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Pranger et al.

(54) COLD FORMED BEAM FOR STRUCTURES AND METHOD OF FORMING THE COLD FORMED BEAM

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(73) Assignee: **NUCOR CORPORATION**, Charlotte, NC (US)

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Publication Classification

(51) **Int. Cl.**

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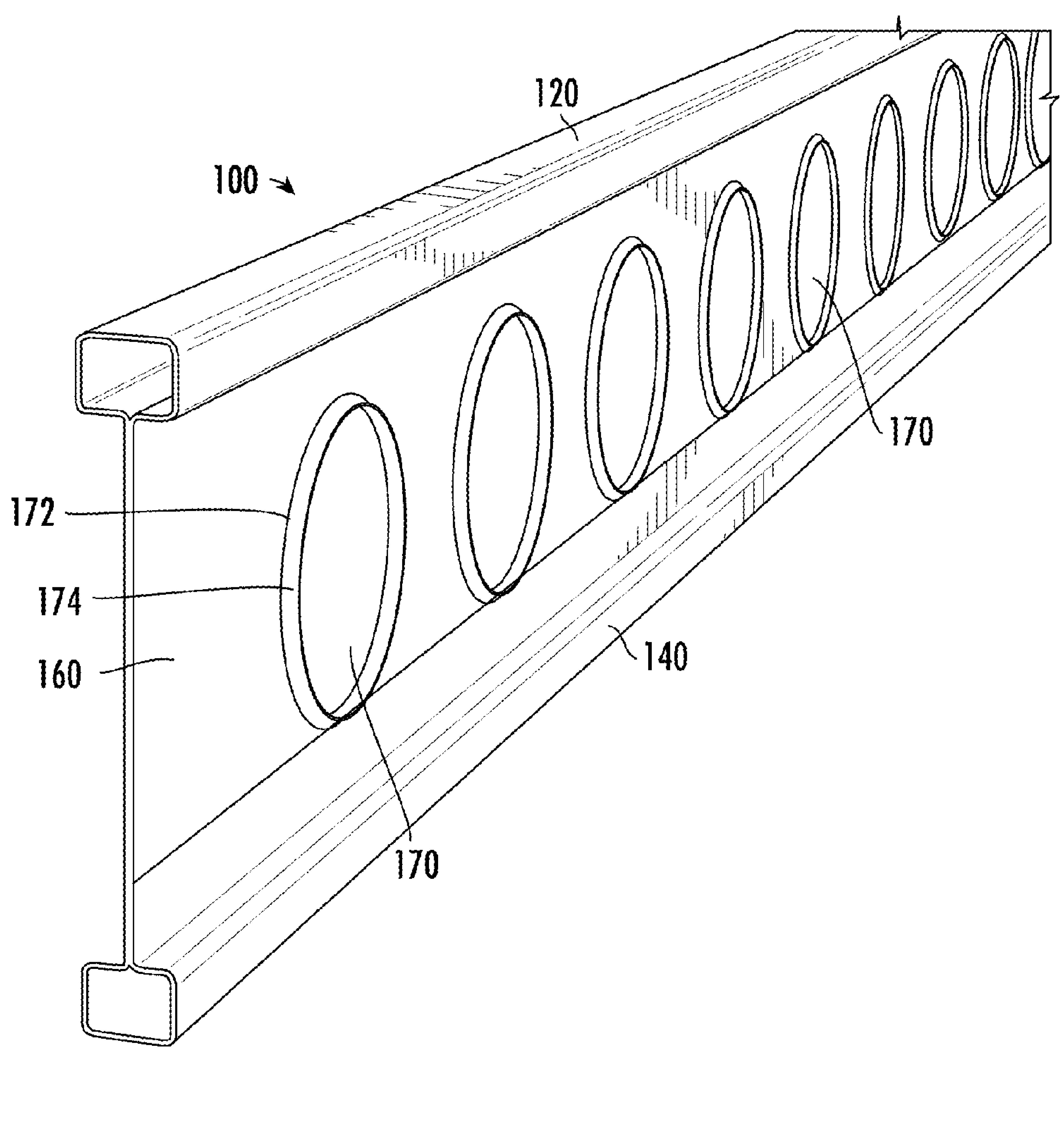
B21B 1/22	(2006.01)
B21D 22/02	(2006.01)
C21D 7/02	(2006.01)
E04C 3/04	(2006.01)

(52) **U.S. Cl.**

CPC ***E04C 3/09*** (2013.01); ***B21B 1/22*** (2013.01); ***B21D 22/02*** (2013.01); ***C21D 7/02*** (2013.01); *B21B 2001/221* (2013.01); *E04C 2003/043* (2013.01); *E04C 2003/0452* (2013.01)

(57) **ABSTRACT**

A cold formed beam formed from a single sheet of steel having an upper member and a lower member (e.g., square, rectangular, other shape) separated by a web. The web may include stamped apertures and/or embossments around at least a portion of the stamped apertures. The cold formed beam may include beam connections that operatively couple the ends of the steel sheet used to form the beam to a portion of the beam (e.g., the web). The beam connections may by interference connectors formed from deformation of two or more layers of beam (e.g., clinching, or the like). Among other benefits, forming the cold formed beam from a single sheet, stamping of the web, and/or the using deformation connections (e.g., clinching, or the like) of the ends of the sheet allows for the pre-coating (e.g., galvanized, painting, or the like) of the sheet before the forming.



