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- (54) **Title:** SYSTEM FOR LOW-FORCE ROLL FOLDING AND METHODS THEREOF

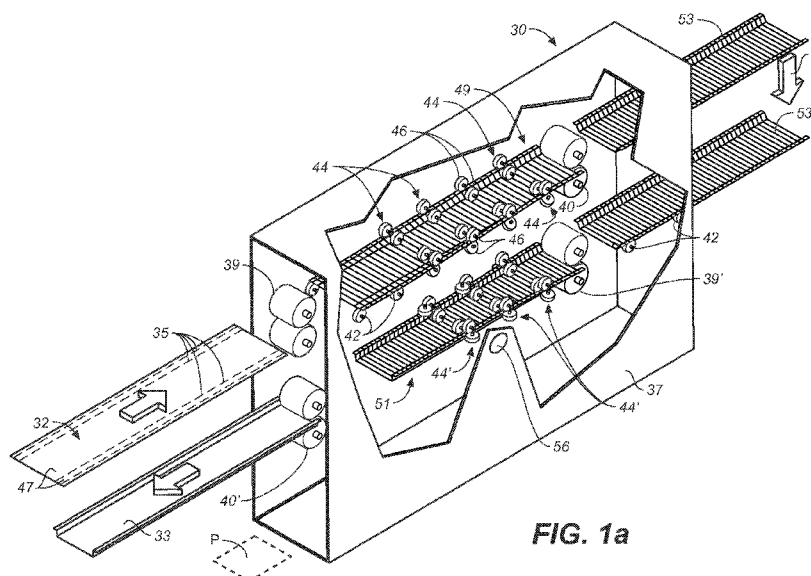


FIG. 1a

- (57) **Abstract:** A system for low-force roll folding effects bending of a two-dimensional sheet material having one or more predetermined fold lines into three-dimensional article. The system may include a sheet material with bend-facilitating structure extending along a length one or more of the predetermined fold lines, a stand of rollers configured to effect bending of the sheet material along the bend-facilitating structure, and a driver to move the stand of folding rollers relative to the sheet material along the length of one or more of the predetermined fold lines to effect bending of the sheet material along the bend-facilitating structure. A method for low-force roll folding is also disclosed.



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SYSTEM FOR LOW-FORCE ROLL FOLDING AND METHODS THEREOF

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/029,322 filed February 16, 2008, entitled SYSTEM FOR LOW-FORCE ROLL FOLDING AND METHODS THEREOF, the entire contents of which is incorporated herein for all purposes by this reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates, in general, to systems for low-force roll folding, and more particularly to devices which may be used for roll folding of sheets having bend-facilitating fold lines, and methods for their use.

Description of Related Art

[0003] Roll forming is a continuous bending operation in which a two-dimensional sheet of material, for example, sheet metal is passed through a series of rollers, each performing an incremental amount of bending, until a particular cross-sectional profile of a three-dimensional product or item is produced. A "flower pattern" represents each incremental cross-sectional profile from flat two-dimensional sheet metal to ultimate

cross-sectional profile of the three-dimensional product. Roll forming is generally used to produce objects formed of sheet metal having straight, longitudinal, and parallel bends.

[0004] A "stand" or set of rollers is required to produce each incremental cross-sectional profile as well as the ultimate cross-sectional profile of the product. Each stand includes cooperating contoured rollers which impart incremental bending upon the sheet metal as it passes through the stand, preferably without changing the thickness of the material. One will appreciate that roll forming machines are generally quite expensive due to the high cost of fabricating the closely tolerant sets of rollers of each stand for each incremental cross-sectional profile.

[0005] U.S. Patent No. 2,127,618 to Reimensneider illustrates an exemplary automobile side rail produced by roll forming. Japanese Patent Application No. 11-188426 illustrates an exemplary channel member also produced by roll forming. Exemplars of machines currently used for roll forming are described by U.S. Patent No. 7,275,403 to Meyer and U.S. Patent No. 7,243,519 to Chuang.

[0006] Again, one will appreciate that such roll forming machines are generally quite expensive due to the high cost of fabricating sets of rollers for each stand. Each set of rollers generally require the use of hardened steels and other metals that are highly machined with close tolerances to a respective incremental cross-sectional profile.

[0007] In light of the foregoing, it would be beneficial to have a forming system which overcomes the above and other disadvantages of known apparatuses for bending sheet materials.

BRIEF SUMMARY OF THE INVENTION

[0008] One aspect of the present invention may be directed to a method for low-force roll folding of a two-dimensional sheet material having one or more predetermined fold lines

into a three-dimensional article. The method includes one or more of the steps of providing a sheet material with bend-facilitating structure extending along a length of one or more of the predetermined fold lines, providing a stand of folding rollers configured to effect bending of the sheet metal along the bend-facilitating structure, and moving the stand of folding rollers relative to the sheet material along the length of one or more of the predetermined fold lines to effect bending of the sheet material along the bend-facilitating structure.

[0009] The method may further include driving the sheet material through the stand of folding rollers. The method may further include driving the sheet material through a plurality of stands of folding rollers in order to effect a series of incremental cross-sectional profiles upon the sheet material. The method may further include providing the sheet material with bend-facilitating structure along a length of diverging predetermined fold lines. The method may further include providing the sheet material with bend-facilitating structure along a non-linear length of predetermined fold lines. The folding rollers may be substantially cylindrical and roll along the sheet material adjacent to but removed from the fold lines. The method may further include adjusting the rotational axes of the folding rollers relative to one another in order to accommodate spring back along the predetermined fold lines. The method may further include manually rolling the stand of folding rollers along the length of the predetermined fold lines.

[0010] Another aspect of the present invention is directed to a system for low-force roll folding of a two-dimensional sheet material having one or more predetermined fold lines into three-dimensional article. Preferably, the system includes a sheet material with bend-facilitating structure extending along a length one or more of the predetermined fold lines, a stand of rollers configured to effect bending of the sheet metal along the bend-facilitating structure, and a driver to move the stand of folding rollers relative to the sheet material along the length of one or more of the predetermined fold lines to effect bending of the sheet material along the bend-facilitating structure.

[0011] The system may further include a plurality of stands of folding rollers, each stand configured to effect an incremental cross-sectional profile upon the sheet material. The sheet material may include bend-facilitating structure along a link of diverging predetermined fold lines. The sheet material may include bend-facilitating structure along a nonlinear length predetermined fold lines. The folding rollers may be substantially cylindrical and roll line the sheet material adjacent to but removed from the fold lines.

[0012] The methods and apparatuses of the present invention(s) have other features and advantages which will be apparent from or are set forth in more detail in the accompanying drawings, which are incorporated herein, and the following Detailed Description of the Invention, which together serve to explain certain principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1a is an isometric view of an exemplary apparatus for low-force roll folding a three-dimensional article from a two-dimensional sheet material in accordance with various aspects of the present invention. FIG. 1b is a schematic view of the initial cross-sectional profile of the two-dimensional sheet material. FIG. 1c is a schematic view of the final cross-sectional profile of the three-dimensional article. FIG. 1d is a plan view of the two-dimensional sheet material of FIG. 1b.

[0014] FIG. 2a is a plan view of another two-dimensional sheet material prepared for low-force roll folding in accordance with various aspects of the present invention. FIG. 2b is a perspective view of a three-dimensional article formed with two-dimensional sheet materials similar to that shown in FIG. 2a.

[0015] FIG. 3a is a schematic view of other incremental cross-sectional profiles as a two-dimensional sheet material (top) is roll folded into a three-dimensional article (bottom) in accordance with various aspects of the present invention. FIG. 3b is a schematic view of

the incremental cross-sectional profiles of FIG. 3a passing through respective sets of fold rollers.

