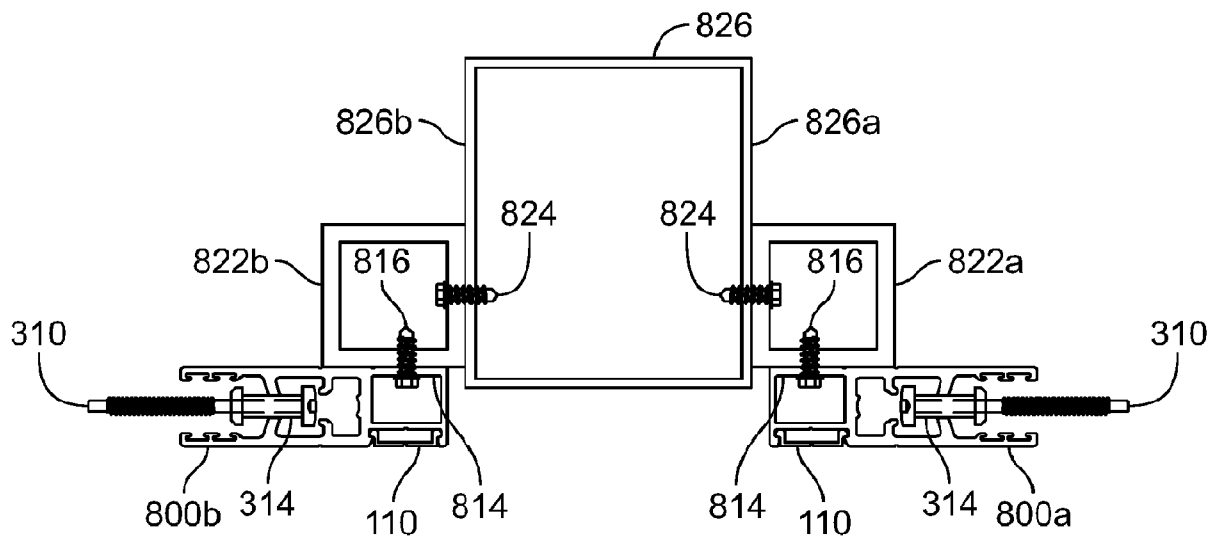


FIG. 31

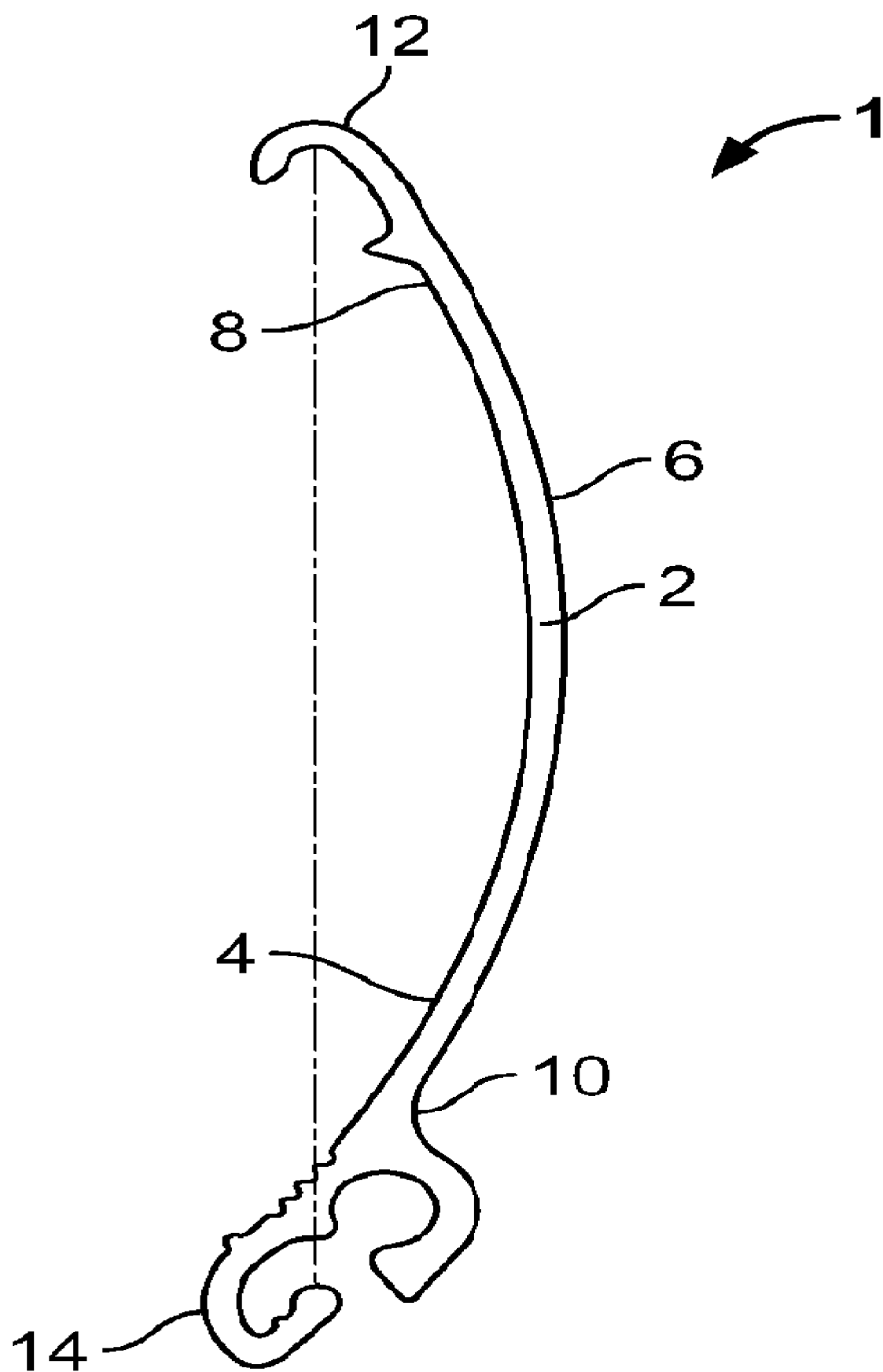


FIG. 1A