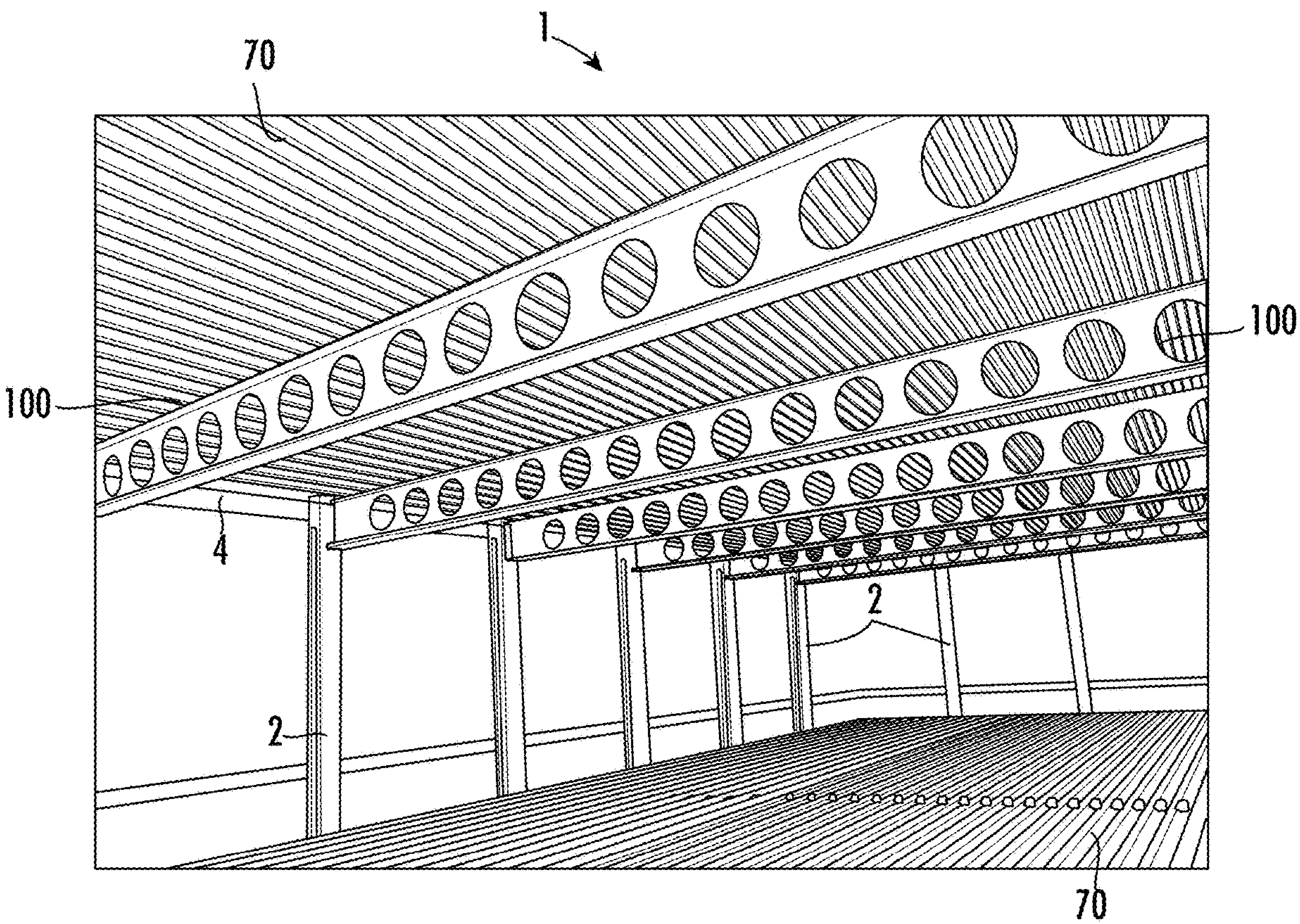


FIG. 1A

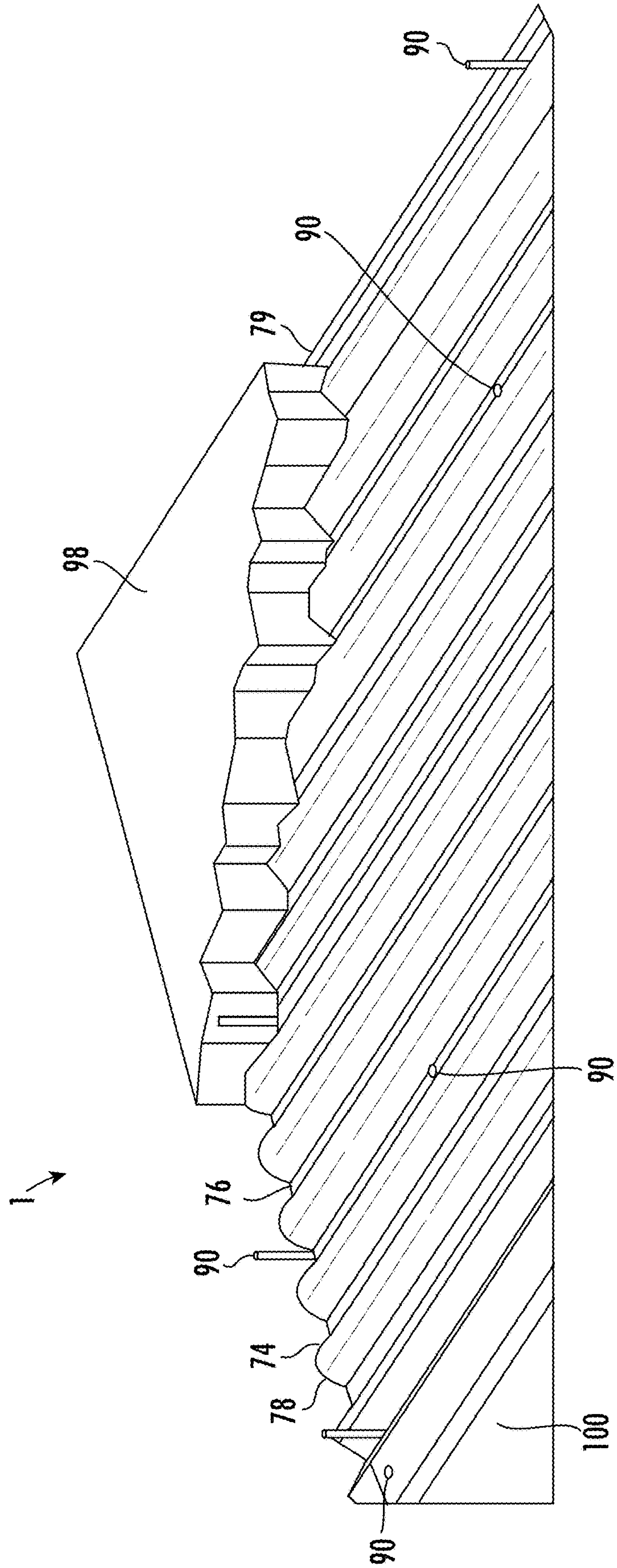


FIG. 1B

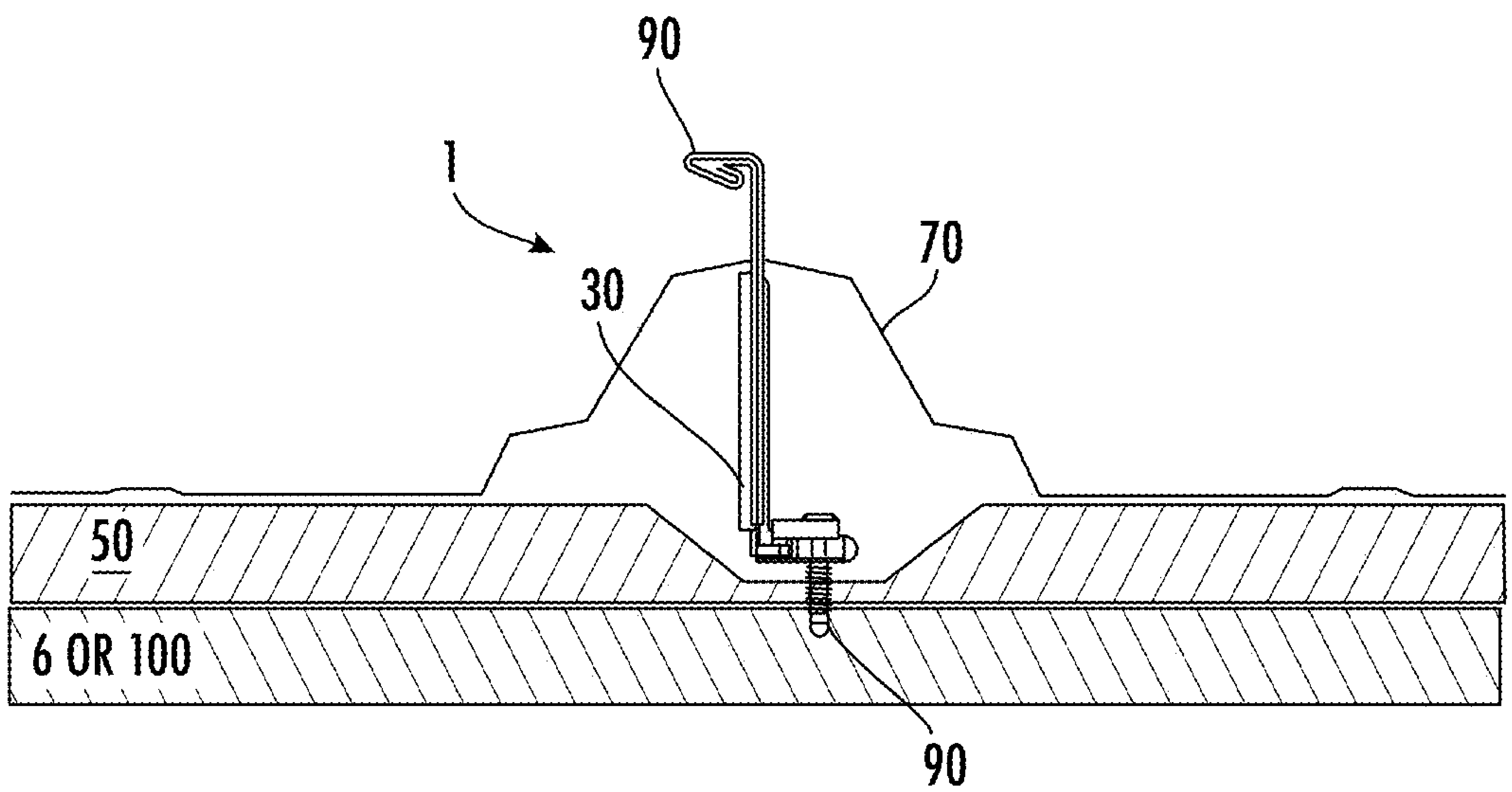


FIG. 1C

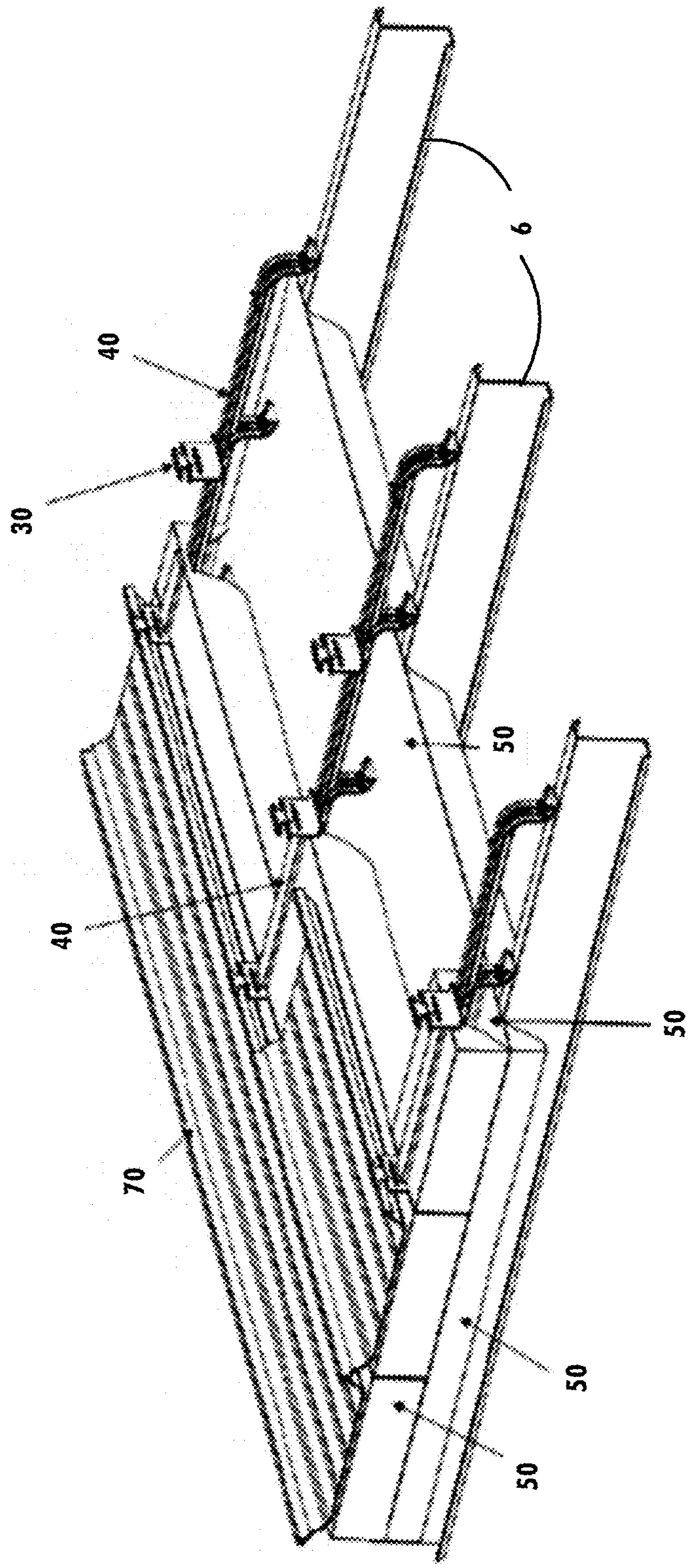


FIG. 1D

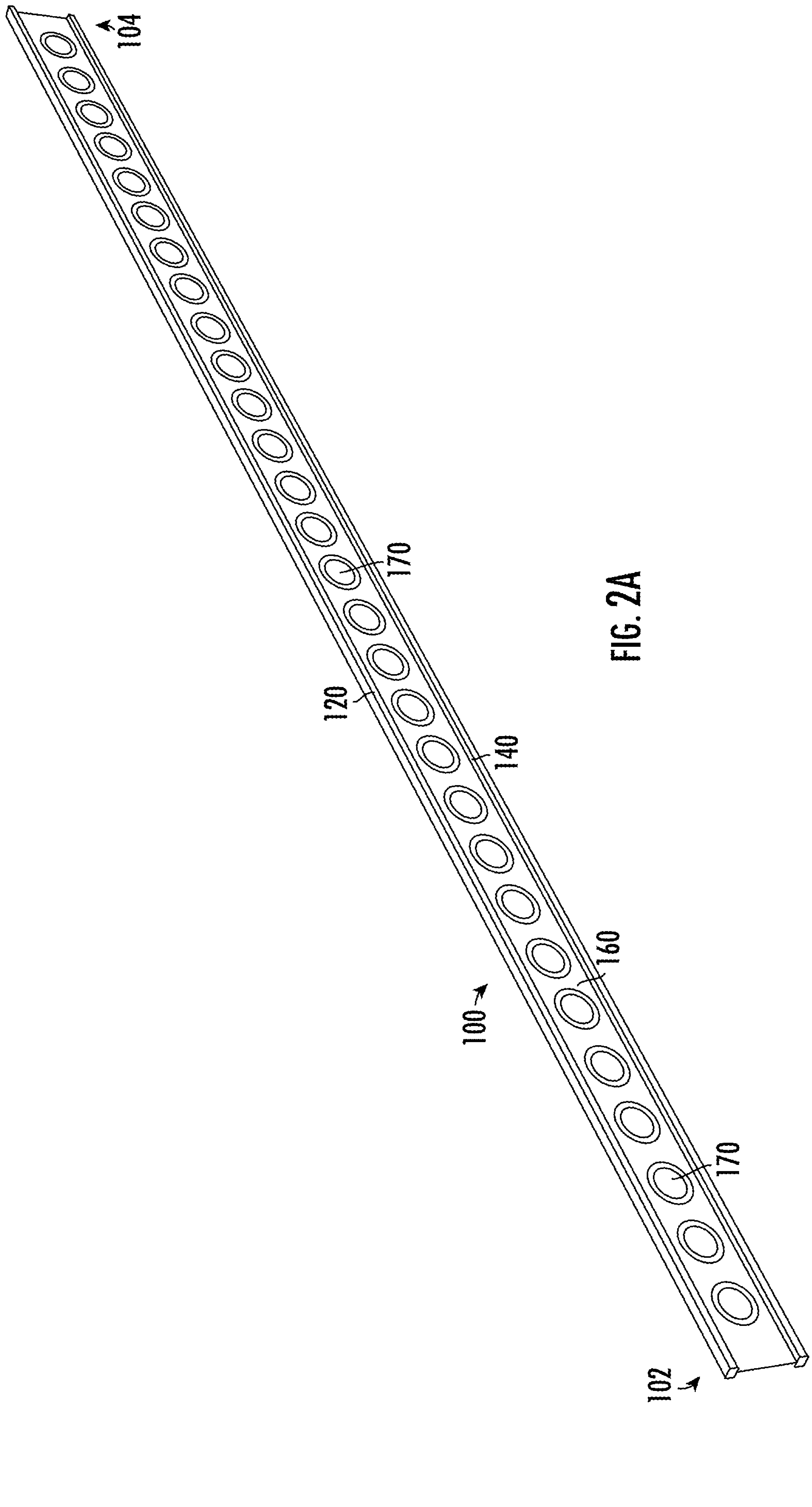


FIG. 2A

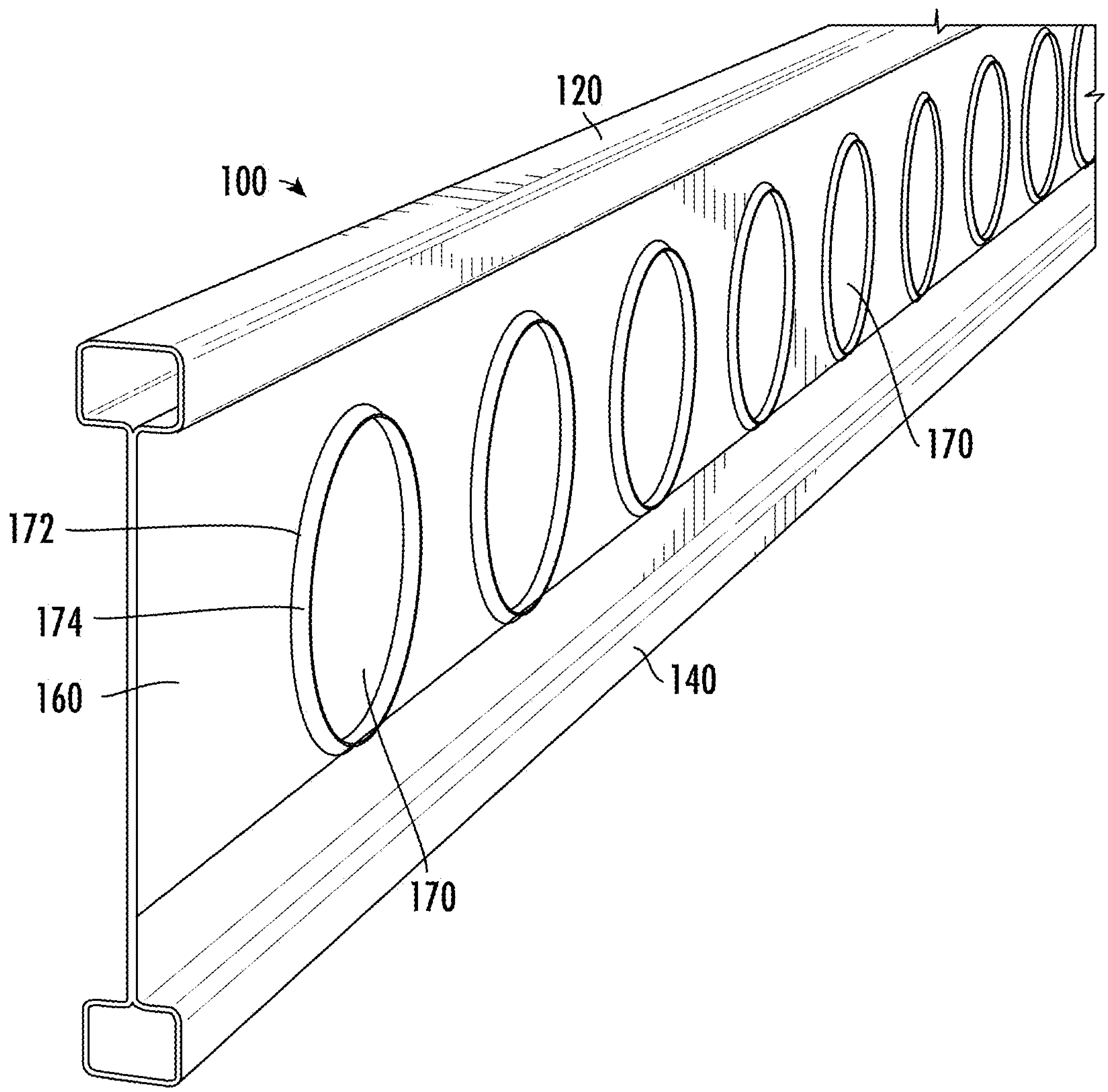


FIG. 2B

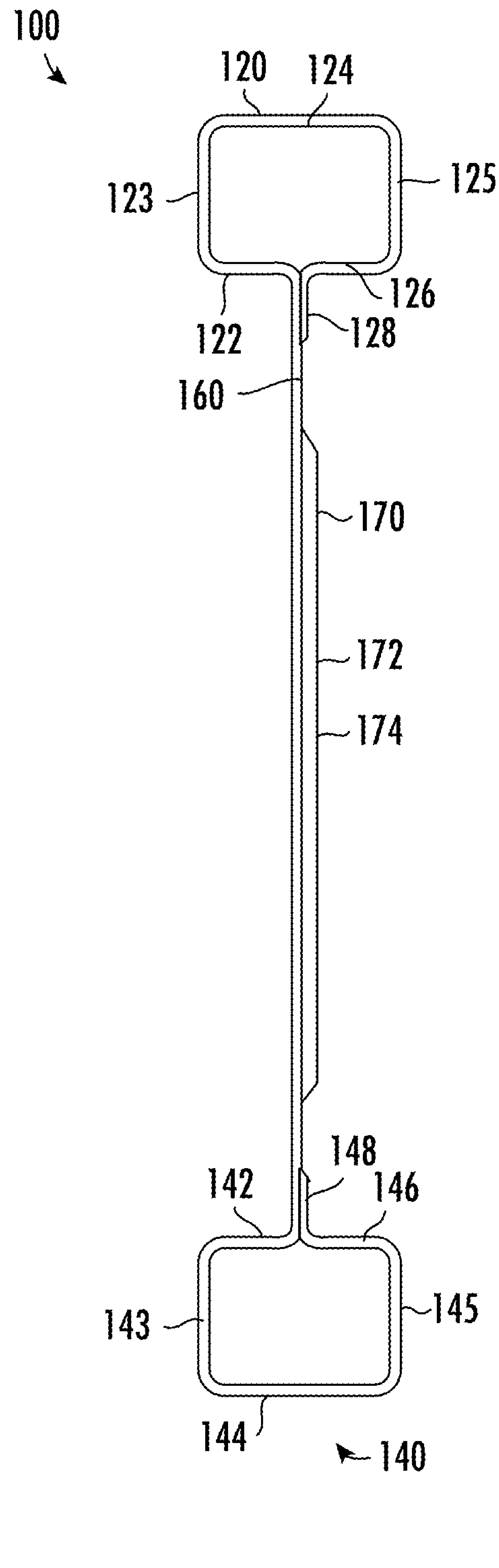

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FIG. 2C

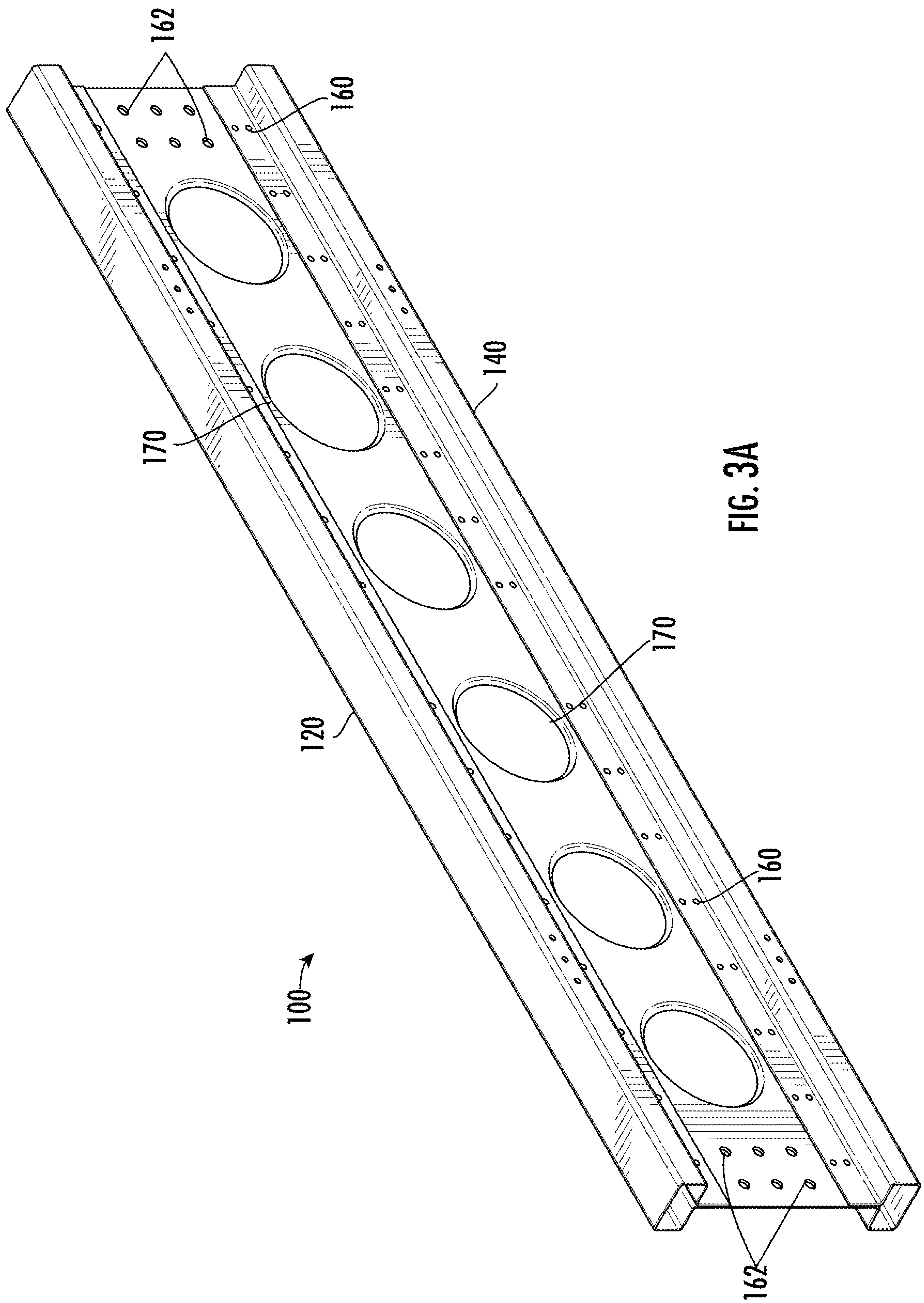

FIG. 3A

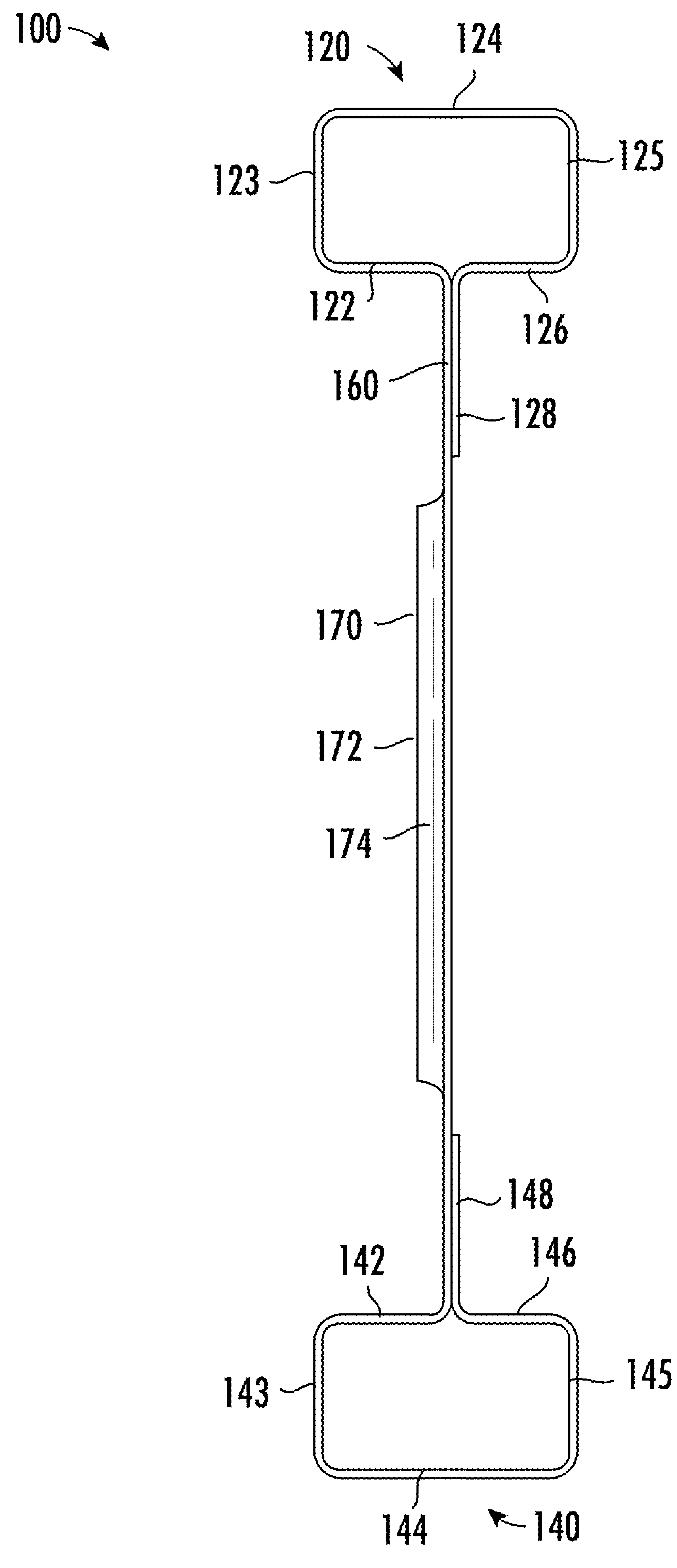
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FIG. 3B

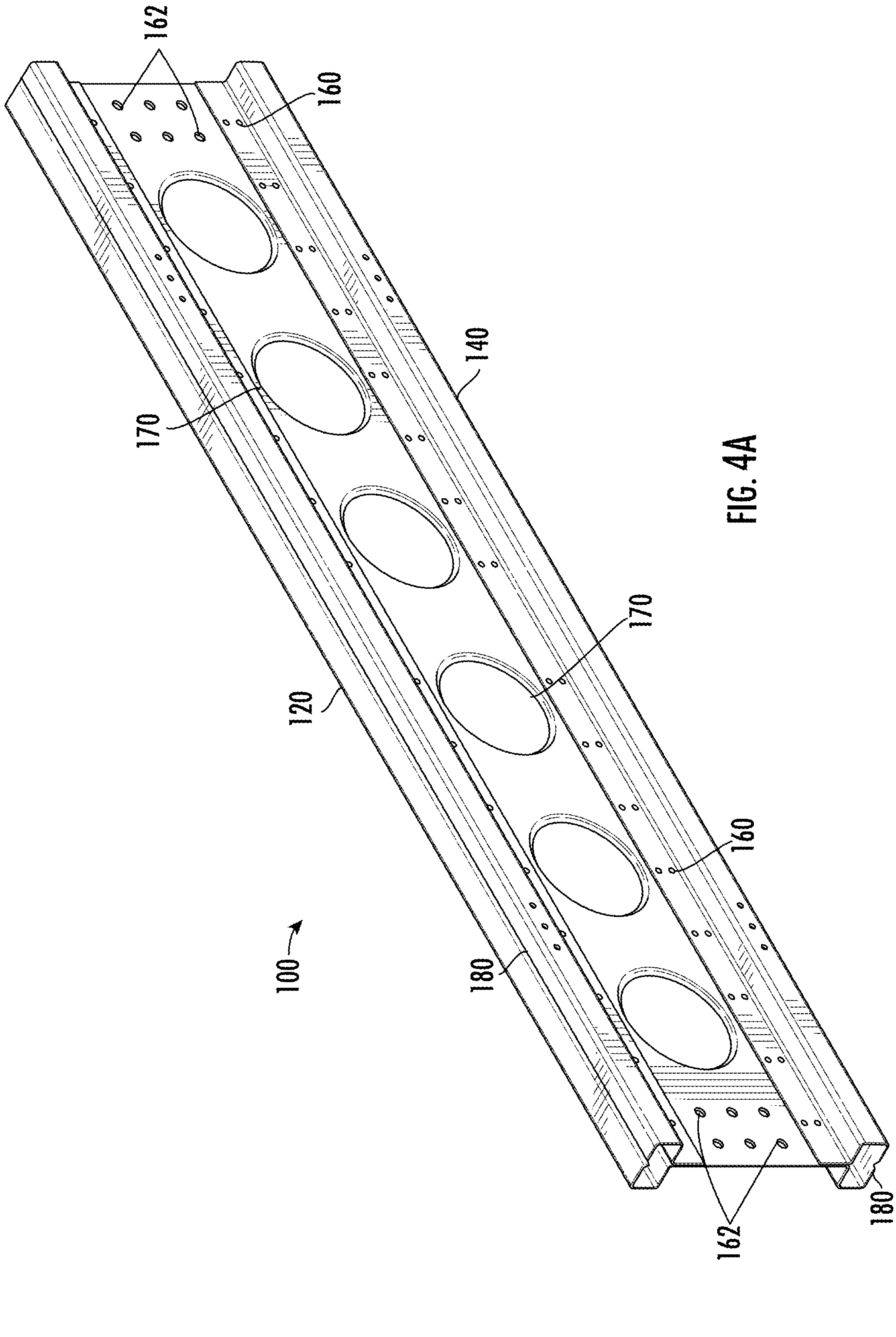

FIG. 4A

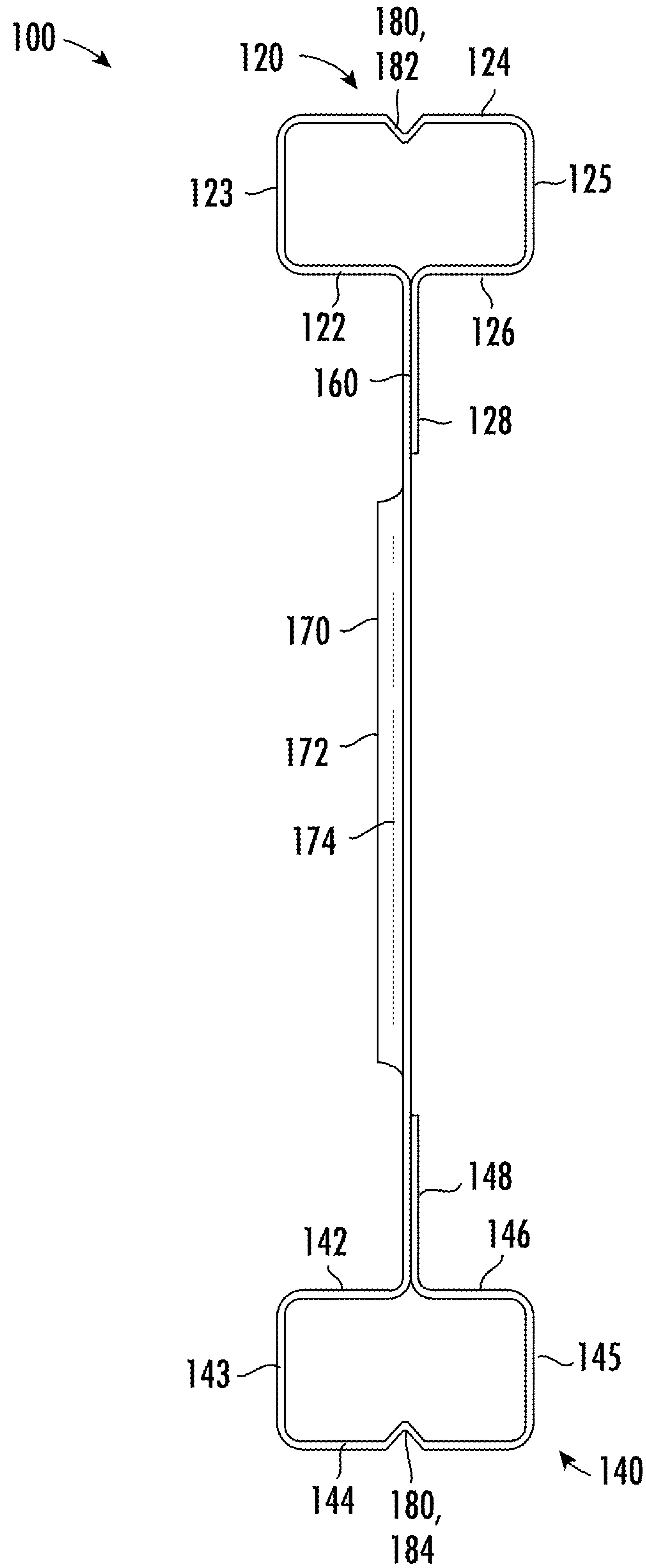
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FIG. 4B