[0016] FIG. 4a is a schematic view of other incremental cross-sectional profiles as a two-dimensional sheet material (top) is roll folded into a three-dimensional article (bottom) in accordance with various aspects of the present invention. FIG. 4b is a schematic view of the incremental cross-sectional profiles of FIG. 4a passing through respective sets of rollers. FIG. 4c is a schematic view of the incremental cross-sectional profiles of FIG. 4a passing through another respective set of rollers similar to those shown in FIG. 4b.

[0017] FIG. 5a is a schematic view of the incremental cross-sectional profiles of FIG. 4a passing through another respective set of rollers similar to those shown in FIG. 4b. FIG. 5b is an enlarged cross-sectional view of a final set of rollers shown in FIG. 5a, said final set of rollers configured to produce a cross-sectional profile, shown in FIG. 5c to accommodate spring-back resulting in the final cross-sectional profile of FIG. 5d. FIG. 5e is an enlarged detail of the rollers of FIG. 5b. FIG. 5f is a schematic side view of the rollers of FIG. 5b illustrating adjustment of the upper roller in phantom.

[0018] FIG. 6a is a schematic view of incremental cross-sectional profiles of another two-dimensional sheet material (top) passing through respective sets of rollers to form a three-dimensional article (bottom) in accordance with various aspects of the present invention. FIG. 6b is an enlarged set of folding rollers shown in FIG. 6a.

[0019] FIG. 7a is an isometric view of another exemplary apparatus for low-force roll folding a three-dimensional article from a two-dimensional sheet material in accordance with various aspects of the present invention. FIG. 7b is an enlarged detail of the apparatus of FIG. 7a

[0020] FIG. 8 is a plan view of another two-dimensional sheet material similar to that shown in FIG. 7a, but prepared for low-force roll folding along non-parallel and diverging fold lines in accordance with various aspects of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Reference will now be made in detail to various embodiments of the present invention(s), examples of which are illustrated in the accompanying drawings and described below. While the invention(s) will be described in conjunction with exemplary embodiments, it will be understood that present description is not intended to limit the invention(s) to those exemplary embodiments. On the contrary, the invention(s) is/are intended to cover not only the exemplary embodiments, but also various alternatives, modifications, equivalents and other embodiments, which may be included within the spirit and scope of the invention as defined by the appended claims.

[0022] Turning now to the drawings, wherein like components are designated by like reference numerals throughout the various figures, attention is directed to FIG. 1a, which illustrates an exemplary roll folding system generally designated by the numeral 30 that may be used to fold a two-dimensional sheet material 32 (see FIG. 1b and FIG. 1d) into three-dimensional article 33 (see FIG. 1c). The roll folding system is designed to be used with ductile sheet materials having engineered fold lines 35 which facilitate bending along predetermined fold lines. As the sheet material is guided through the machine along a predetermined path of travel, its cross-sectional profile is gradually transformed from a flat sheet into a three-dimensional article having a desired cross-sectional profile.

[0023] In contrast to conventional roll forming machines, which require a carefully crafted set of rollers for each stand conforming with an incremental cross-sectional profile, the roll folding system of the present invention may utilize simple roller wheels, which need not conform with any particular cross-sectional profiles. Accordingly, the roll folding system of the present invention greatly reduces the capital costs of roll folding

equipment because it does not require costly machining of rollers precisely conforming to cross-sectional profiles.

[0024] The roll folding systems in accordance with the present invention are particularly suited for bending two-dimensional sheet materials having engineered fold lines which utilize various fold geometries and configurations including, but not limited to, those disclosed by U.S. Patent Nos. 6,481,259, U.S. Patent No. 6,877,349, U.S. Patent Application Publication No. US 2006/0021413 A1, U.S. Patent No. 7,152,449, U.S. Patent No. 7,032,426, U.S. Patent No. 7,152,450, U.S. Patent Application Publication No. US 2005/0005670 A1, U.S. Patent No. 7,263,869, U.S. Patent No. 7,222,511, U.S. Patent Application Publication No. US 2005/0257589 A1, U.S. Patent Application Publication No. US 2006/0213245 A1, U.S. Patent No. 7,296,455, U.S. Patent Application Publication No. US 2006/0130551 A1, U.S. Provisional Patent Application No. 60/911,910, U.S. Provisional Patent Application No. 60/974,466, U.S. Provisional Patent Application No. 60/974,468, and U.S. Patent Application No. 11/925,195, the entire contents of which patents and patent applications are incorporated herein by this reference.

[0025] The roll folding systems of the present invention is designed to take advantage of various aspects of manufacturing with engineered fold lines. For example, accurate machine tool tolerances are relatively less critical because the location of desired fold lines are engineered into the sheets of material. Accordingly, the roll folding systems of the present invention can, but need not, take the form of a high-efficiency light-duty machine which may be capable hundreds of thousands and/or millions of cycles due to relatively minimal wear and tear. Special materials, expensive and time-consuming machining, hardening, heat treatments, and/or other costly processes may be reduced or avoided because the need for precise machine tool tolerances is reduced. Instead, the tolerances are built into the sheet of material whereby a less expensive and lighter-duty roll folding may be utilized to fold a two-dimensional sheet of material into its final

shape, or in some cases one or more intermediate shapes. As such, the present roll folding systems may be constructed with milder steel, laser cut parts and other relatively inexpensive components such as those including mild steels, plastics, composites and/or other materials typically considered to be too soft to be built for metal forming equipment, as well as die cast and other relatively less precise componentry. Of course, the foregoing does not necessarily preclude heavy-duty construction using hardened steels. Rather, it allows enhanced flexibility depending on factors such as duty cycle, economy, weight, and the like.

[0026] One will appreciate, however, that the present roll folding systems are also suited for bending other types of ductile sheet materials about a fold line including, but not limited to, sheet metal prepared with the above-mentioned engineered fold lines, predetermined fold lines defined by scoring and/or other suitable means.

[0027] One will appreciate that a number three-dimensional products may be formed by the roll folding of the present invention which include both relatively narrow flanges and relatively wide flanges. For example, the three-dimensional products may include, but are not limited to, various enclosure components, electronic chassis components, automotive components, appliance components, transport components, construction components, HVAC components, aerospace components, and the like.

[0028] Returning to FIG. 1a, an exemplary roll folding system 30 generally includes a machine chassis 37 configured to support and position various sub-assemblies of the roll folding system. For example, upper receiving drive rollers 39 are rotatably supported by the machine chassis in an otherwise conventional manner and driven by a suitable drive means. Upper exiting drive rollers 40 are similarly mounted and driven on the machine chassis. Lower receiving and exiting drive rollers 39', 40' are also provided in a similar fashion. The drive rollers are configured to receive and propel sheet material 32 through

the roll folding system as the roll folding system folds the sheet material into three-dimensional article 33.

[0029] One or more guide rollers 42 may be provided to generally support and guide the sheet material as it passes through the roll folding system.

[0030] A number of “stands” 44 or sets of folding rollers 46 are also provided to impart the folding force upon the sheet material. The folding rollers may be spring loaded to apply a relatively uniform force against the sheet material as the sheet material passes by the folding rollers. The folding rollers are configured and positioned to roll along continuous surfaces 47 of the sheet material substantially parallel to or along respective fold lines in order to impart folding force upon the sheet material as the sheet material passes through the respective set of folding rollers.

[0031] As noted above, sheet material 32 includes preformed engineered fold lines and thus requires less force to effect bending along the fold lines. Furthermore, as the preformed engineered fold lines self identify precisely where the sheet material will bend and in particular where a deformation will occur, the folding rollers need only approximately position the continuous surfaces to effect bending.

[0032] Furthermore, since the sheet material includes engineered fold lines 35, the amount of force necessary to effect bending of the sheet material is greatly reduced. In contrast to conventional roll forming machines, which require a carefully crafted set of hardened and/or relatively hard rollers for each stand of rollers conforming with an incremental cross-sectional profile, the roll folding system of the present invention may utilize simple off-the-shelf roller wheels, which need not conform with any particular cross-sectional profiles. For example, the roller wheels may be formed of urethane, rubber, or other suitable materials that are applicable to relatively low force environments. For example, Delrin® skids may provide an alternative to the rollers for

applying force against the sheet material as it passes by each stand. Accordingly, the roll folding system of the present invention greatly reduces the capital costs associated with conventional roll forming equipment because it does not require the machining of rollers precisely conforming to cross-sectional profiles.

[0033] One will appreciate that the light-duty nature of the present roll folding system may facilitate roll folding of pre-painted sheet materials wherein the rollers and/or skids would effect little scuffing and/or scrubbing along the surface of the sheet material as it passes through the stands. Also, one will appreciate that relatively large-radii roller wheels may be utilized, and may facilitate loading of, or receiving of the sheet material into and through each stand.

[0034] In the illustrated embodiment, roll folding system 30 includes an upper series 49 and a lower series 51 of stands 44, in which the two-dimensional sheet material 32 is fed to left-to-right into roll folding system 30 and through the upper series of stands to form an intermediate article 53, which intermediate article may again be fed right-to-left into the roll folding system through the lower series of stands to form the final three-dimensional article 33. The roll folding system is preferably configured to guide the intermediate article from the upper series to the lower series of stands by conventional means, for example, allowing the intermediate article to drop or otherwise move down in the direction of arrow D. The "out-and-return" configuration of the roll folding system is particularly advantageous in that a single operator may operate the roll folding system from a single position (e.g., position P). One will appreciate, however, that a single series of stands may be provided in which the sheet material moves outwardly in a single direction.

[0035] In the illustrated embodiment, the upper series is provided with four stands 44, that is four sets of rollers corresponding with four incremental cross-sectional profiles, and the lower series is provided with three stands 44' or three sets of rollers

corresponding with two additional incremental cross-sectional profiles and the final cross-sectional profile of three-dimensional article 33. One will appreciate, however, that one, two, three or more stands may be provided to effect the desired amount of bending.

[0036] In contrast to conventional roll forming technology, the roll folding system of the present invention may also be used to form three-dimensional articles having nonuniform cross-sectional profiles. For example, FIG. 2a illustrates a sheet of material having fold lines 35a that are not parallel but instead converge toward one another. Such a configuration of fold lines may be used to produce articles of varying cross-sectional width dimensions such as the horn-shaped article 54 shown in FIG. 2b. As is shown in FIG. 2a, the fold lines on either side may be parallel to one another (see, e.g., fold lines 35a) or may converge toward one another (see, e.g., fold lines 35a').

[0037] As shown in FIG. 1a, roll folding system 30 may be provided with one or more tuning knobs 56 to adjust the of each stand 44 by suitable means. One will also appreciate that a tuning knob may be provided for each subset of stand rollers in order to independently adjust the subset of rollers on each lateral side of the stand.

[0038] The roll folding system of the present invention is particularly useful for folding sheet materials into a wide variety of three-dimensional articles. For example, with reference to FIG. 3a and FIG. 3b, roll folding system 30 may be used to fold sheet material 32b in to a three-dimensional article 33b in the form of a channel-shaped closed box beam. In the illustrated embodiment, eight stands 44b of rollers are utilized to flare each side of sheet material 32b upwardly and inwardly to form a closed box beam 58, as shown in FIG. 3b. The uppermost stand gently flares the outermost edge of sheet material 32b upwardly, while the next two stands continue to flare the outermost edge upwardly and began to flare inwardly while flaring inner sidewalls upwardly. The next stand begins to guide the outermost edge inwardly, while the remaining stands further guide the outermost edge and sidewalls to close the box beam. As can be seen in this schematic

series, the rollers of each stand may be uniformly sized wheels which are configured to roll upon the flat surfaces of sheet material 32b between fold lines 35b.

[0039] One will appreciate that the orientation of folding rollers may very widely depending upon the desired cross-sectional profile. For example and with reference to FIG. 4a, the roll folding system of the present invention may be utilized to create a double channel beam 60. One will further appreciate, that a number of configurations may be utilized to affect folding of a particular desired cross-sectional profile, as can be seen in FIG. 4b and FIG. 4c. For example, each stand 44c of folding rollers 46c may be rotatably mounted on parallel axes, as shown in FIG. 4b. Alternatively, each stand 44d may include folding rollers 46d rotatably mounted on orthogonal axes. One will appreciate that limiting rotational axes to either horizontal or perpendicular/vertical axes simplifies machine design. Also, by positioning the wheels substantially perpendicular to the surface of the sheet material, one may limit the amount of scrubbing or scuffing of the folding rollers upon the sheet material.

[0040] In still a further embodiment of the present invention, contoured folding rollers 61 may be utilized to impart folding forces upon the sheet material, as shown in FIG. 5a, in which a two-dimensional sheet material is also roll folded into a three-dimensional article 33e (bottom). With reference to FIG. 5b and FIG. 5c, the contoured folding rollers may be configured with a cooperating recess 63 and protrusion 65 in order to over bend sheet material 32e (see FIG. 5c) in order to accommodate spring-back resulting in a desired cross-sectional profile (see FIG. 5d). One will appreciate that other configurations may be utilized to effect over-bending including the positioning of folding rollers. In this embodiment, the contoured folding rollers are rotatably mounted on parallel axes and, as such, may be easily adjusted relative to one another. For example and as shown in FIG. 5f, one of the contoured rollers may be adjusted “within plane” such that the axis of one roller 61 may be slid back-and-forth relative to the axis of a cooperating roller 61’ in order to adjust the distance between recess 63 and protrusion 65. In the illustrated

embodiment, roller 61.5 may be slid back and forth within a horizontal plane to adjust the amount of over-bending, that is, the amount of bending beyond a desired angle in order to accommodate spring back. One will appreciate that the rollers may be configured such that they are adjustable by sliding or otherwise adjusted along an inclined plane or along a vertical plane instead of a horizontal direction.

[0041] FIG. 6a is a schematic view of a series of incremental cross-sectional profiles of yet another two-dimensional sheet material passing through respective sets of rollers to form a three-dimensional article 33f (bottom) in accordance with various aspects of the present invention. In this embodiment, folding rollers 46f are fixed relative to one another in a roller mount 67 but positioned in such a manner that the rollers follow along fold lines 35f, 35f', 35f''. With such configuration, the folding rollers impart folding forces upon sheet material 32f along the fold lines and, as such, the configuration tends to follow the fold lines in the sheet material due to the geometric constraints created by the position of the fold lines. In one embodiment, the roller mount may be in the form of a hand tool having a grip 68 in which case, an operator may manually sweep a first roller mount along the length of the sheet material to impart the first incremental cross-sectional profile thereon, and follow by sweeping other roller mounts to impart the subsequent incremental cross-sectional profiles thereon, and ultimately, the final cross-sectional profile thereon.