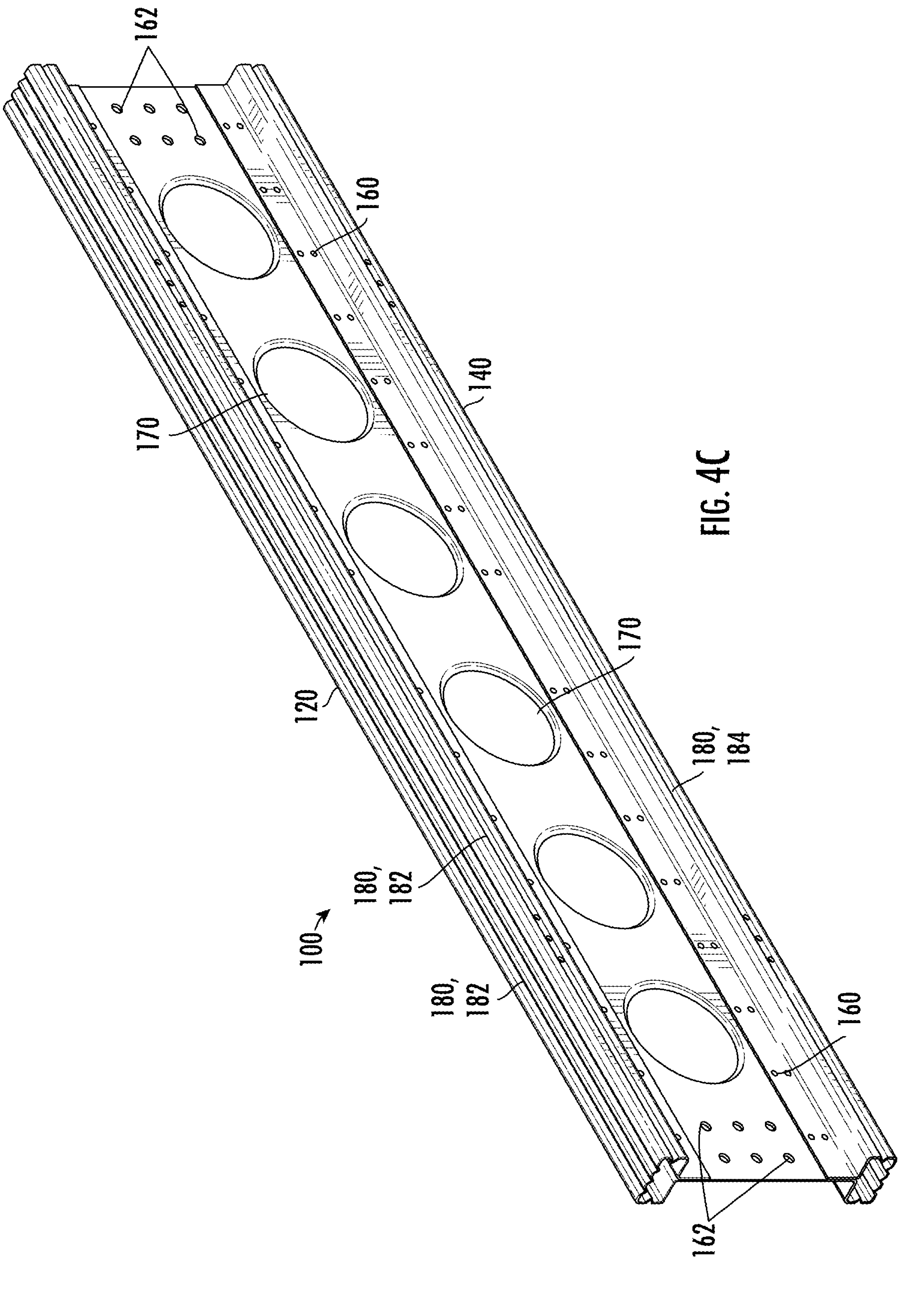

FIG. 4C

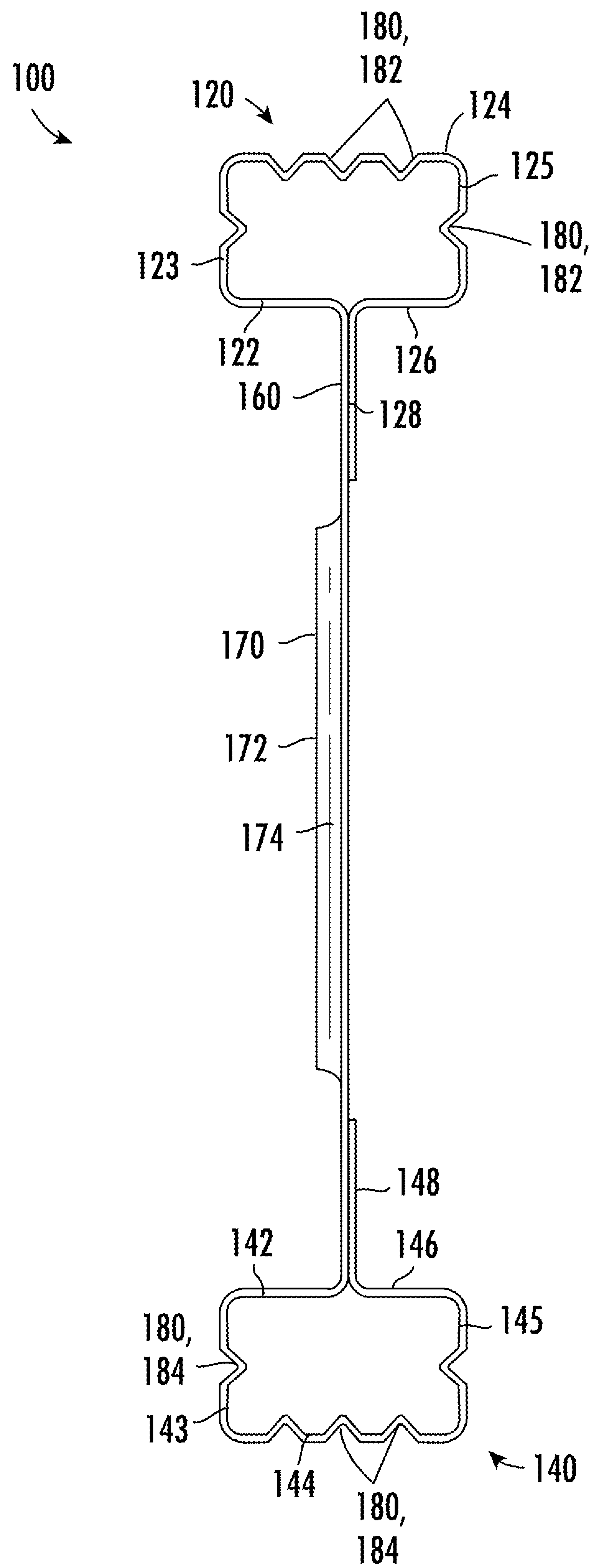
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FIG. 4D

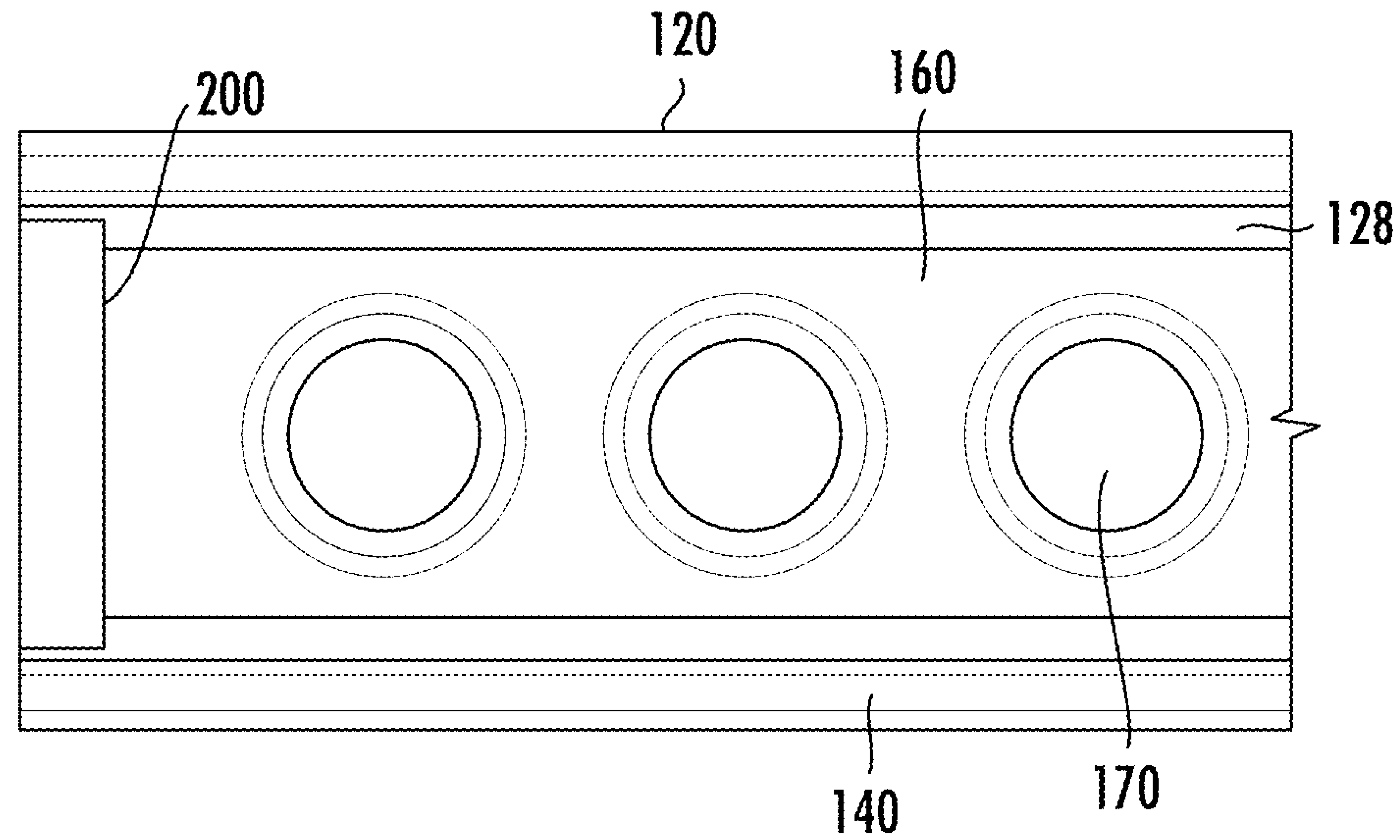

FIG. 5A

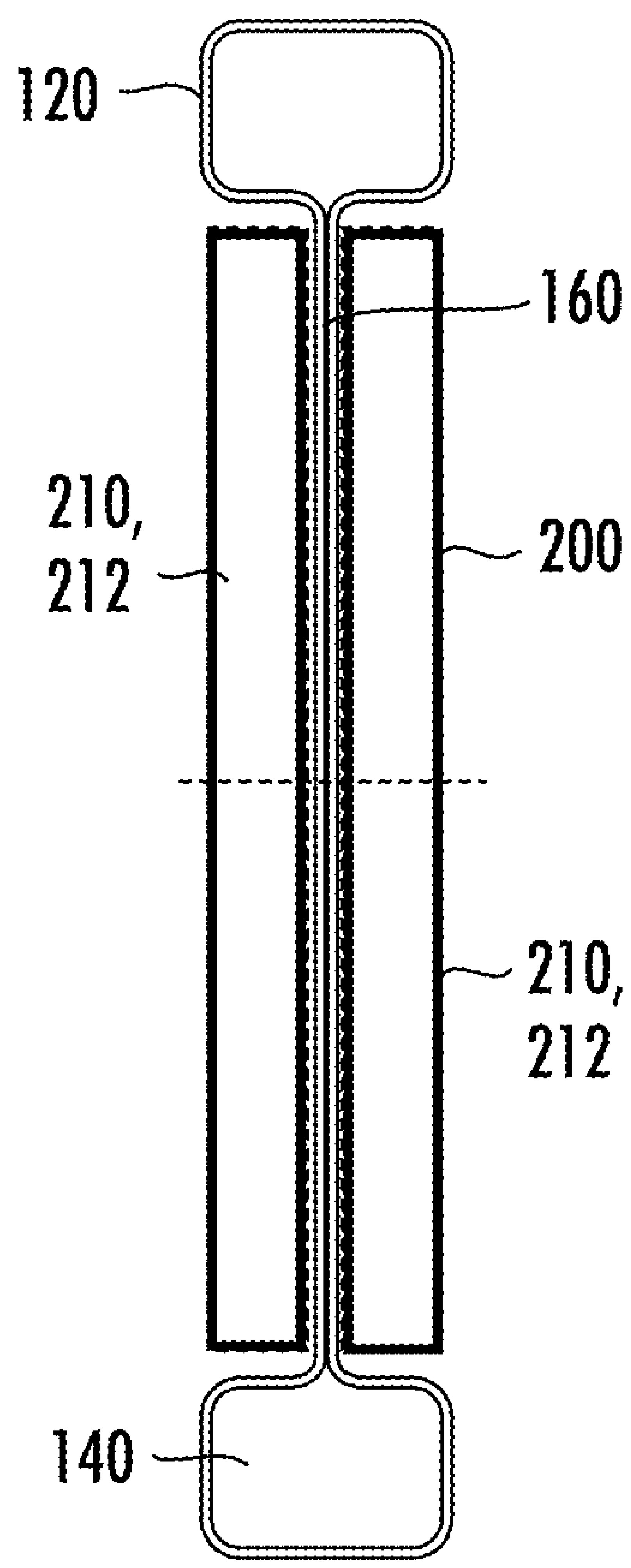

FIG. 5B

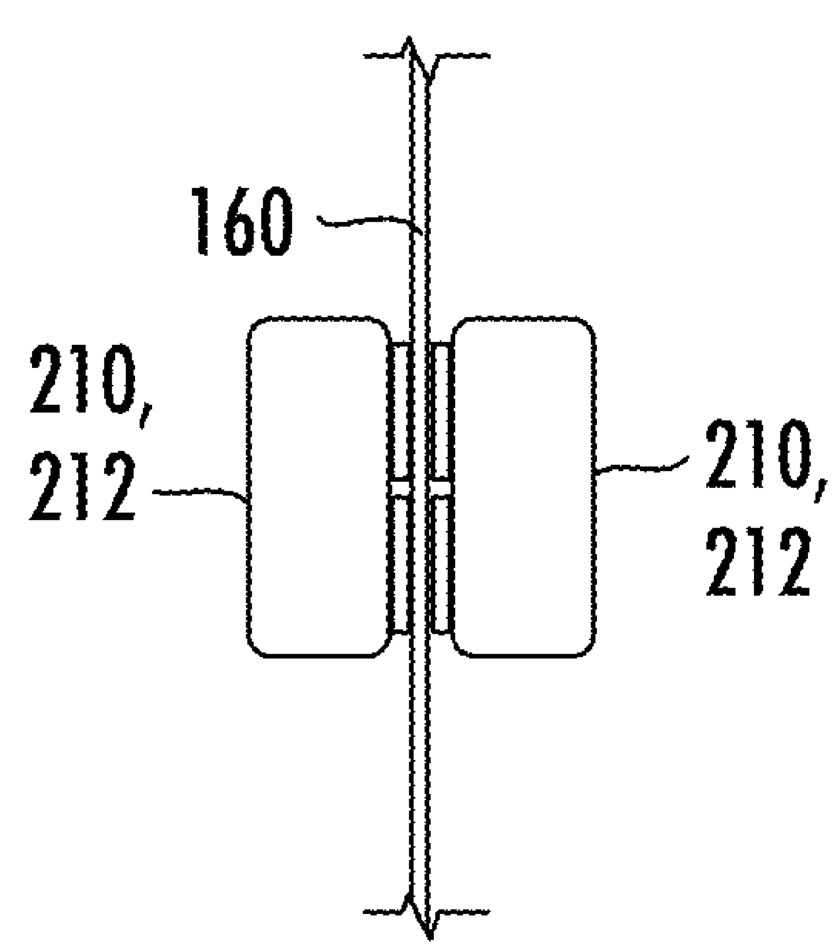

FIG. 5C

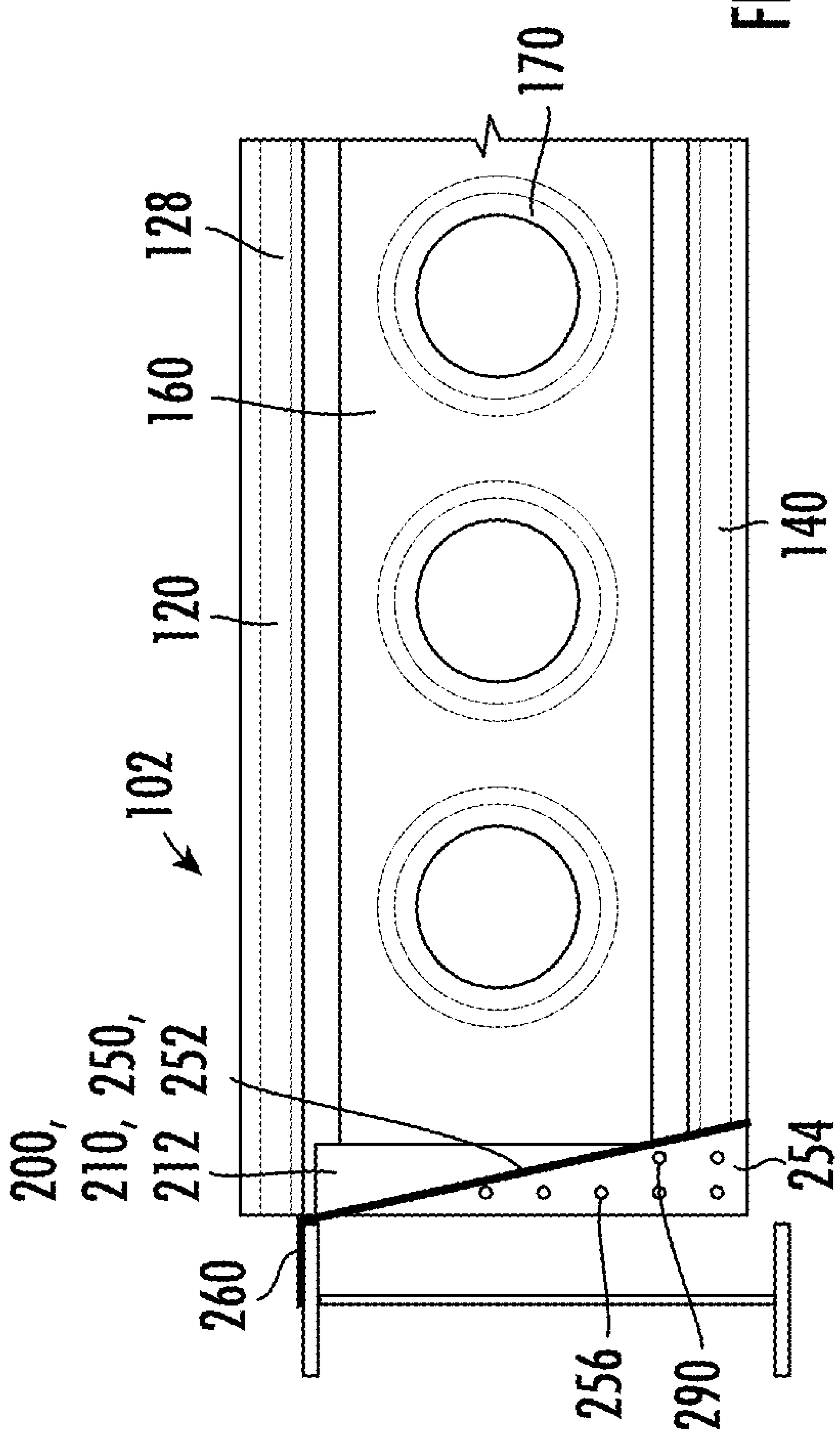
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FIG. 6A

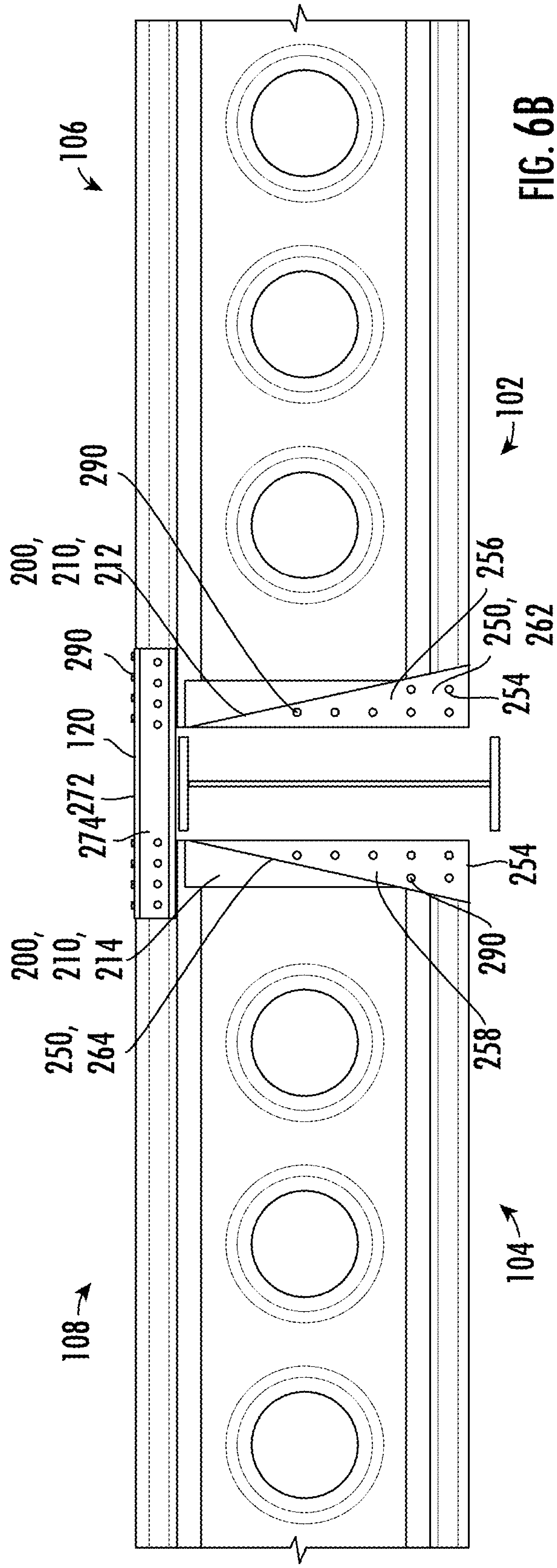
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FIG. 6B