[0042] In another exemplary embodiment of the present invention, roll folding system 30g is similar to roll folding system 30g described above but it incorporates movable roller mounts in order to fold a two-dimensional sheet material 32g into a three-dimensional article 33g having compound curves as shown in FIG. 7. Like reference numerals have been used to describe like components of roll folding system 30 and roll folding system 30g.

[0043] In this embodiment, each stand 44g includes opposing roller mounts 67g slidably supported by a machine chassis 37g such that folding rollers 46g are allowed to move laterally in order to effect bending and follow the lateral profiles of sheet material 32g. Each roller mount is allowed to move up and down in order to follow the basic curvature of the sheet material as the sheet material is bent along fold lines 35g, as shown in FIG. 7a. Accordingly, the roller mounts 67g and the respective stand folding rollers 46g are limited to two degrees of freedom. The folding rollers float in the sense that they may move up-and-down and in-and-out, but they are fixed relative to the longitudinal length of machine chassis 37g. As such, respective sets of folding rollers may be provided to effect each incremental cross-sectional profile as the two-dimensional sheet of material 32g passes through roll folding system 30g. As the orientation of rollers mounted on each roller mount is fixed relative to one another, and because an upper roller and a lower roller is aligned with respective inside corners or valleys of the incremental cross-sectional profiles, the set of rollers will closely follow along the path of the fold lines. One will appreciate that the rollers may be configured such that their orientation may vary in order to accommodate fold lines that converge or diverge from one another such as those shown in FIG. 8. Preferably springs or other suitable biasing means are utilized to bias the roller mounts back to an initial position to facilitate receipt of the sheet material between the respective folding rollers.

[0044] One will appreciate that the roll folding system of the present invention may be utilized in combination with other conventional metalworking stations or processes. For example, the present roll folding systems may be utilized with various configurations that punch and cut off parts during otherwise conventional continuous operations, such as cutting a part to length when supplying coils are used to supply the sheet metal "blanks" to the roll folding system. Further, various configurations of stations may be utilized to add features such as holes, notches, embossments, and/or shear forms by punching, stamping, and or other known processes found in conventional roll forming lines. For example, fastening structures 70 (see, e.g., FIG. 2a and FIG. 2b) may take the form of

spring clips of the type disclosed by U.S. Patent Application Publication No. US 2006/0277965 A1, and/or other integral fastening structure, which structure may be stamped directly into the sheet metal either before or after the sheet metal passes through the roll folding system.

[0045] For convenience in explanation and accurate definition in the appended claims, the terms “up” or “upper”, “down” or “lower”, “inside” and “outside” are used to describe features of the exemplary embodiments with reference to the positions of such features as displayed in the figures.

[0046] In many respects various modified features of the various figures resemble those of preceding features and the same reference numerals followed by subscripts “a”, “b”, “c”, “d”, “e”, “f” and “g” designate corresponding parts.

[0047] The foregoing descriptions of specific exemplary embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teachings. The exemplary embodiments were chosen and described in order to explain certain principles of the invention and their practical application, to thereby enable others skilled in the art to make and utilize various exemplary embodiments of the present invention, as well as various alternatives and modifications thereof. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

WHAT IS CLAIMED IS:

1. A method for low-force roll folding of a two-dimensional sheet material having one or more predetermined fold lines into a three-dimensional article, said method comprising:

providing a sheet material with bend-facilitating structure extending along a length of one or more of said predetermined fold lines;

providing a stand of folding rollers configured to effect bending of said sheet metal along said bend-facilitating structure; and

moving said stand of folding rollers relative to the sheet material along said length of one or more of said predetermined fold lines to effect bending of the sheet material along said bend-facilitating structure.

2. A method for low-force roll folding according to claim 1, said method further comprising:

driving the sheet material through said stand of folding rollers.

3. A method for low-force roll folding according to claim 1, said method further comprising:

driving the sheet material through a plurality of stands of folding rollers in order to effect a series of incremental cross-sectional profiles upon the sheet material.

4. A method for low-force roll folding according to claim 1, said method further comprising:

providing said sheet material with bend-facilitating structure along a length of diverging predetermined fold lines.

5. A method for low-force roll folding according to claim 1, said method further comprising:

providing said sheet material with bend-facilitating structure along a non-linear length of predetermined fold lines.

6. A method for low-force roll folding according to claim 1, wherein said folding rollers are substantially cylindrical and roll along the sheet material adjacent to but removed from said fold lines.

7. A method for low-force roll folding according to claim 1, further comprising:

adjusting the rotational axes of said folding rollers relative to one another in order to accommodate spring back along said predetermined fold lines.

8. A method for low-force roll folding according to claim 1, further comprising:

manually rolling said stand of folding rollers along said length of said predetermined fold lines.

9. A system for low-force roll folding of a two-dimensional sheet material having one or more predetermined fold lines into three-dimensional article, said system comprising:

a sheet material with bend-facilitating structure extending along a length one or more of said predetermined fold lines;

a stand of rollers configured to effect bending of said sheet metal along said bend-facilitating structure; and

a driver to move said stand of folding rollers relative to the sheet material along said length of one or more of said predetermined fold lines to effect bending of the sheet material along said bend-facilitating structure.

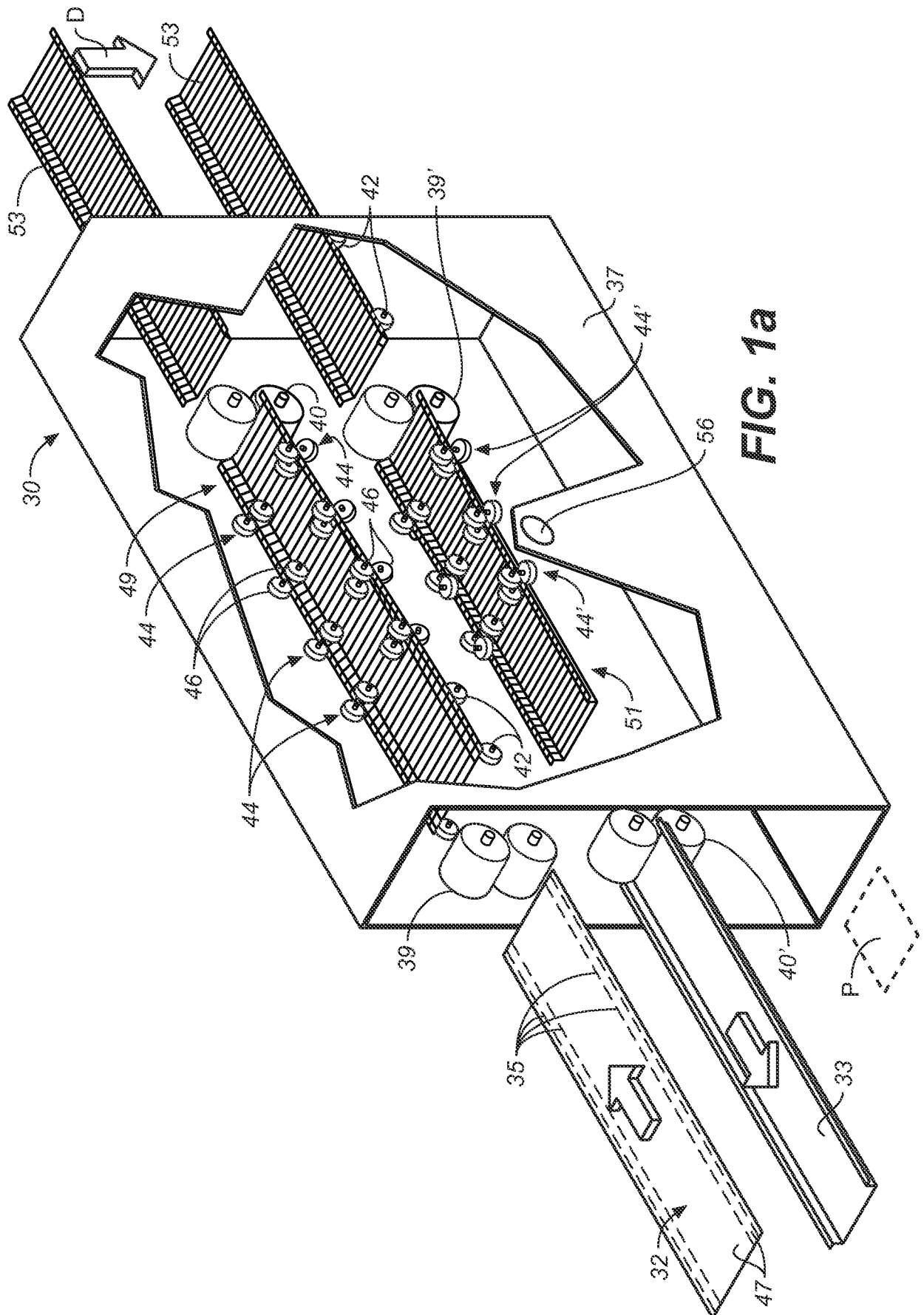
10. A system for low-force roll folding according to claim 9, further comprising:

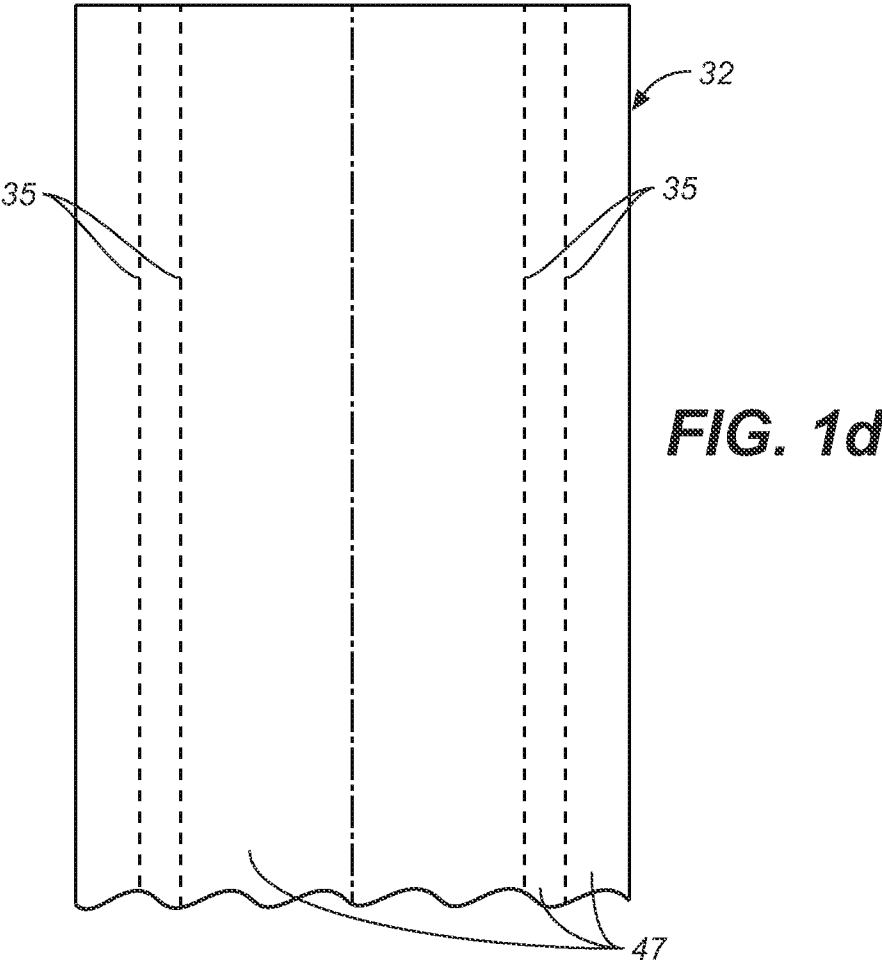
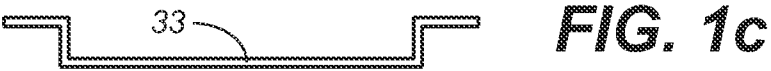
a plurality of stands of folding rollers, each stand configured to effect and incremental cross-sectional profile upon the sheet material.

11. A system for low-force roll folding according to claim 9, wherein said sheet material includes bend-facilitating structure along a link of diverging predetermined fold lines.

12. A system for low-force roll folding according to claim 9, wherein said sheet material includes bend-facilitating structure along a nonlinear length predetermined fold lines.

13. A system for low-force roll folding according to claim 9, wherein said folding rollers are substantially cylindrical and roll line the sheet material adjacent to but removed from said fold lines.





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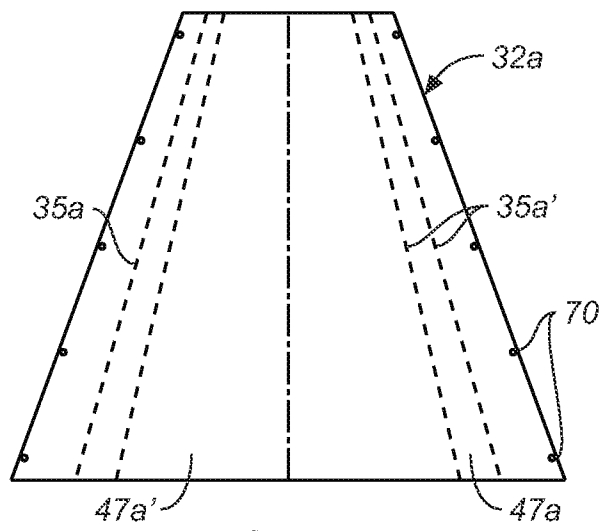