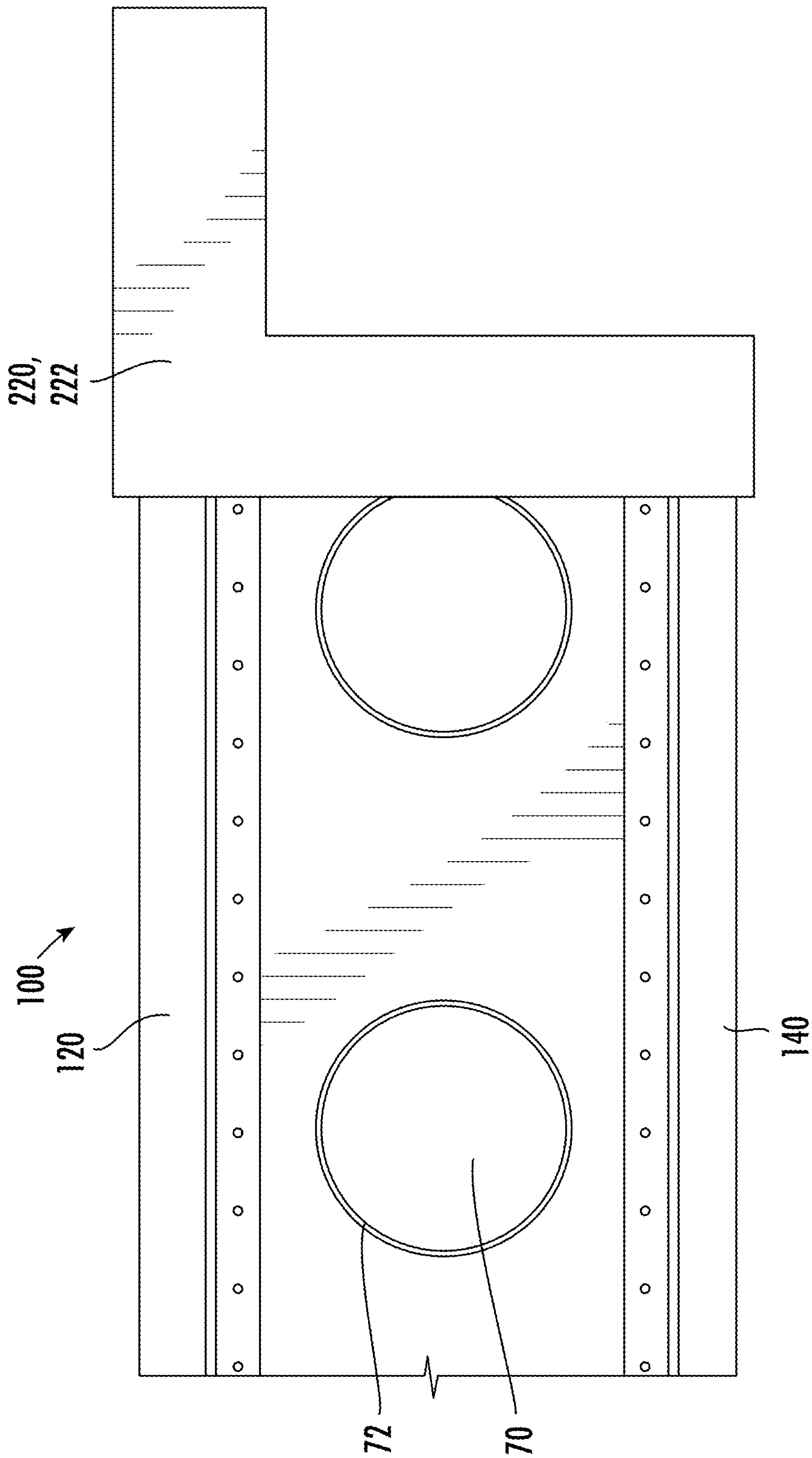

FIG. 6C

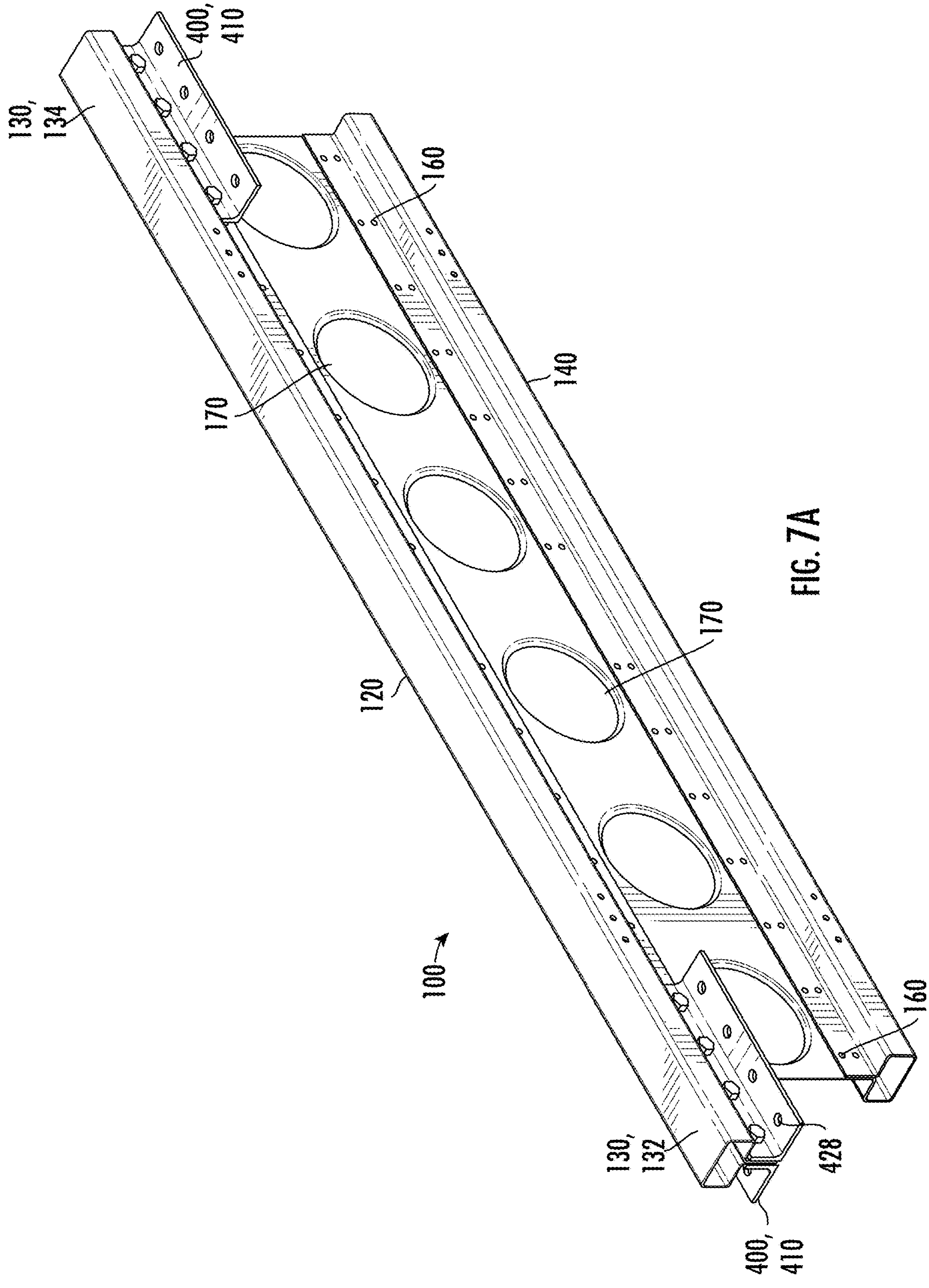

FIG. 7A

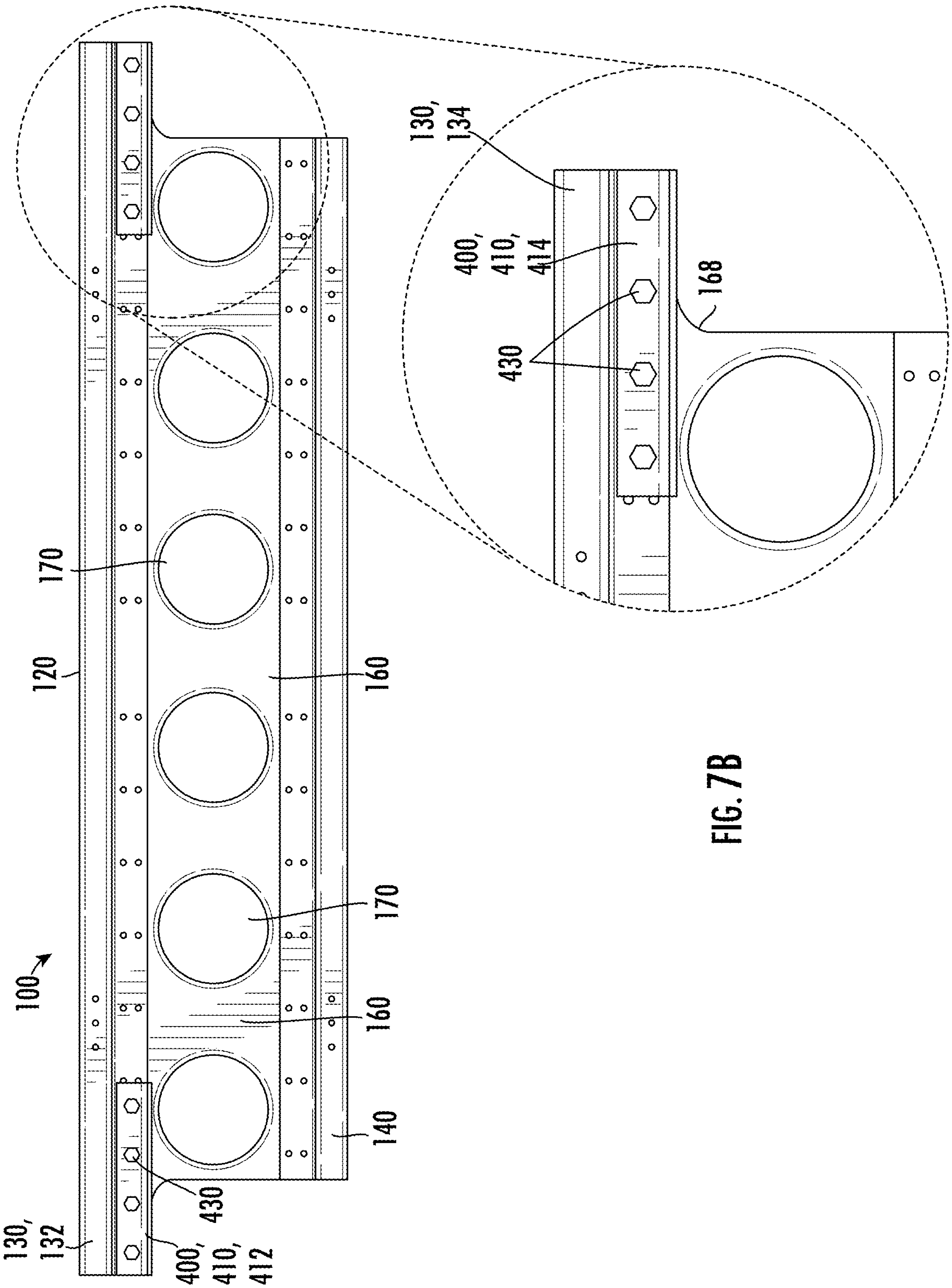
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FIG. 7B

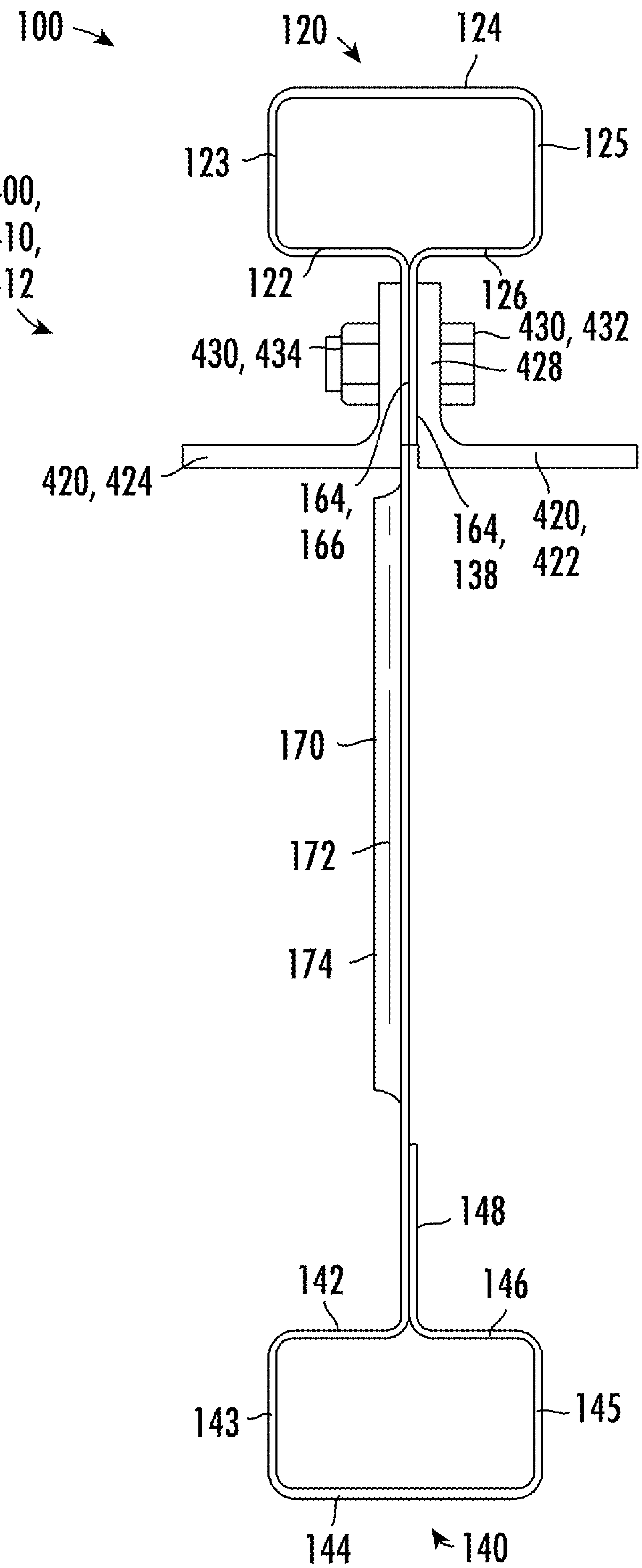
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FIG. 7C

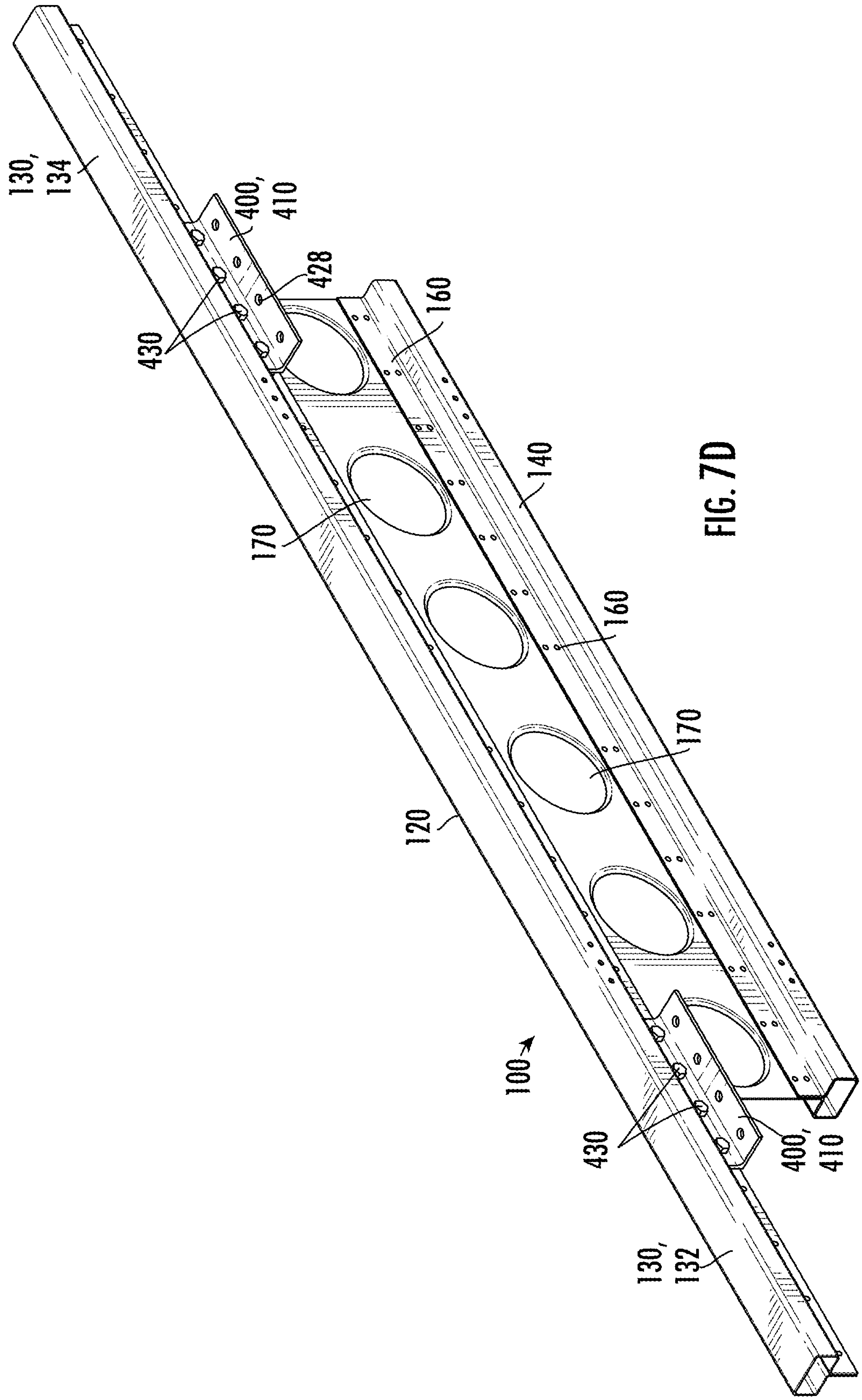
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FIG. 7D

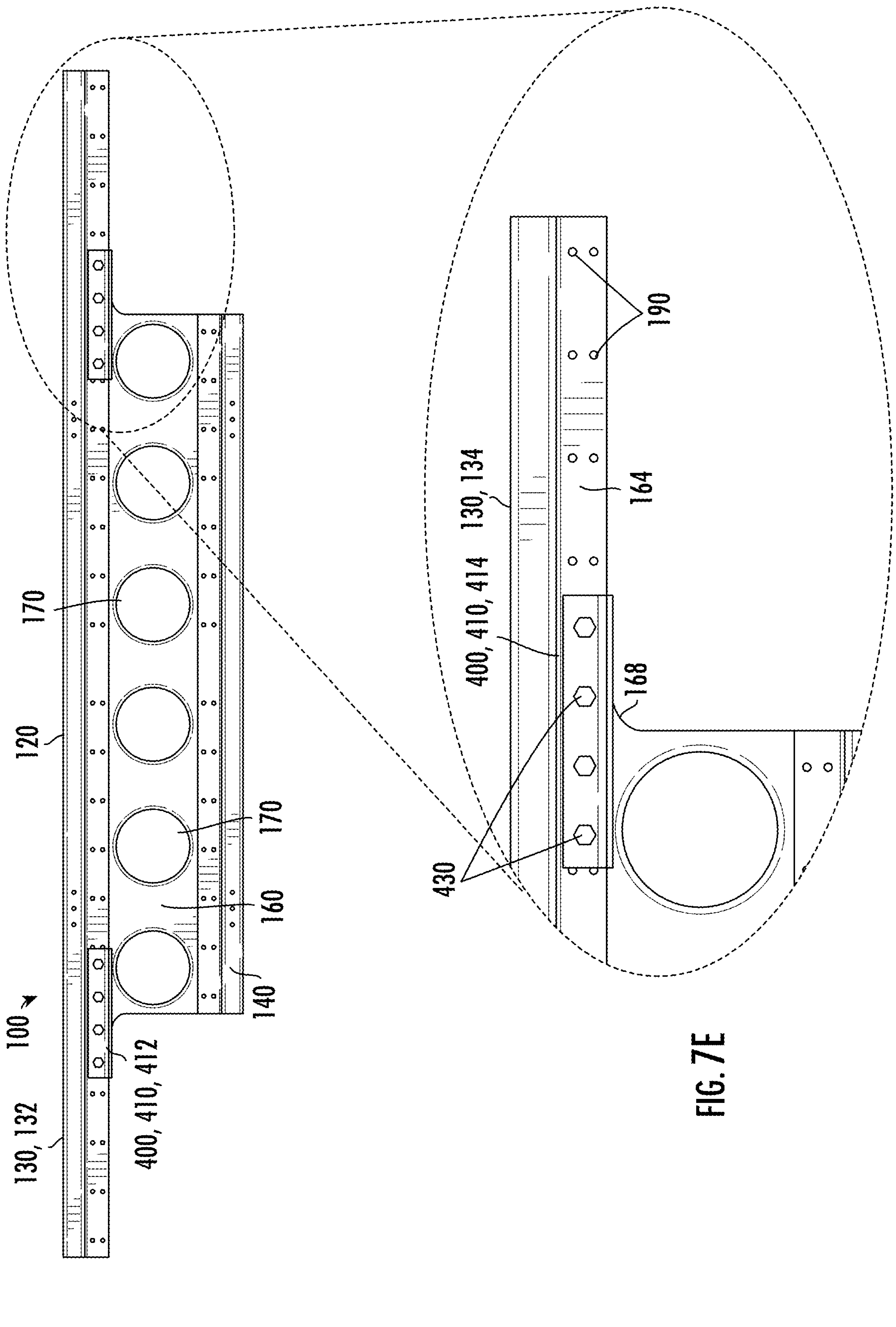
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FIG. 7E

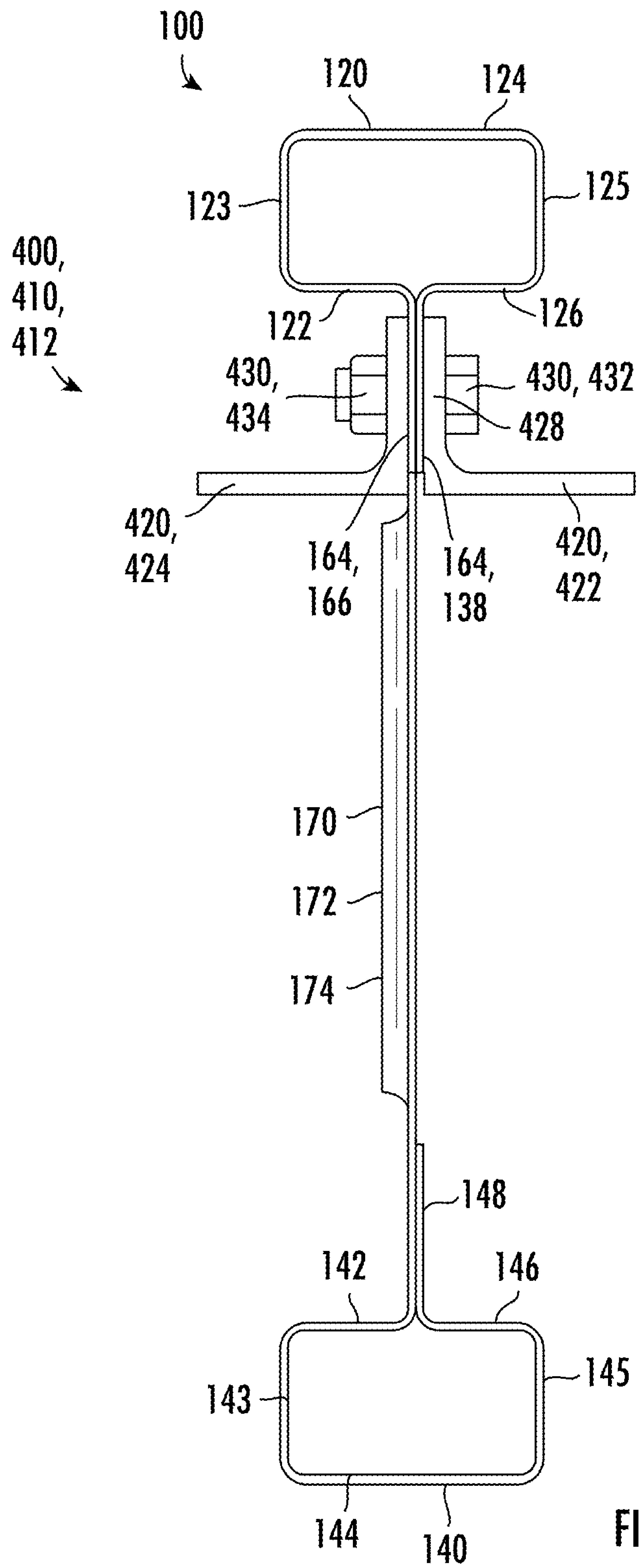
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FIG. 7F