FIG. 2a

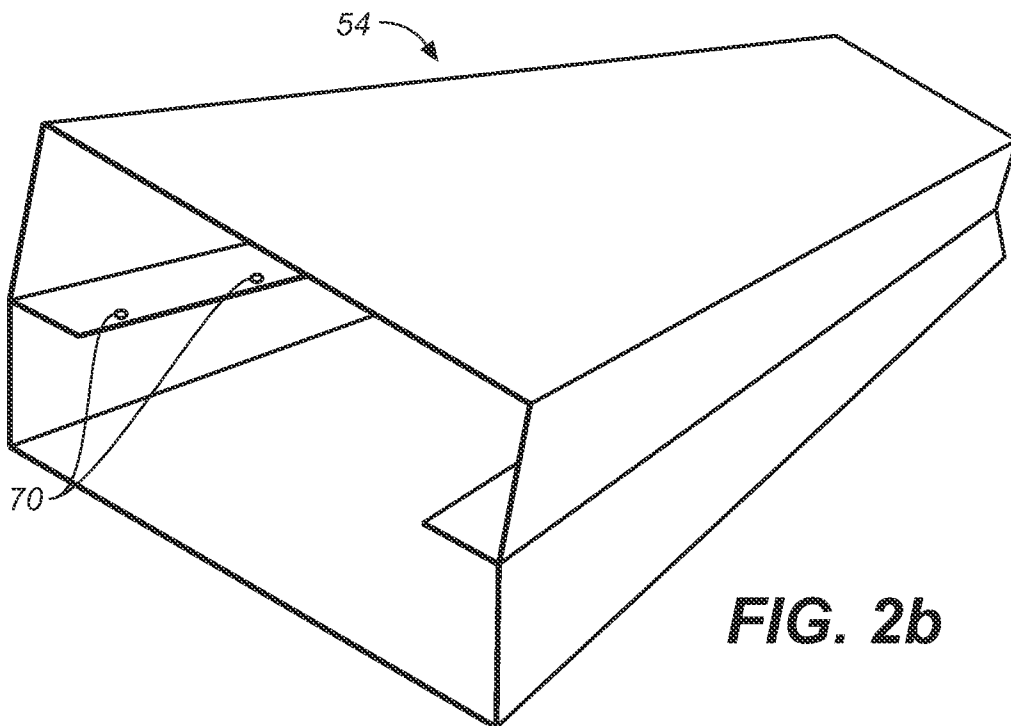


FIG. 2b

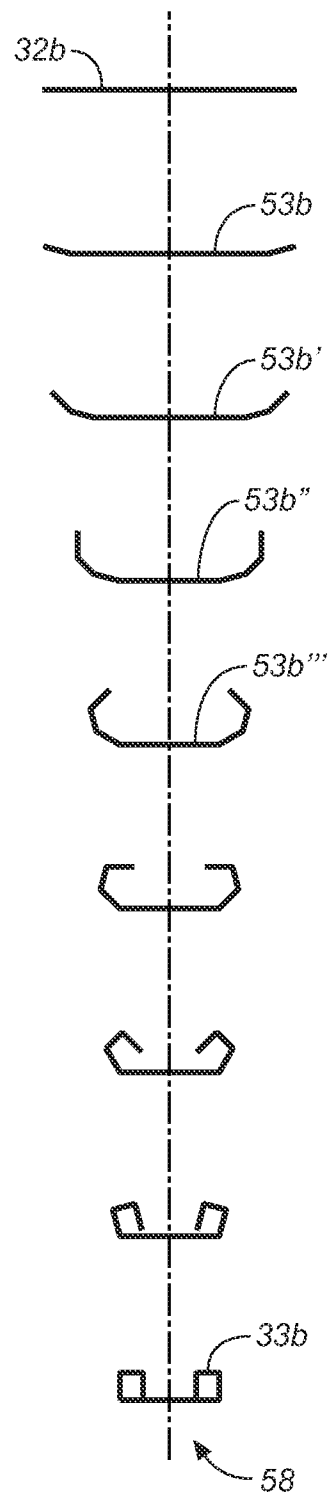


FIG. 3a

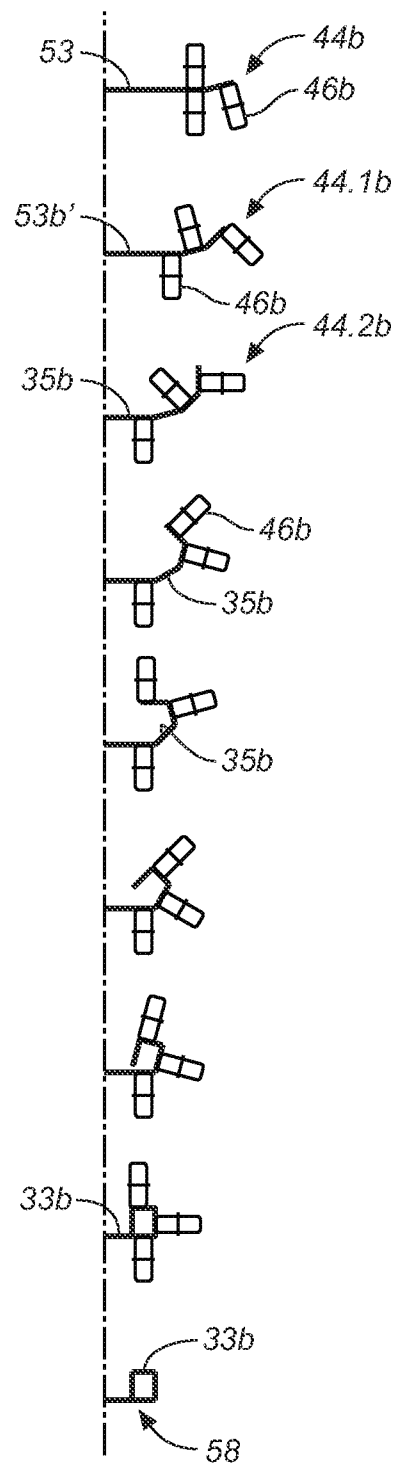
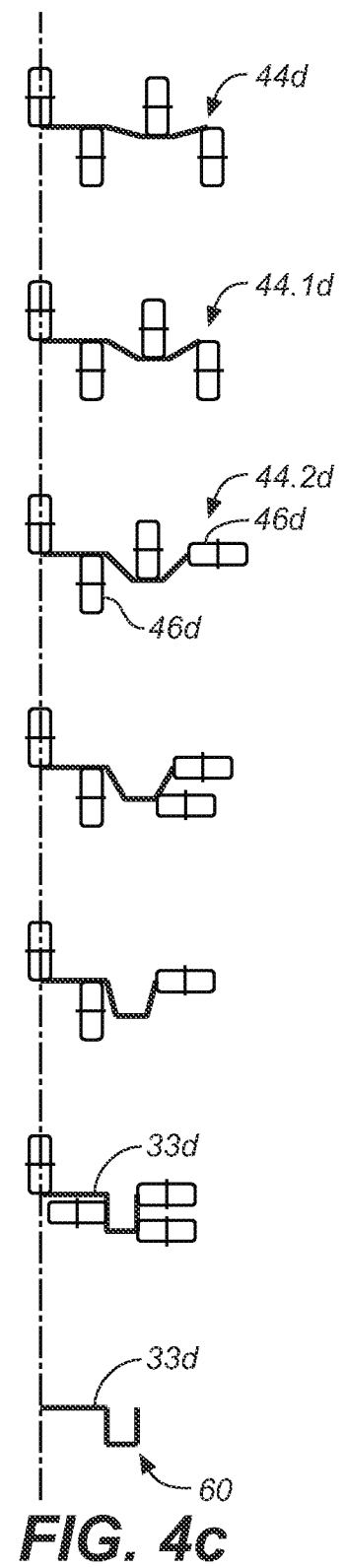
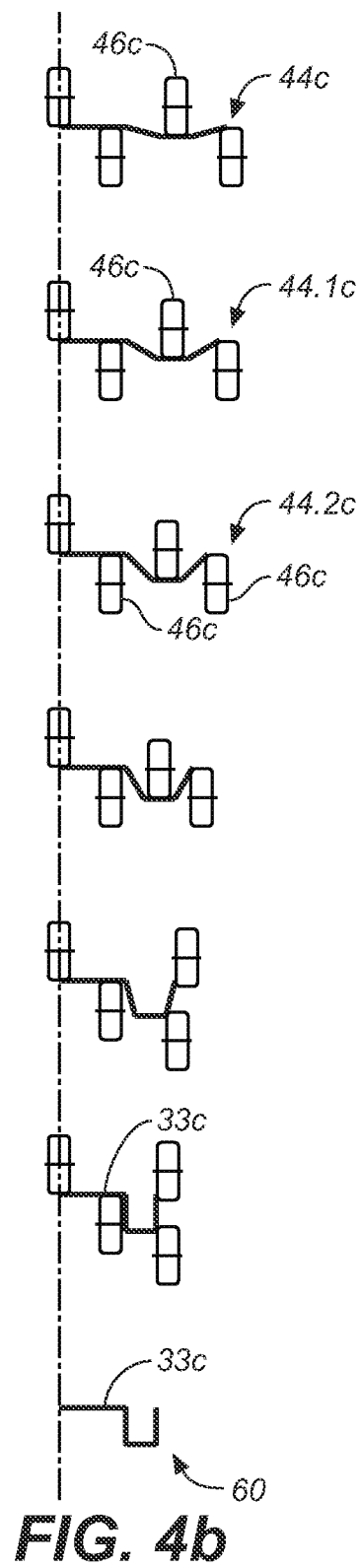
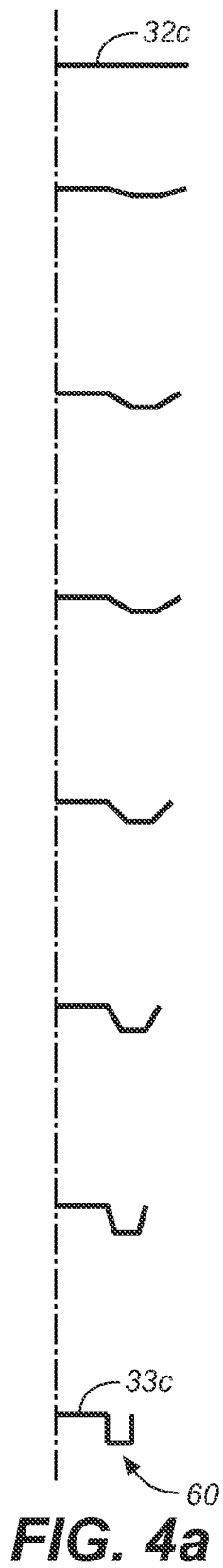