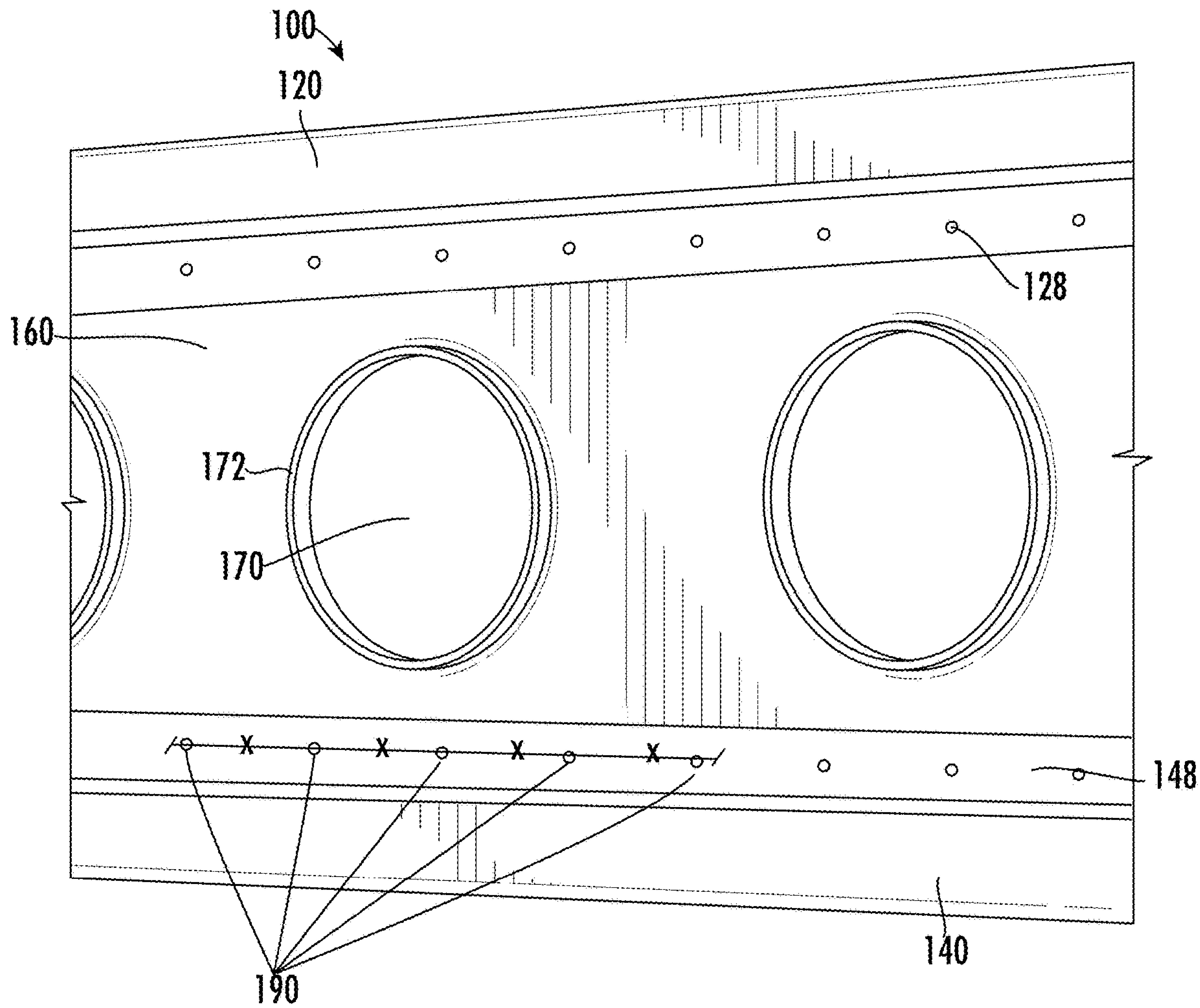

FIG. 8A

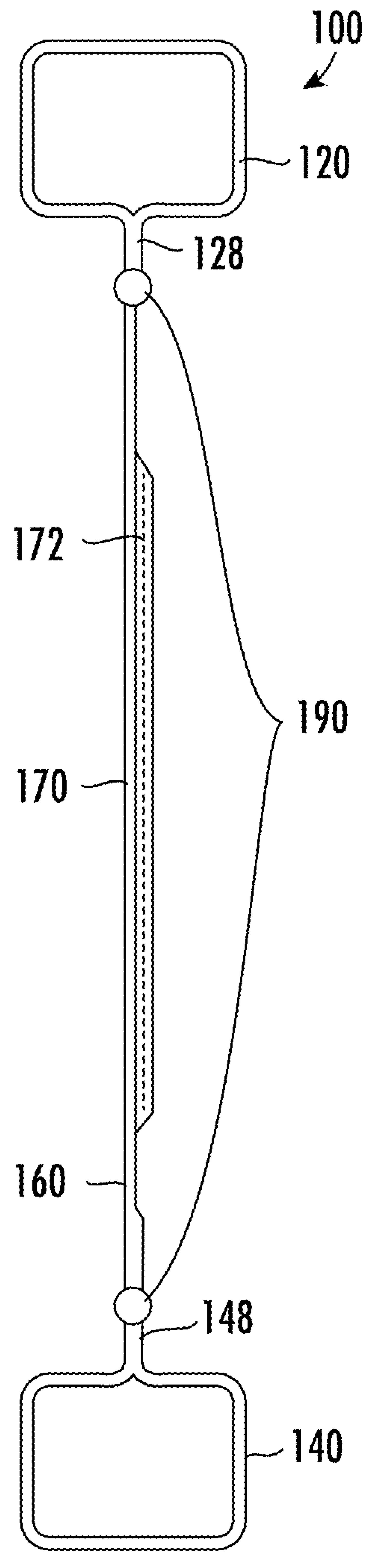

FIG. 8B

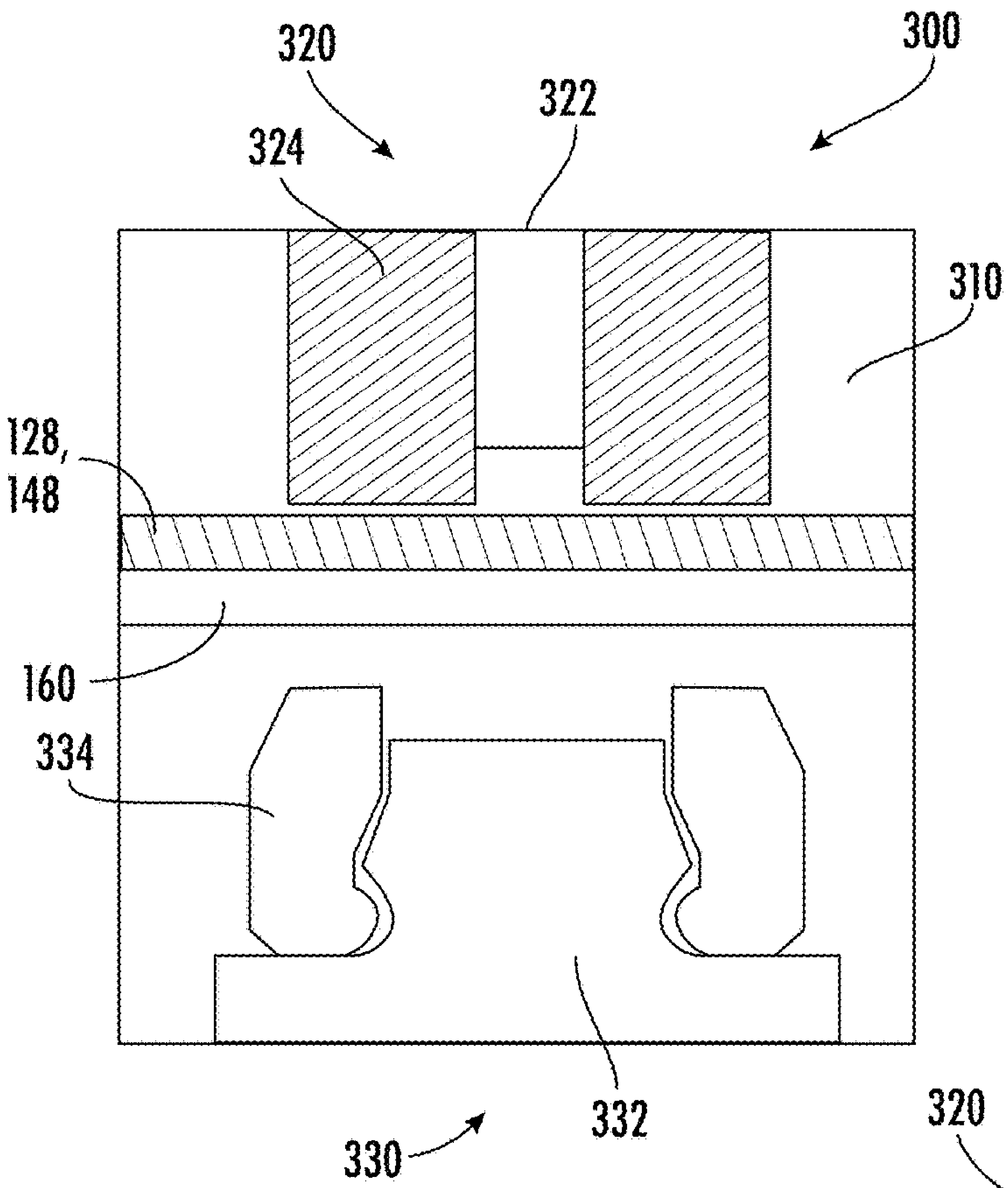
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FIG. 9A

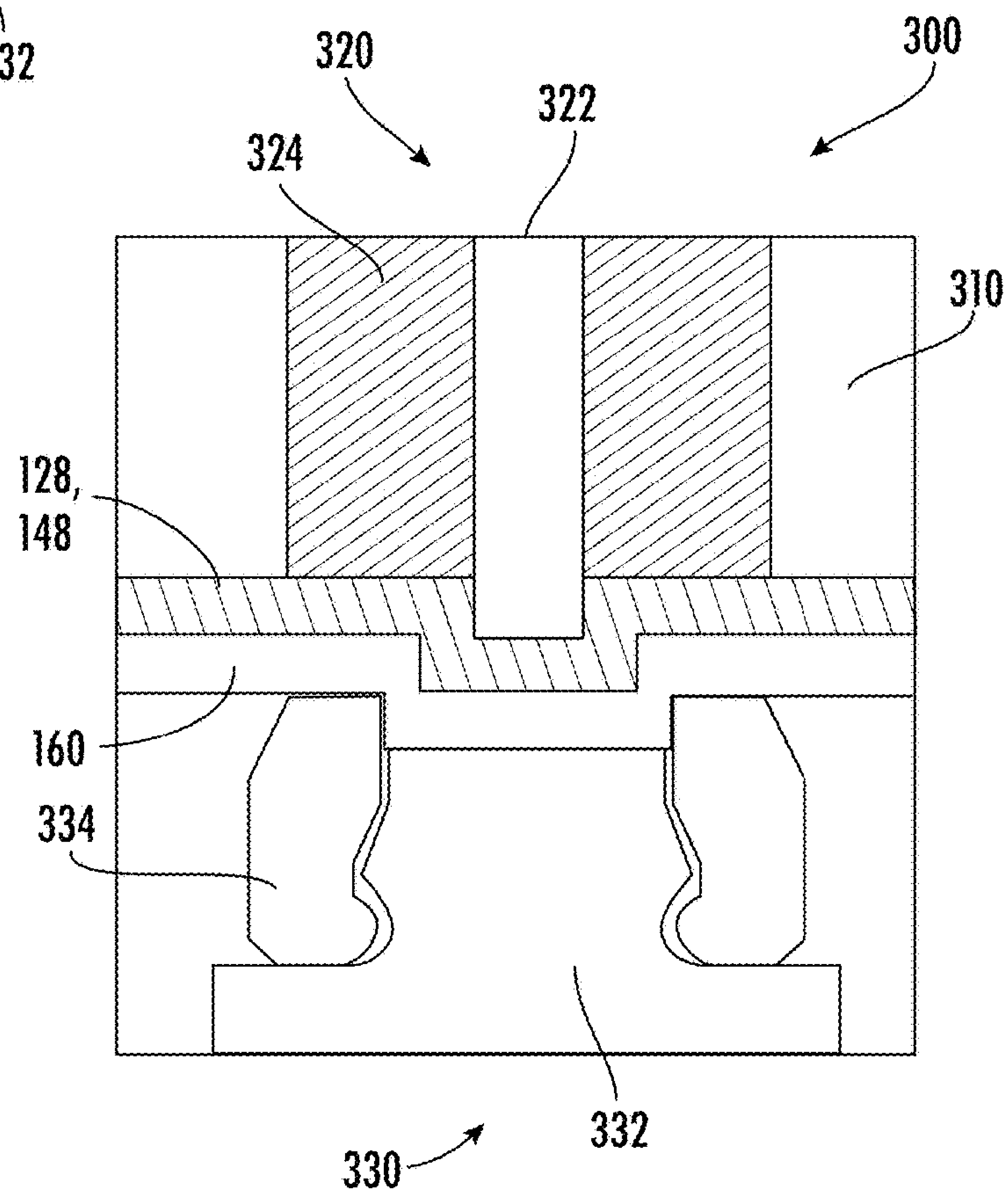
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FIG. 9B

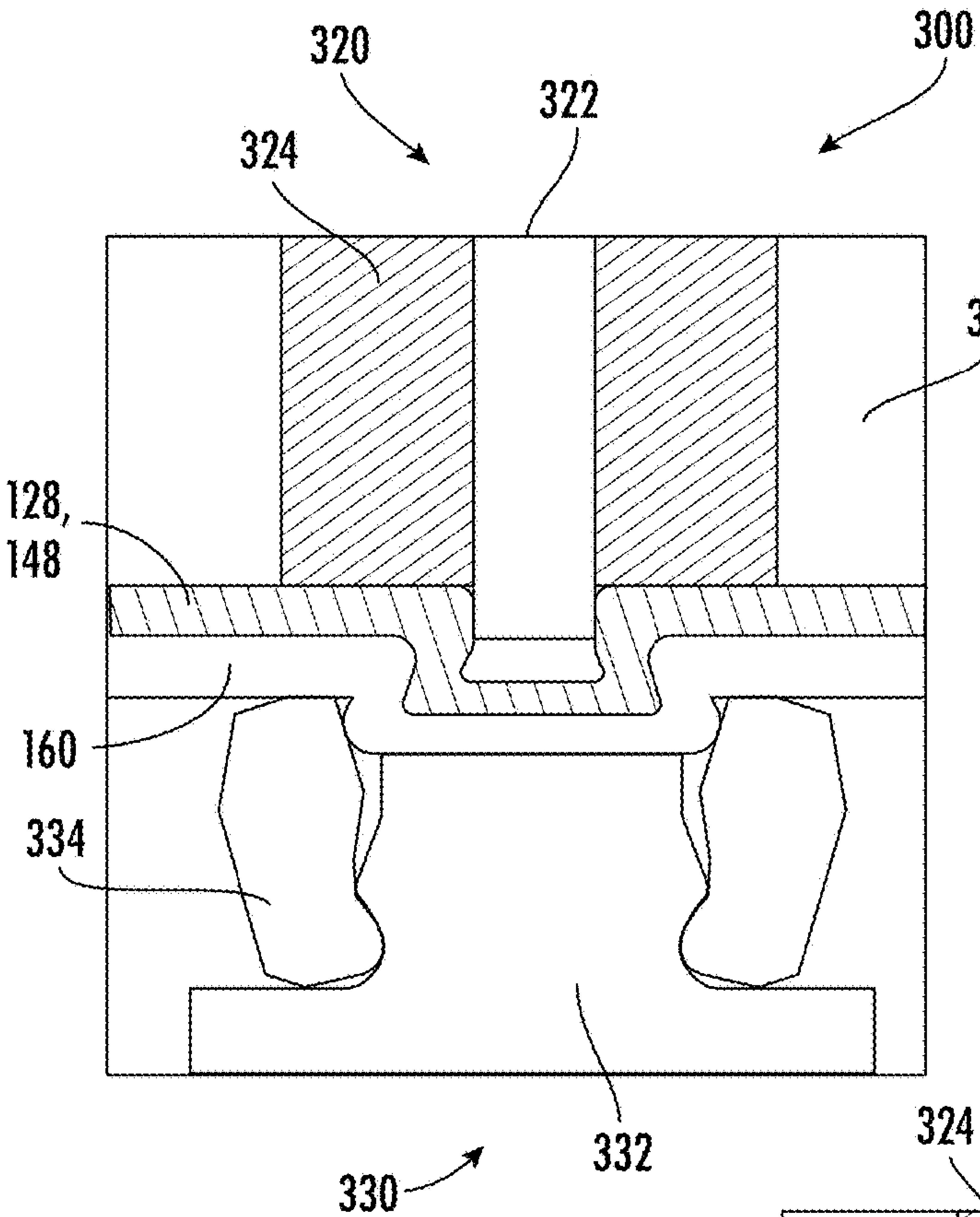
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FIG. 9C

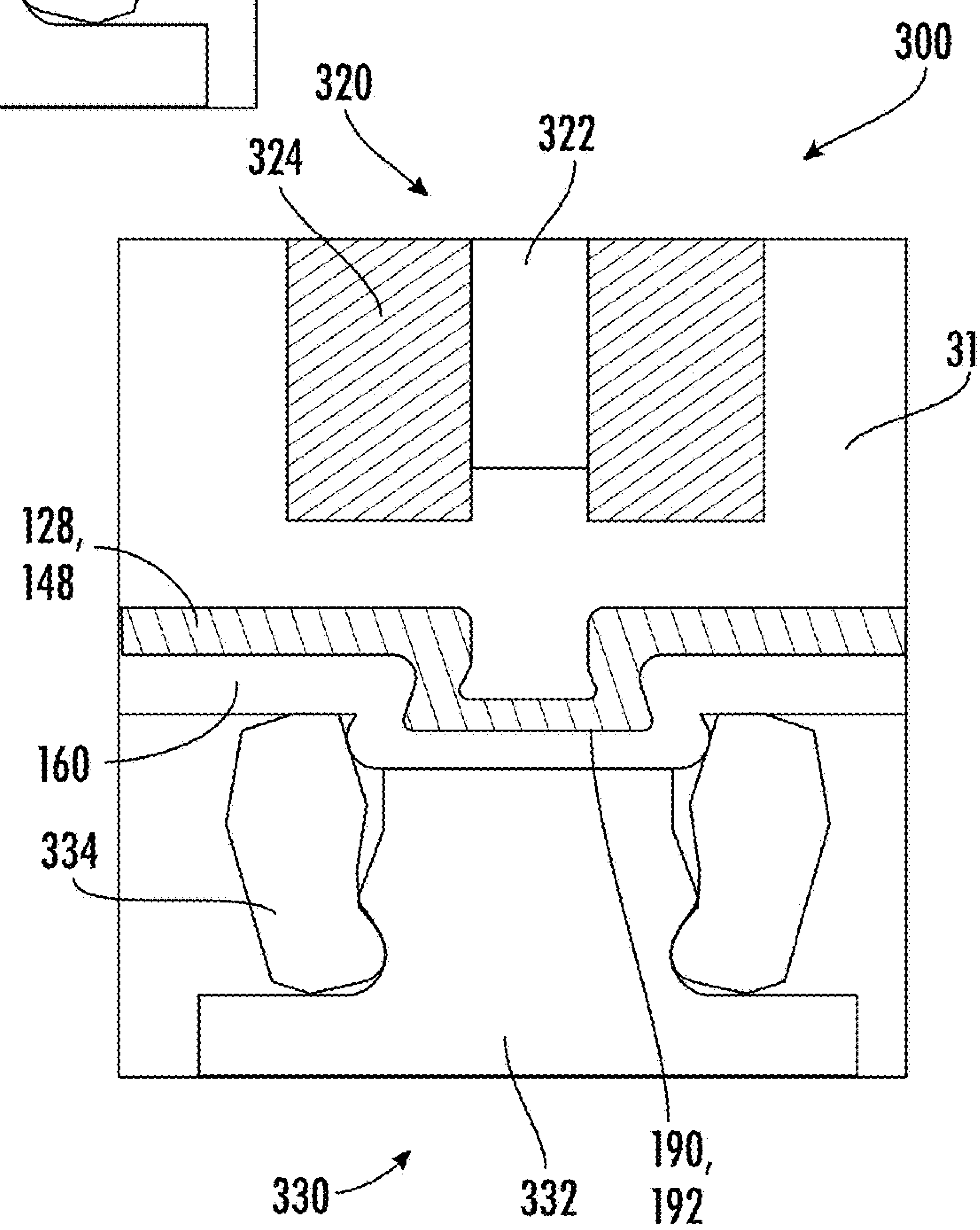
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FIG. 9D

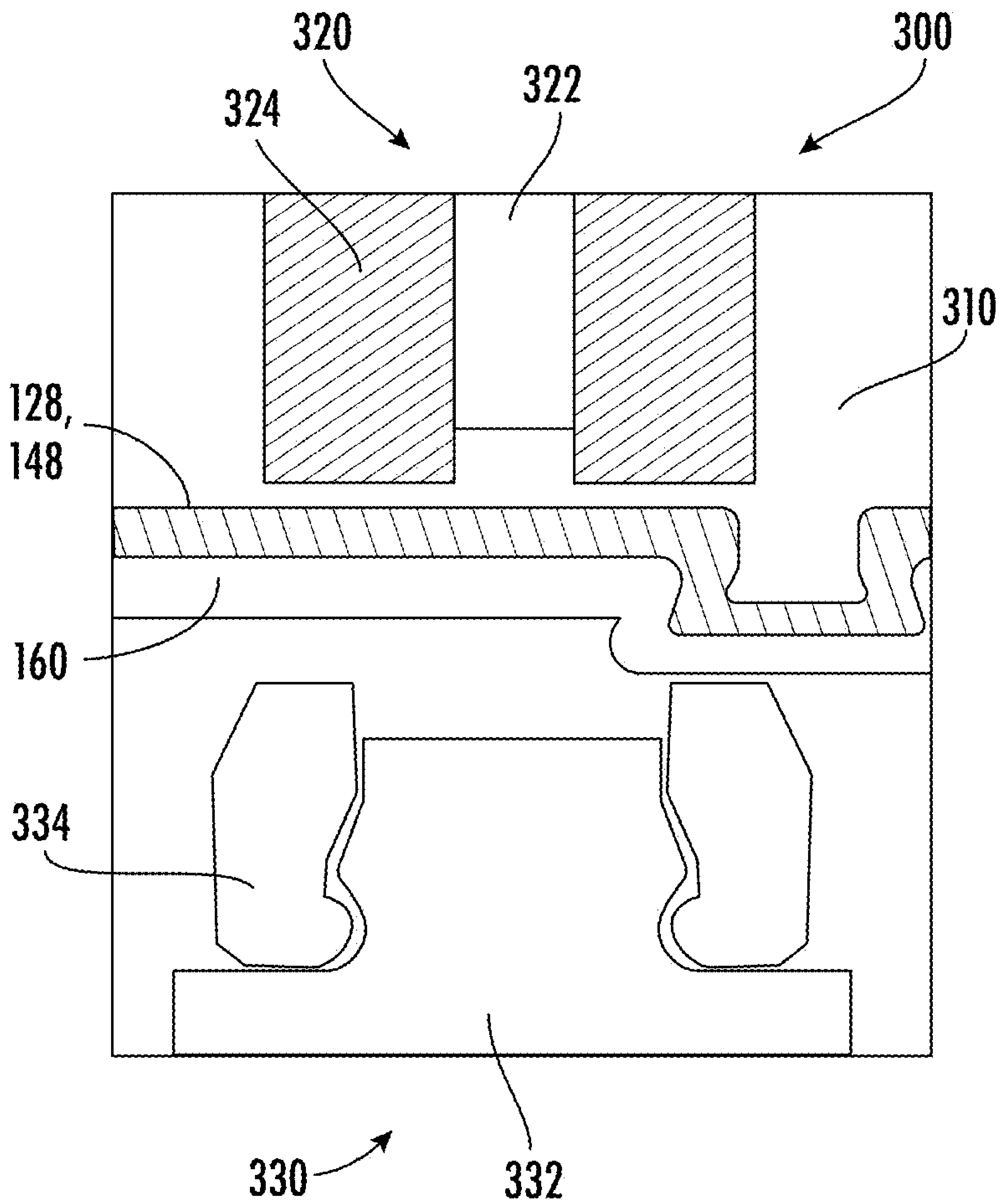

FIG. 9E

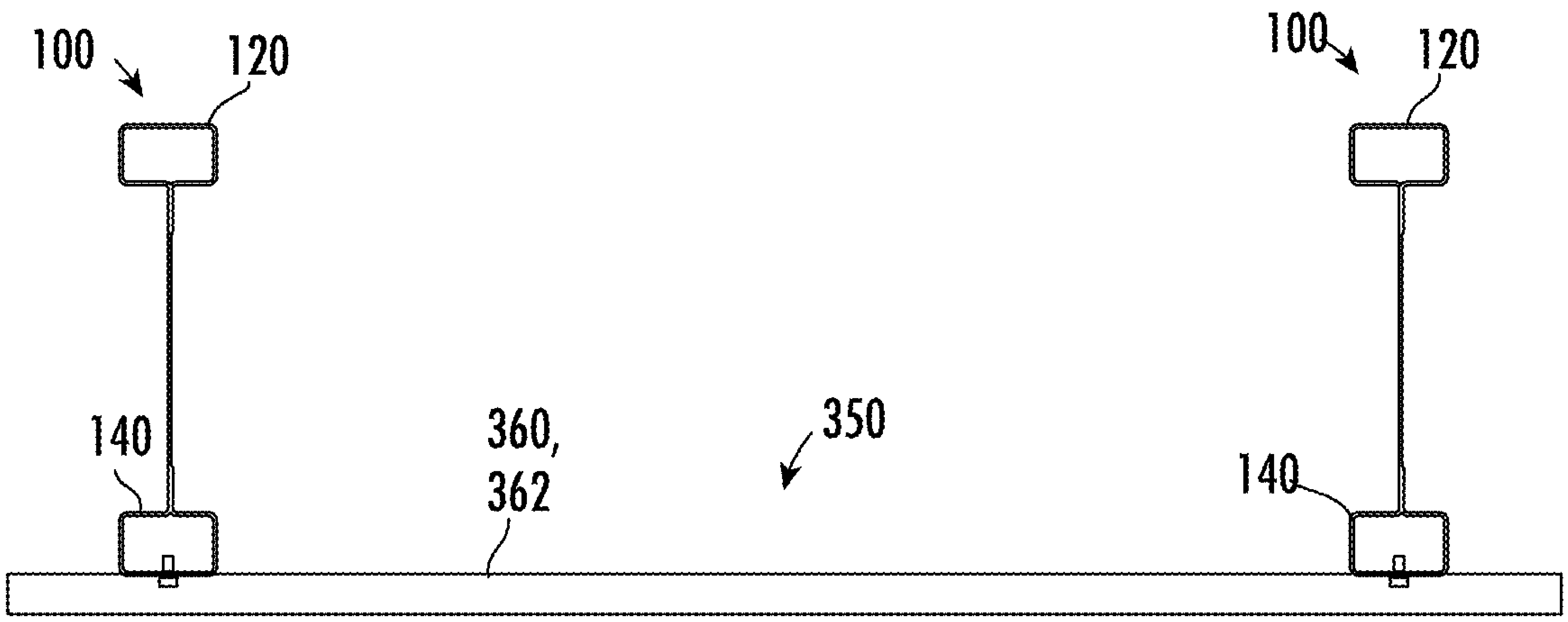

FIG. 10A

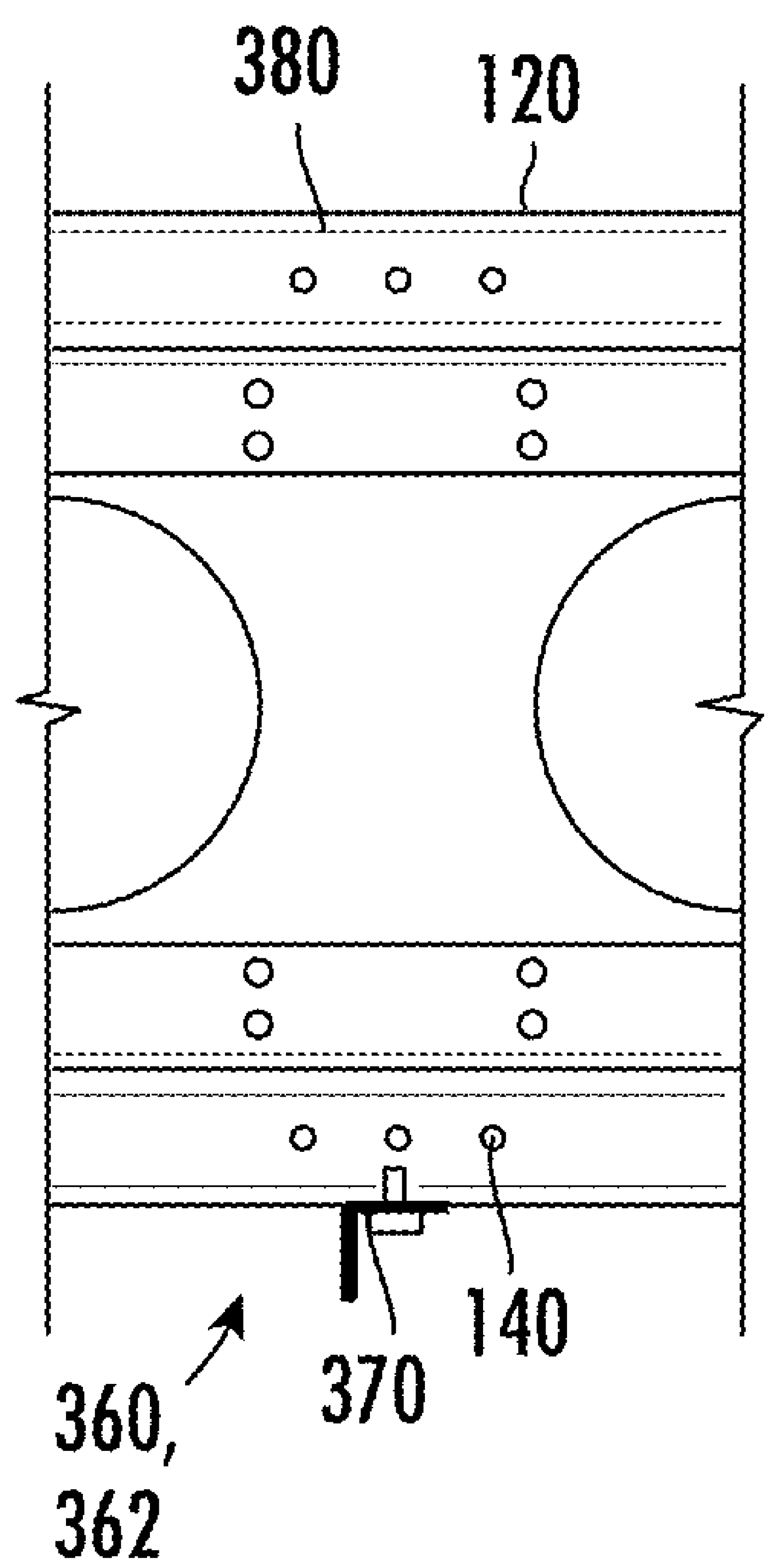

FIG. 10B

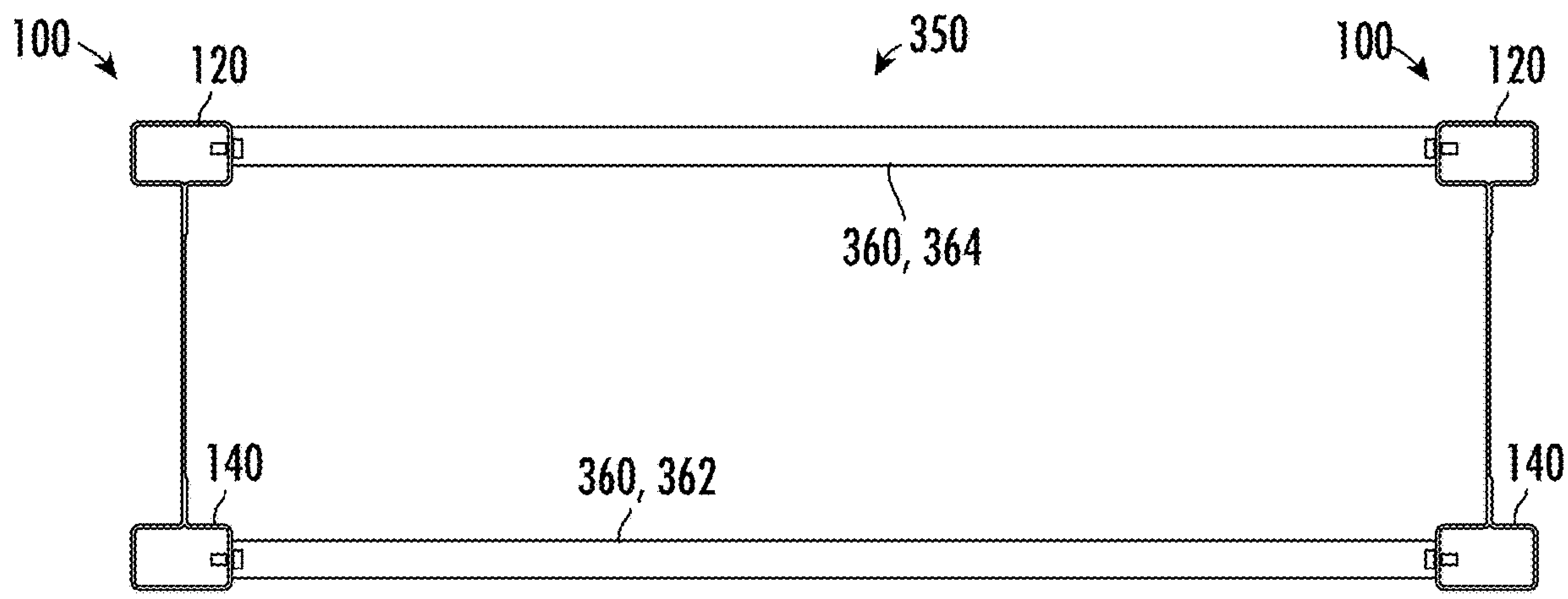

FIG. 10C

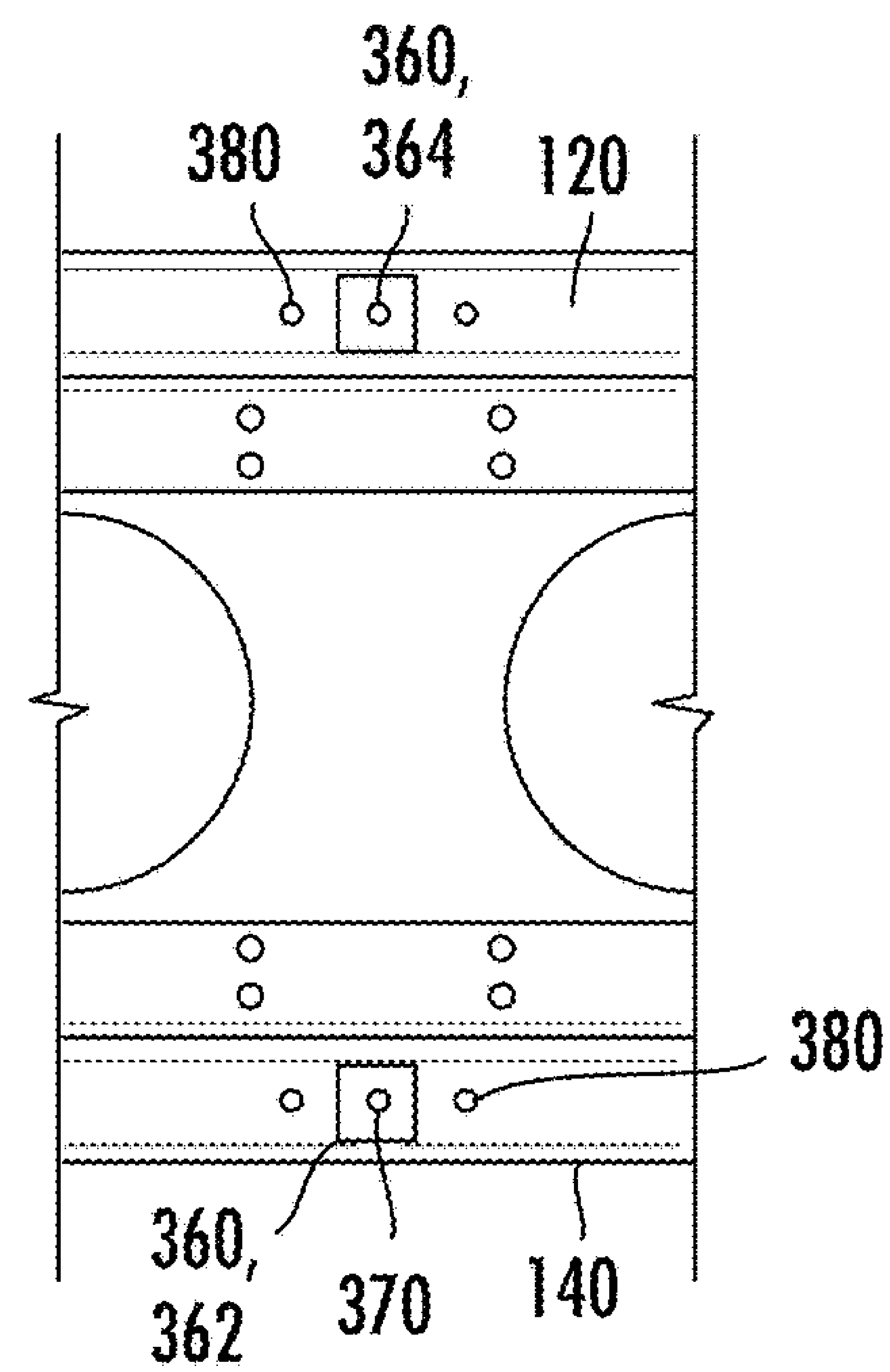

FIG. 10D

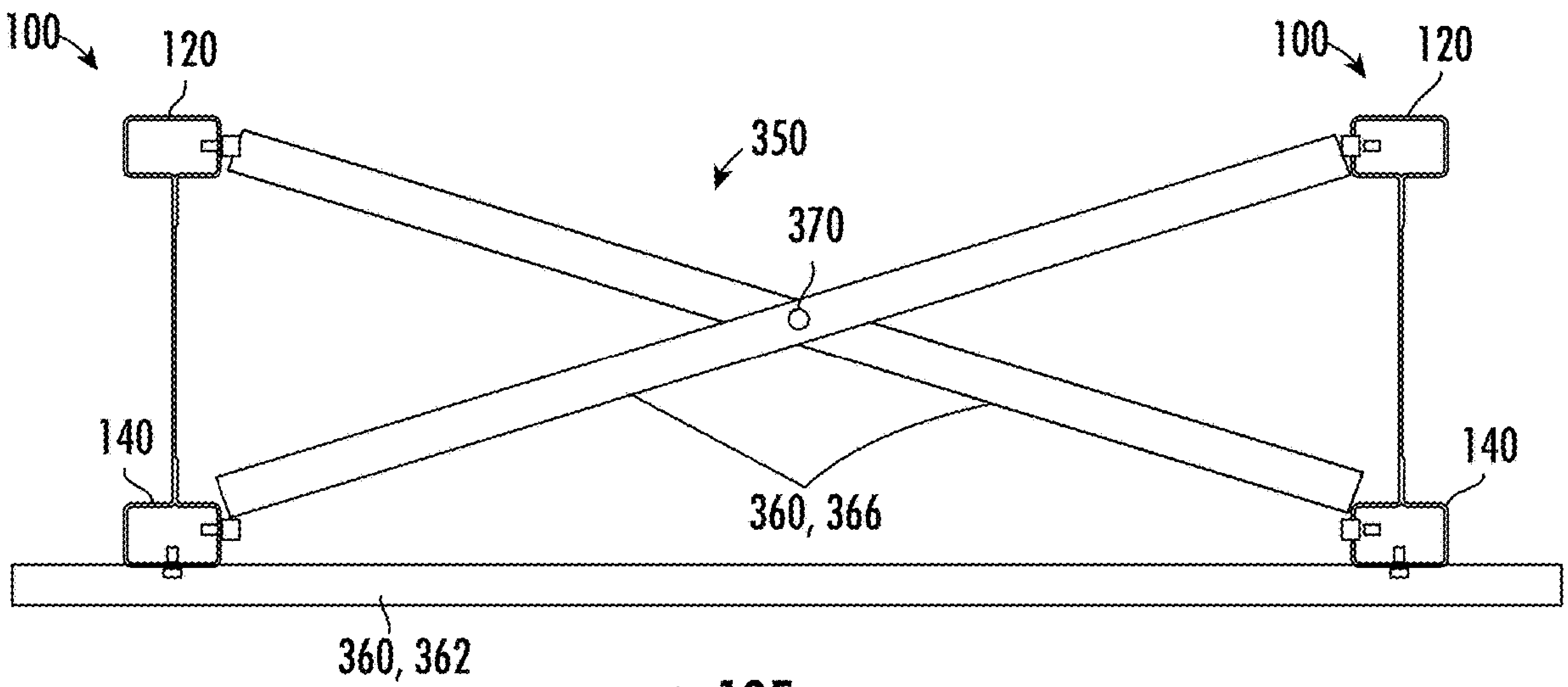

FIG. 10E

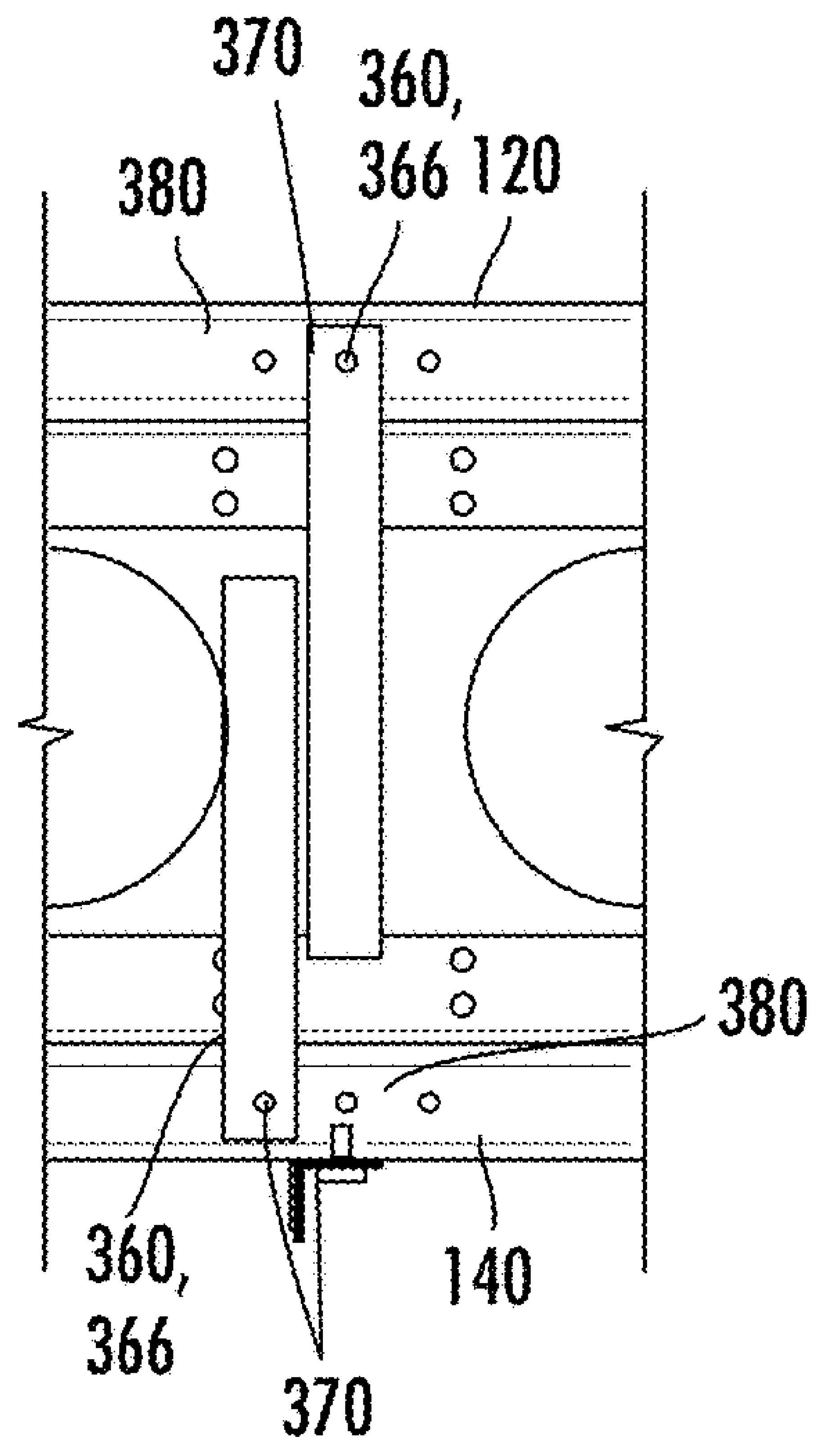

FIG. 10F