FIG. 3b

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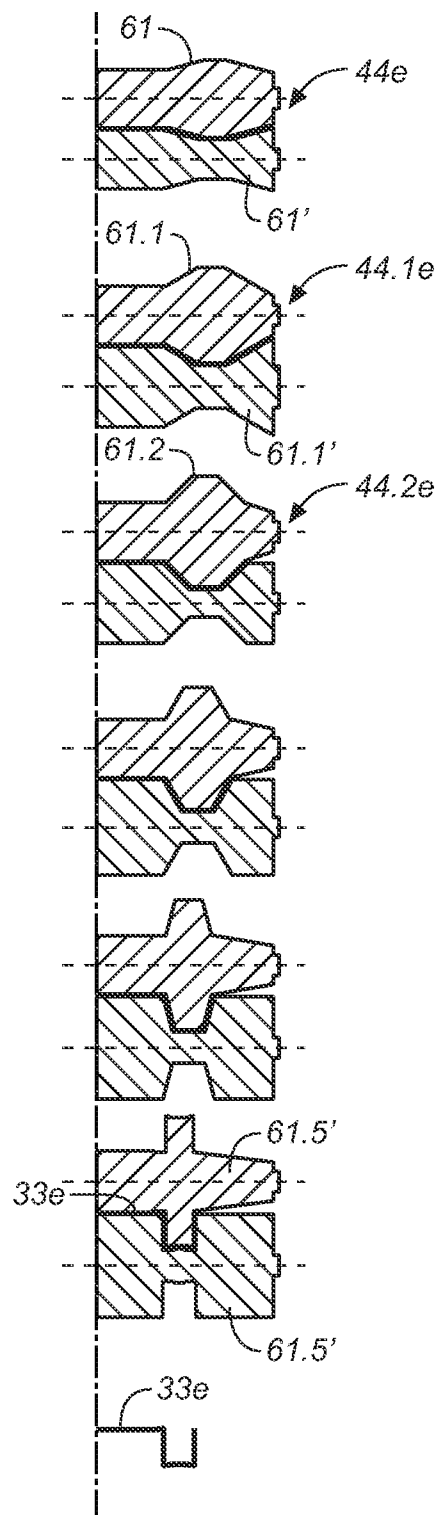
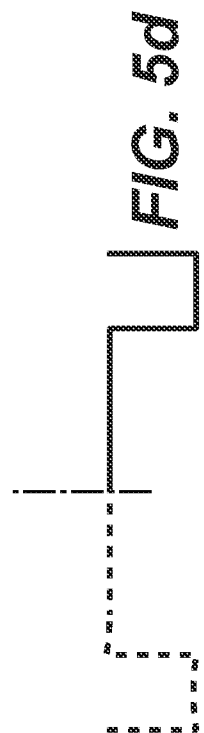
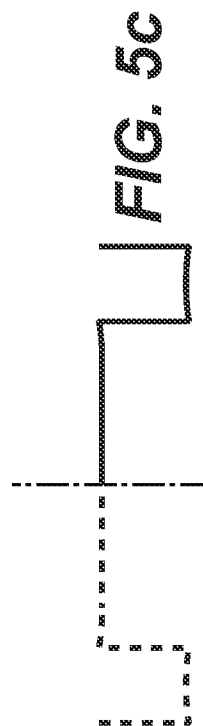
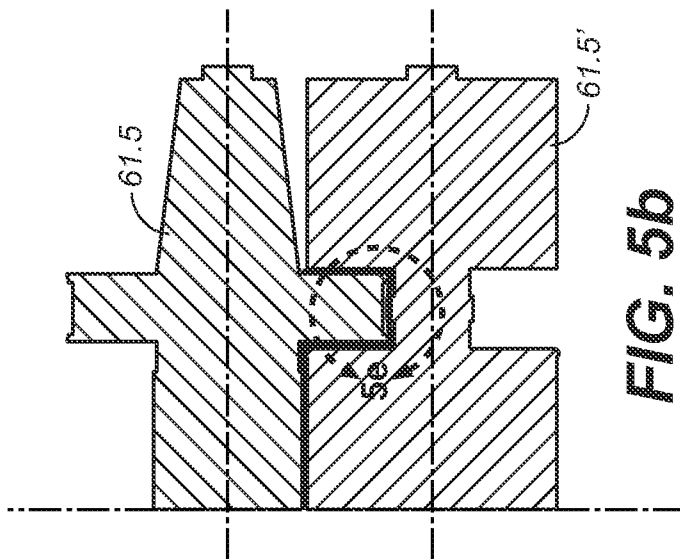
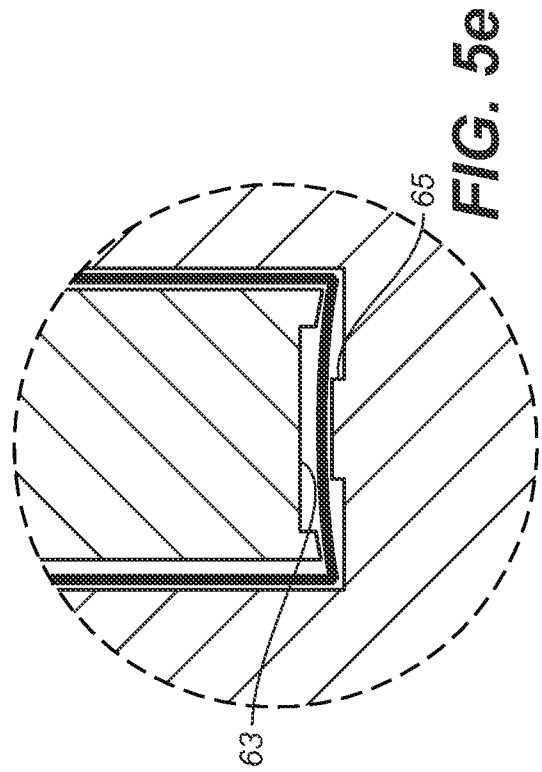
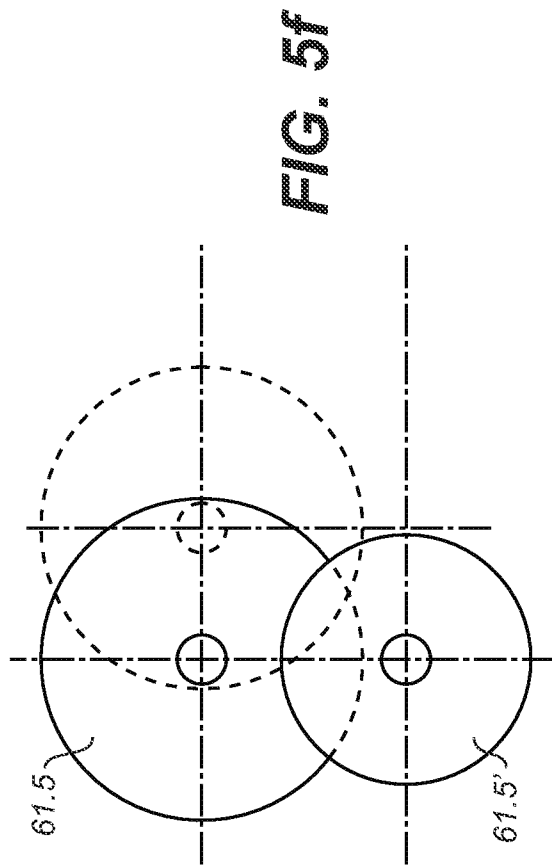