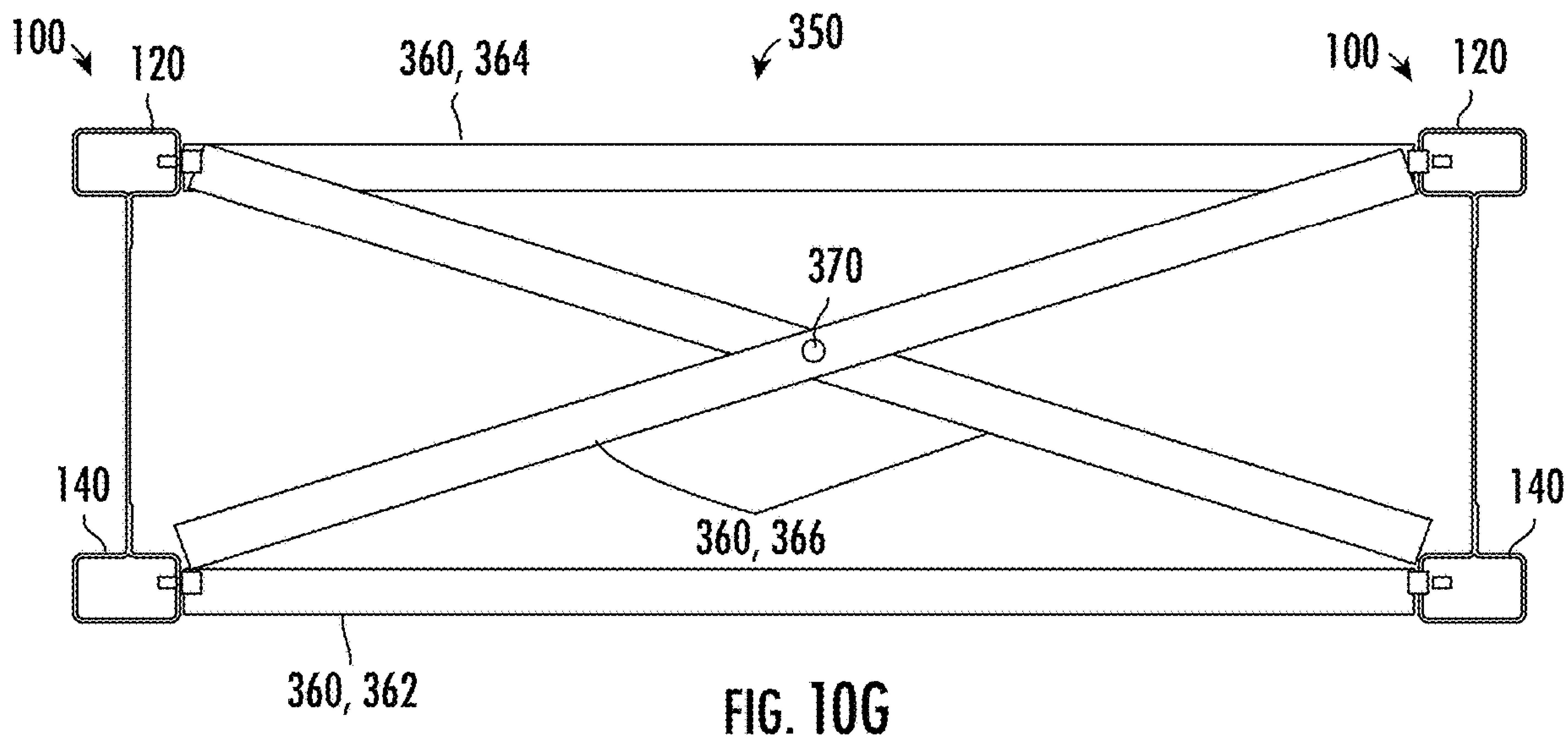

FIG. 10G

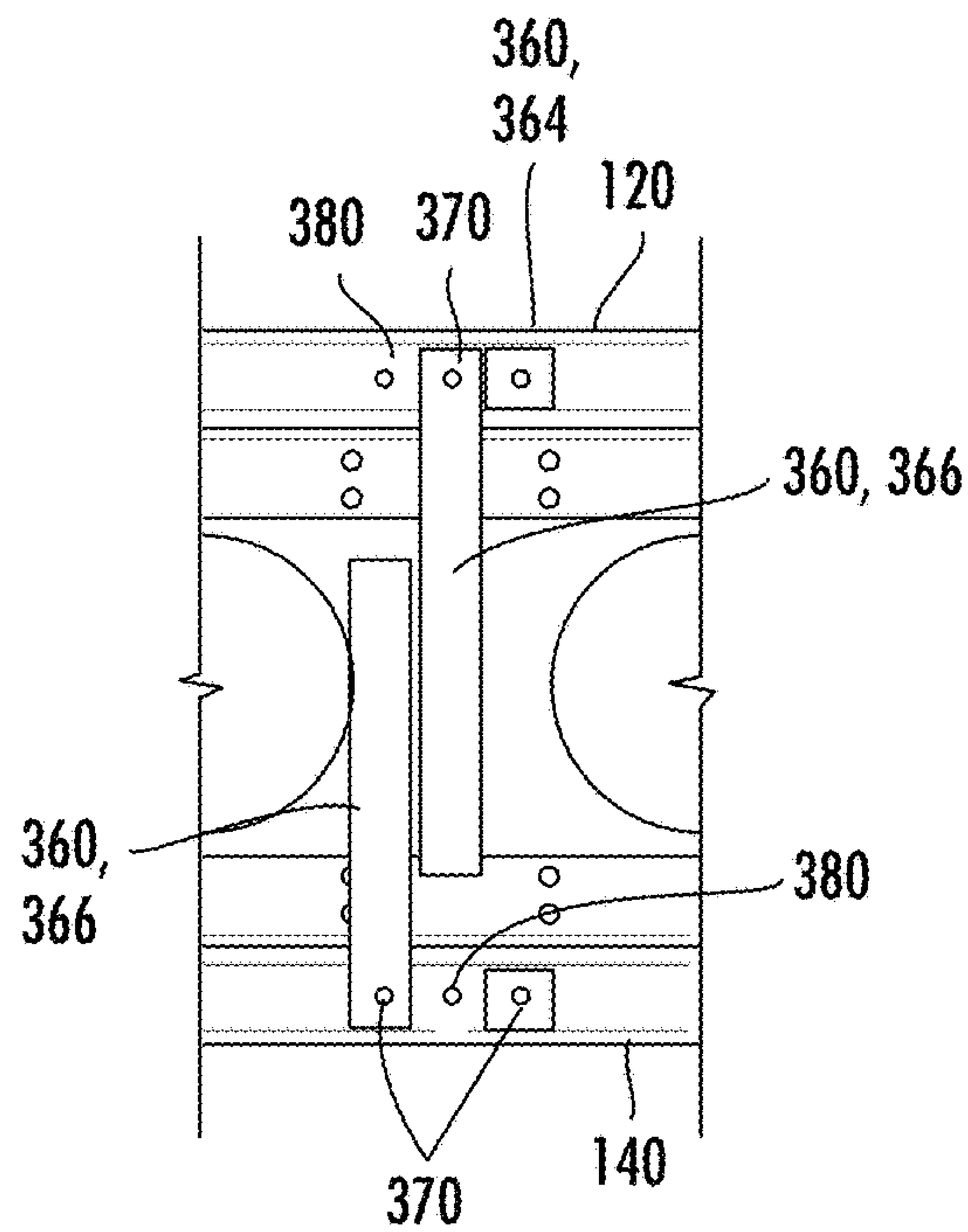

FIG. 10H

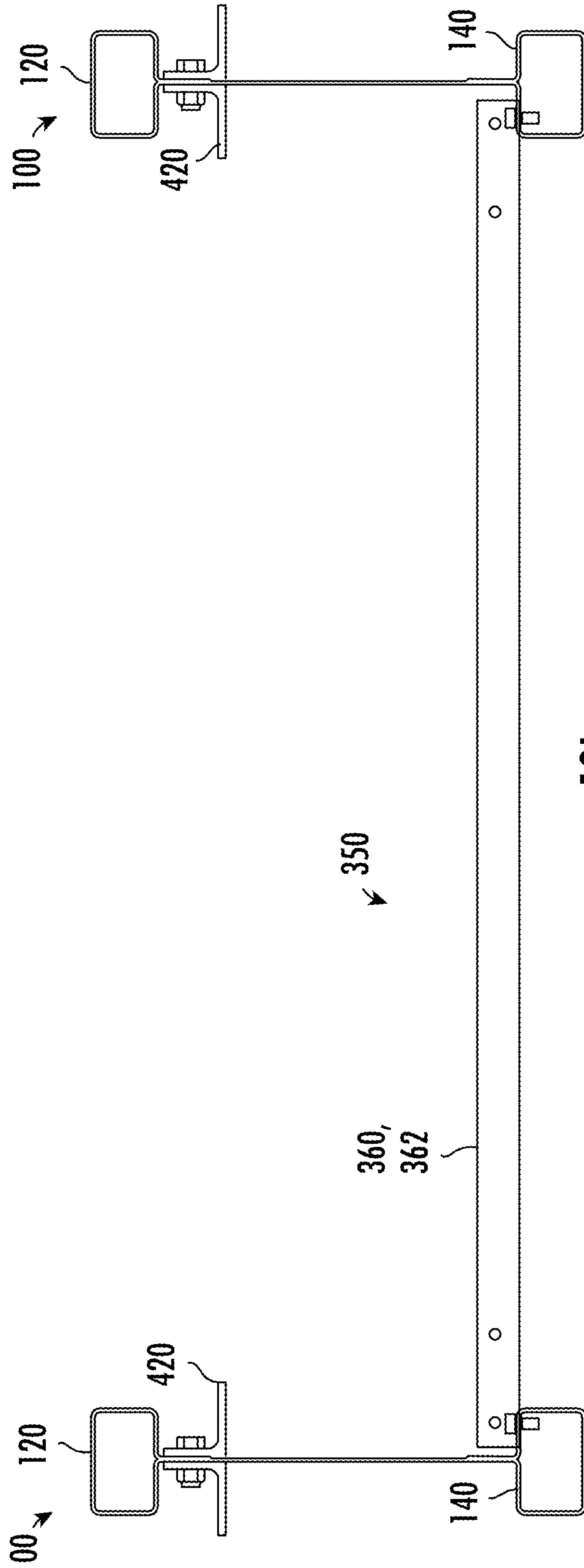

FIG. 10I

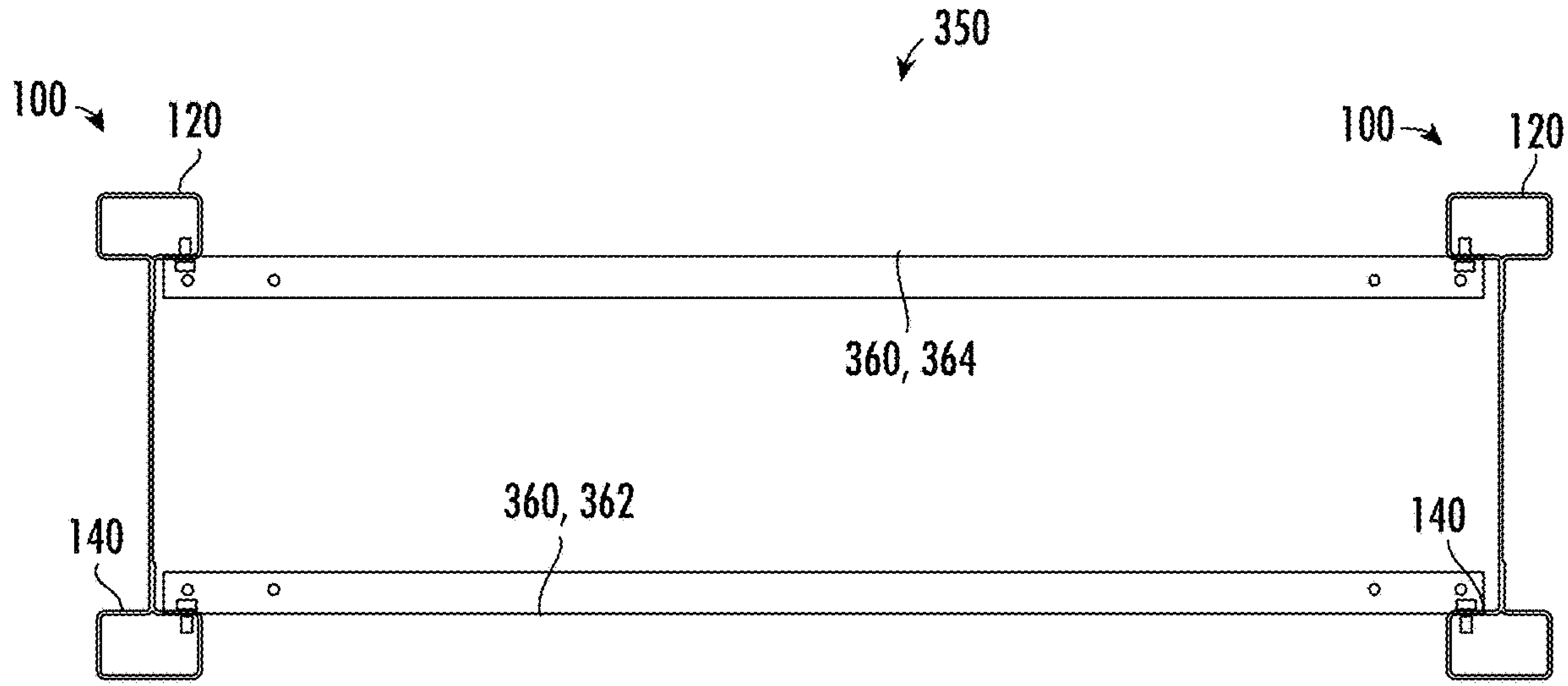

FIG. 10J

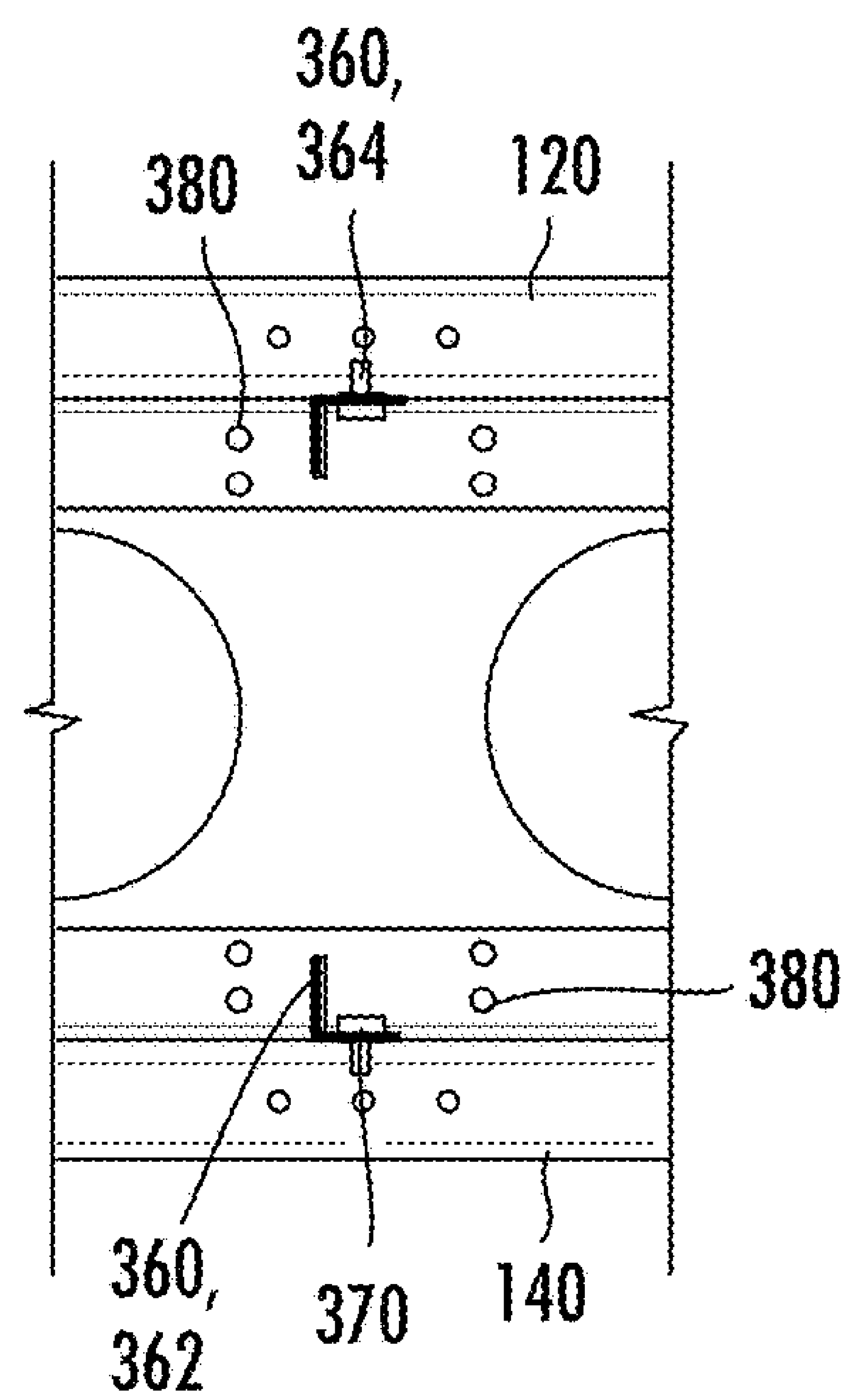

FIG. 10K

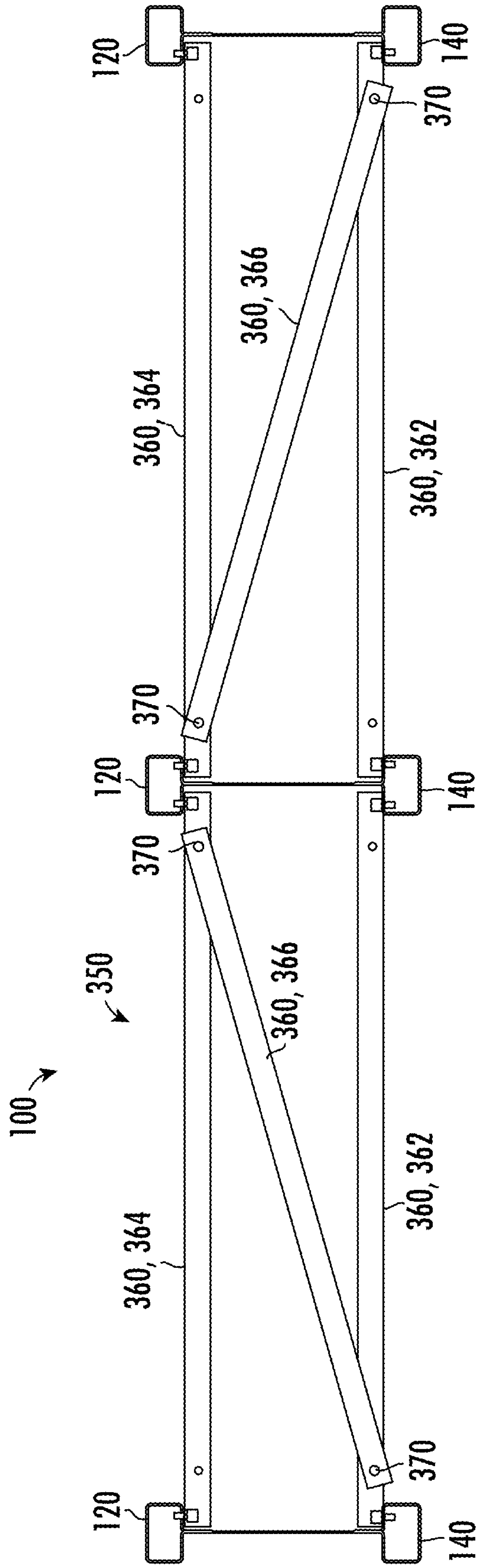
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FIG. 10L