FIG. 5a



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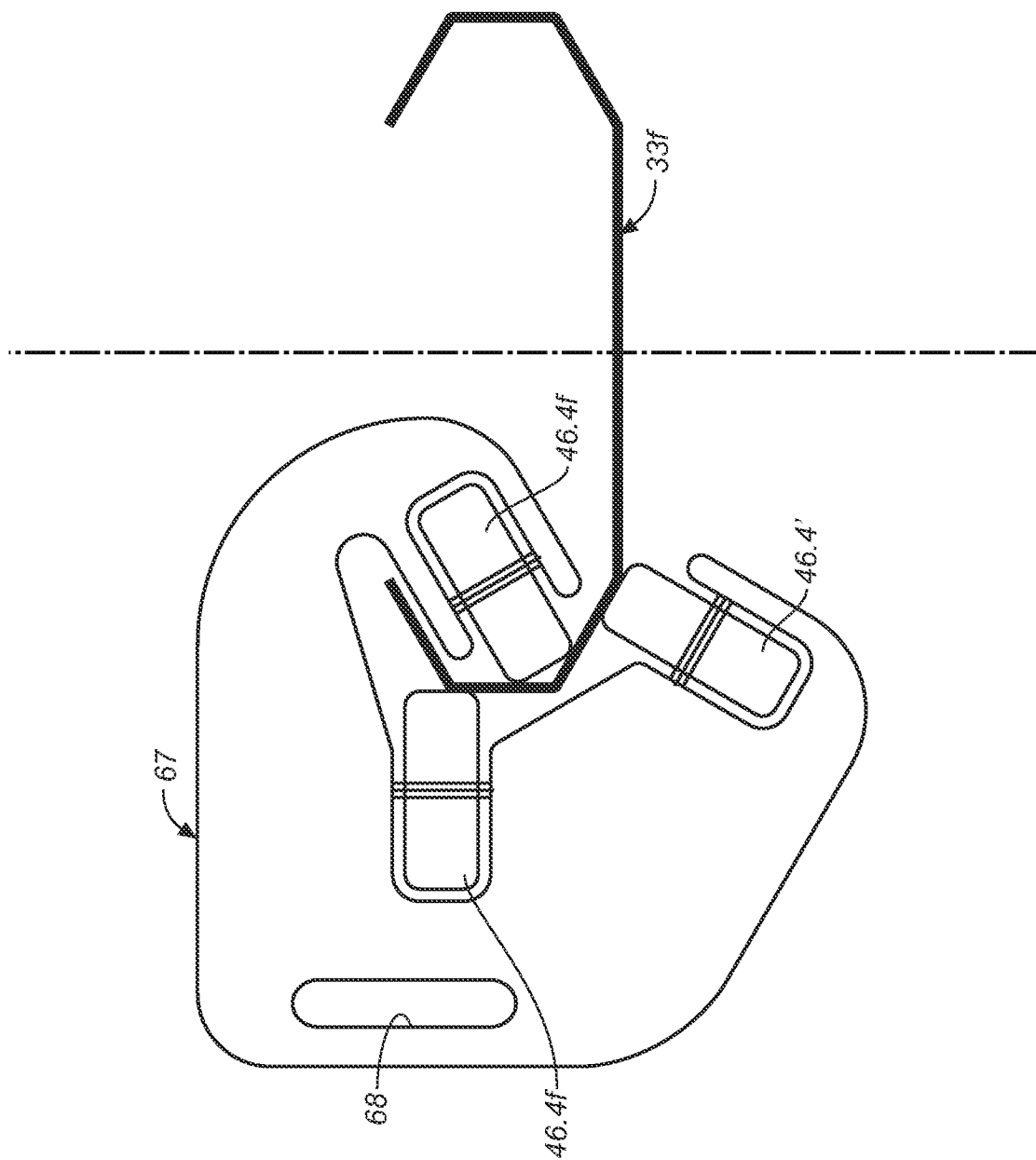


FIG. 6b

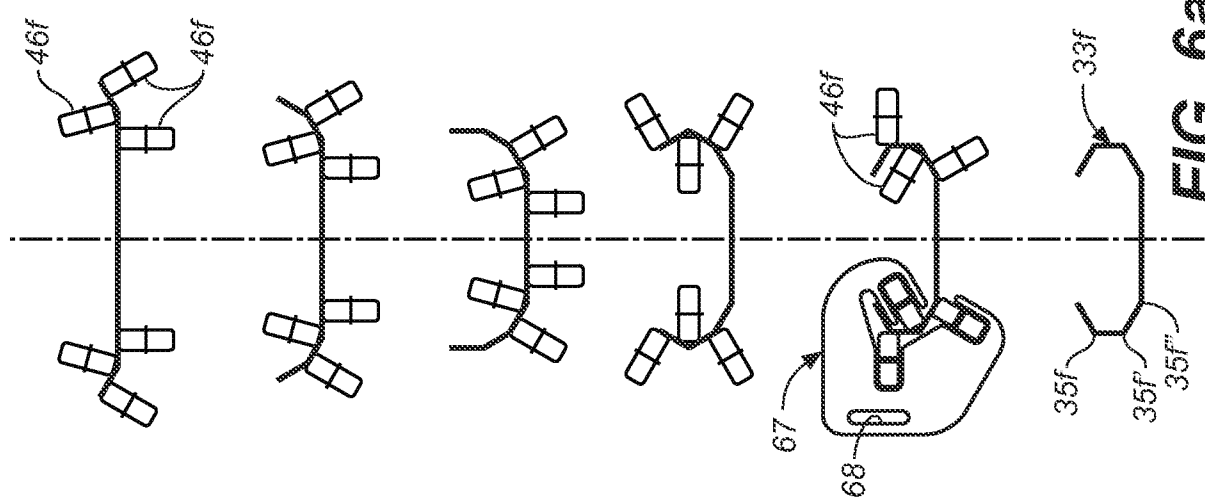


FIG. 6a