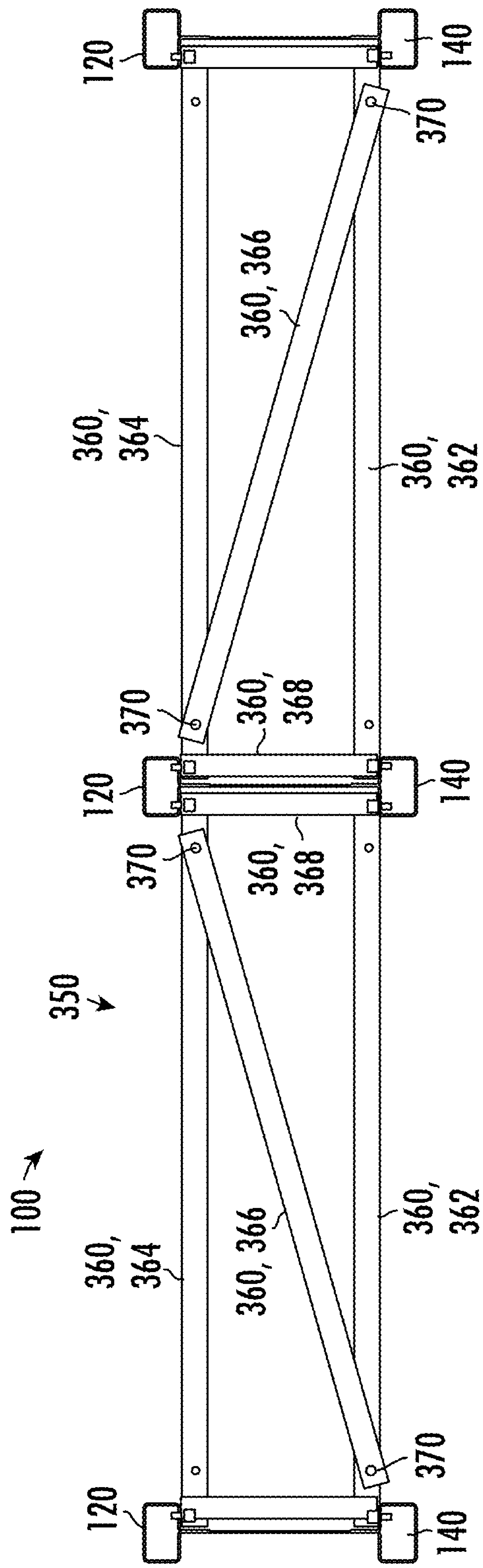
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FIG. 10M

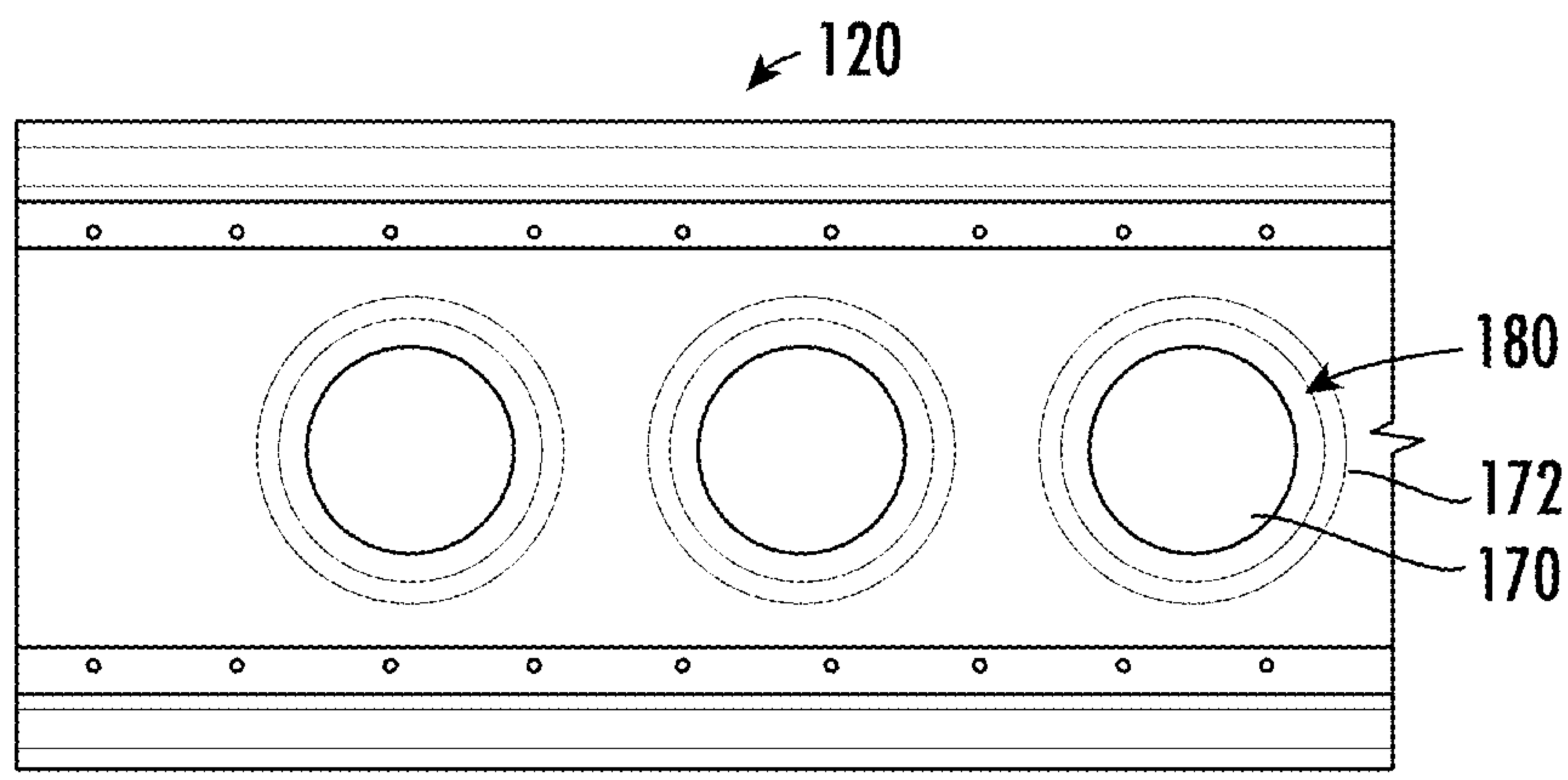

FIG. 11A

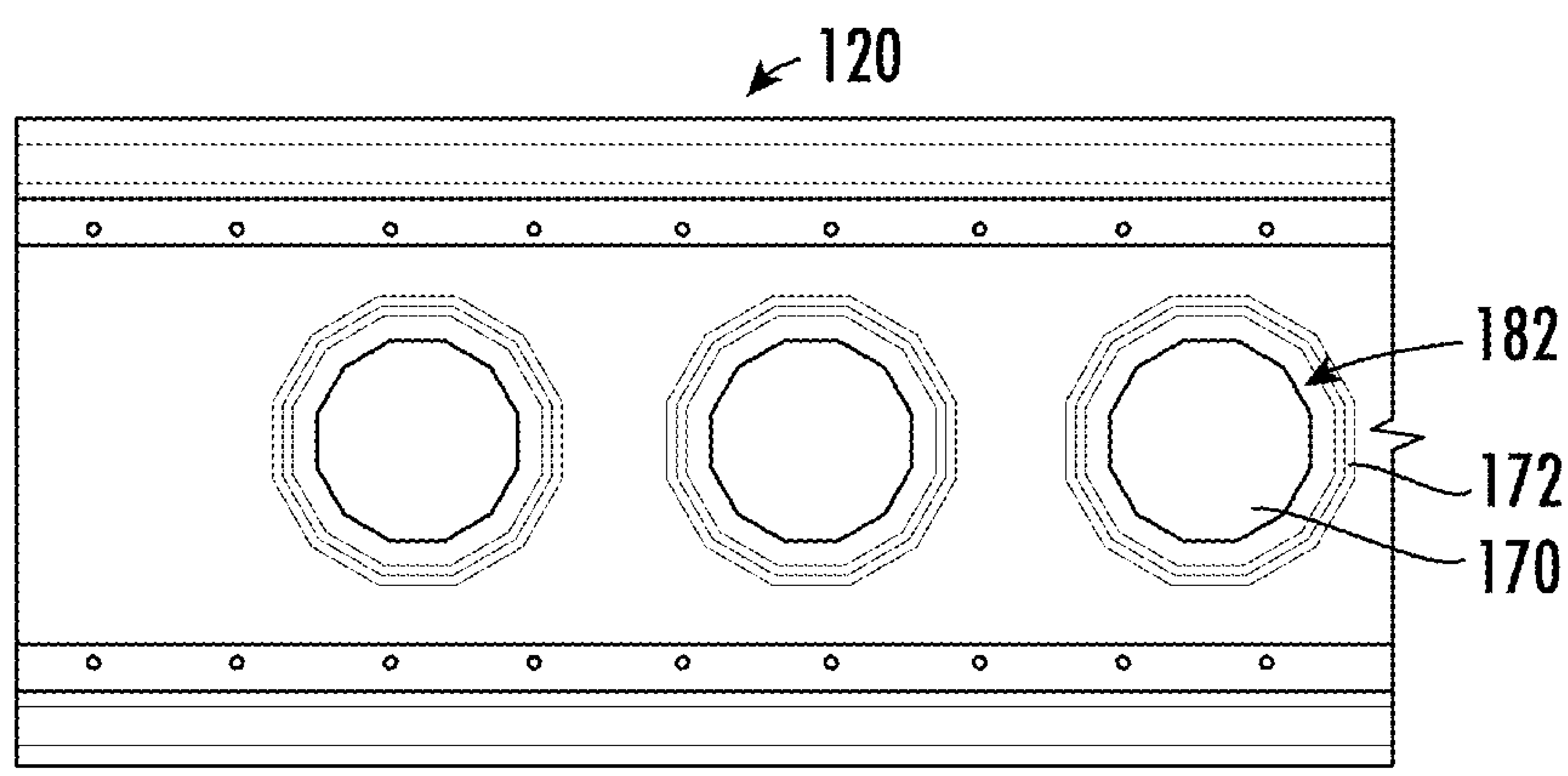

FIG. 11B

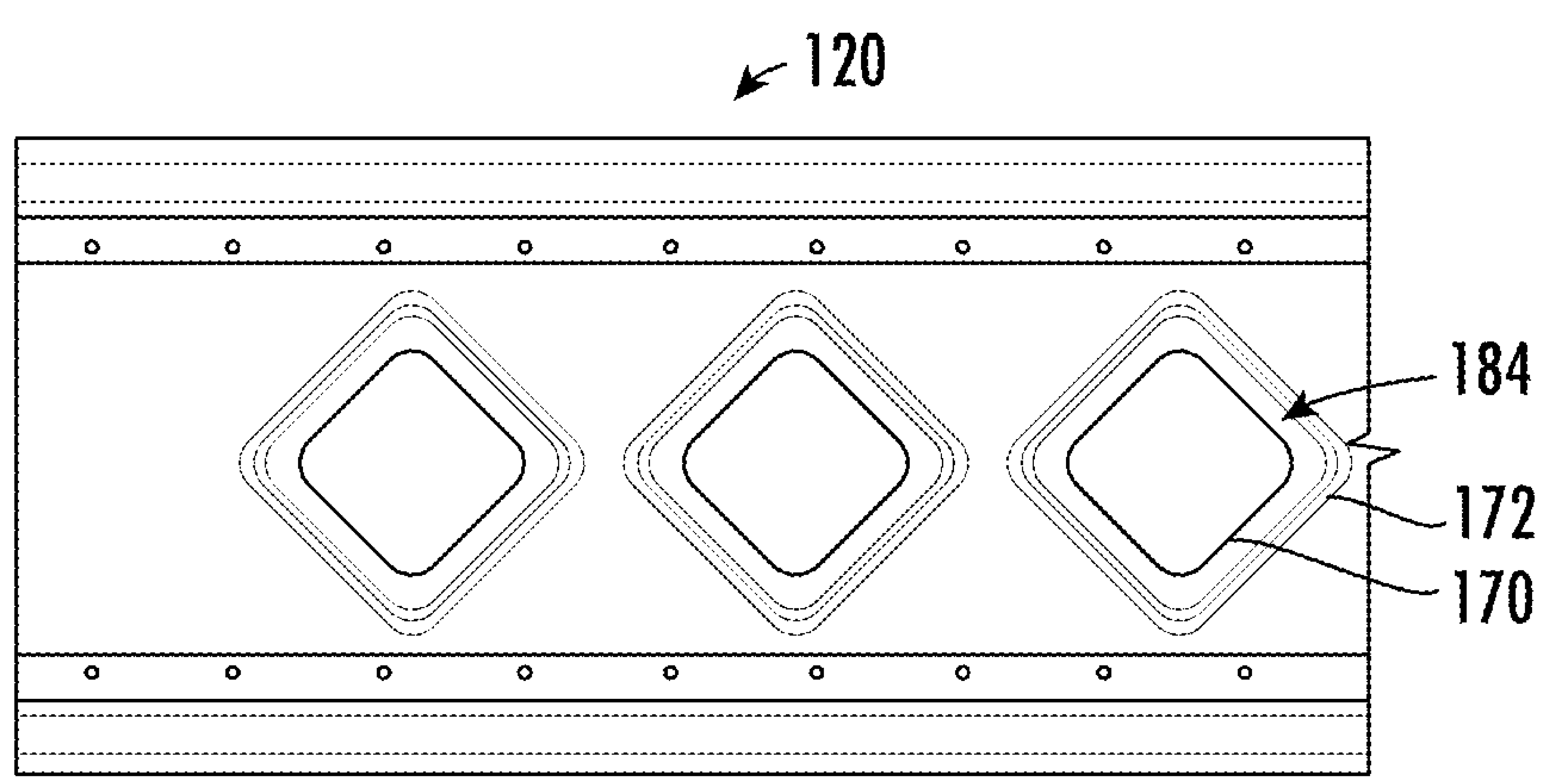

FIG. 11C

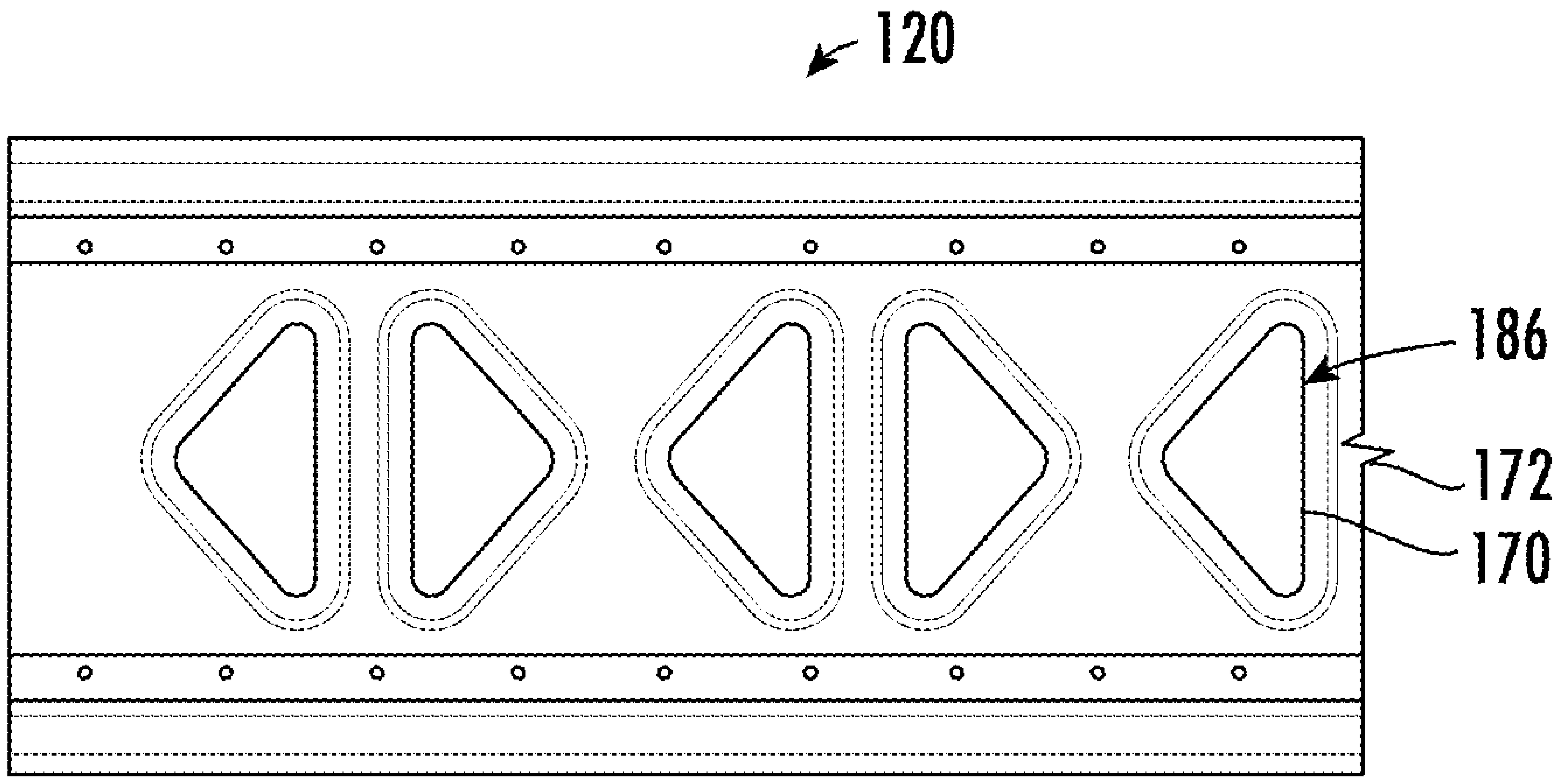

FIG. 11D

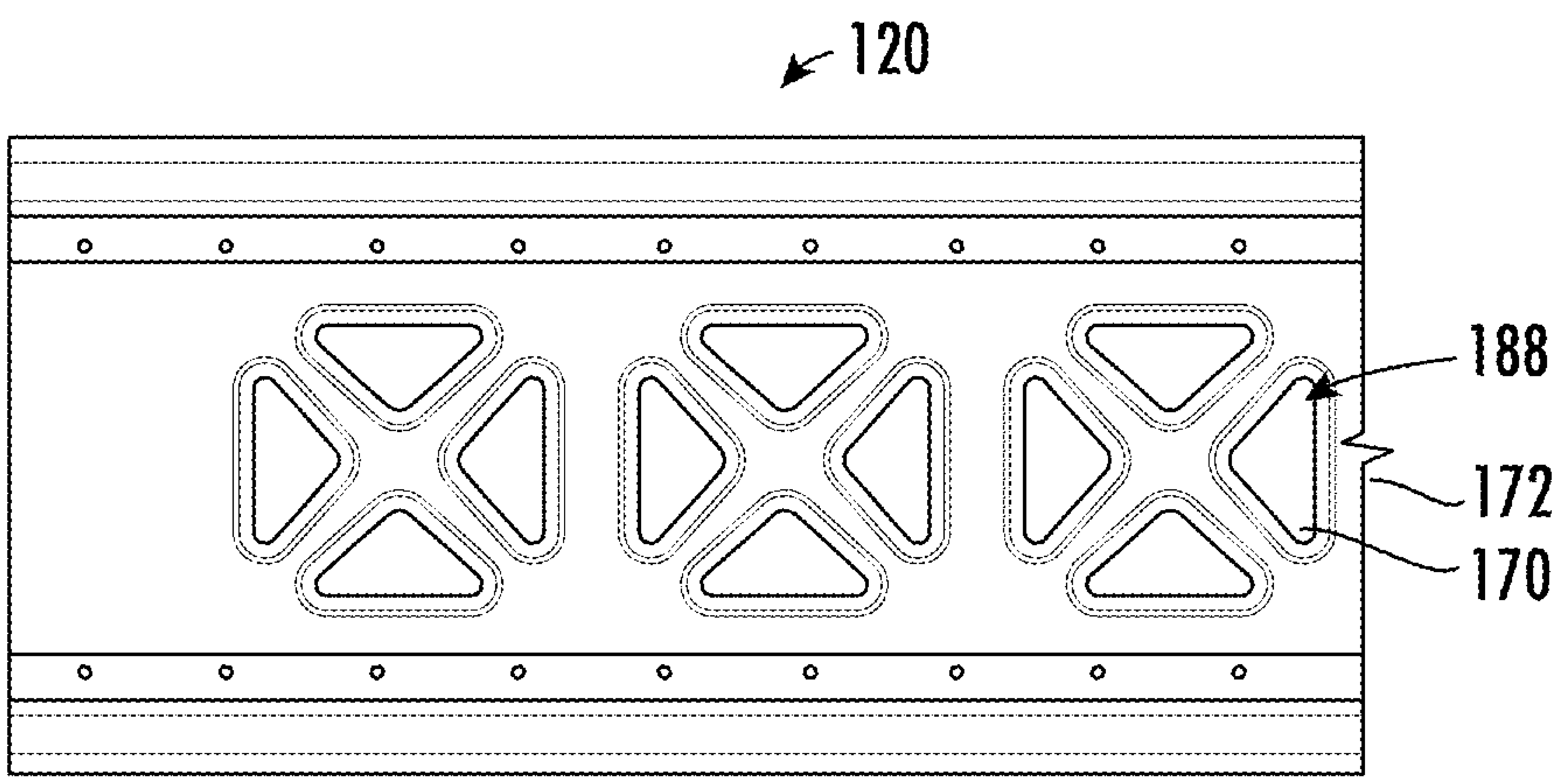

FIG. 11E

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PROCURE A STEEL SHEET (E.G., FROM MANUFACTURING, PURCHASING, OR THE LIKE). THE STEEL SHEET MAY BE PRE-COATED (E.G., GALVANIZED, PAINTED, COATED IN ANOTHER MATERIAL, OR THE LIKE).
510

FORM (E.G., ROLL, OR THE LIKE) THE SHEET INTO AN UPPER MEMBER (E.G., ROLL AN EDGE OF THE SHEET INTO ONE OR MORE UPPER FLANGES TO FORM THE SHAPE OF THE UPPER MEMBER), A LOWER MEMBER (E.G., ROLL AN EDGE OF THE SHEET INTO ONE OR MORE LOWER FLANGES TO FORM THE SHAPE OF THE LOWER MEMBER), ONE OR MORE EXTENSION MEMBERS (E.G., IN THE SAME SHAPE AS THE UPPER MEMBER), AND/OR FORM THE ONE OR MORE WEB FLANGES FROM THE UPPER MEMBER, THE LOWER MEMBER, AND/OR THE EXTENSION MEMBER.
520

FORM THE WEB APERTURES (E.G., HAVING ONE OR MORE SHAPES, IN ONE OR MORE ORIENTATIONS, AND/OR ONE OR MORE EMBOSSMENTS) IN THE WEB OF THE COLD-FORMED BEAM. THE EXTENSION WEB OF THE EXTENSION MEMBER MAY ALSO BE FORMED AT THIS TIME (E.G., COPED PORTION). THE WEB APERTURES AND/OR EXTENSION WEB MAY BE FORMED BY STAMPING THE WEB.
530

FORM THE PLURALITY OF BEAM CONNECTORS, SUCH AS WEB CONNECTORS BETWEEN THE ONE OR MORE WEB FLANGES AND THE WEB OF THE COLD-FORMED BEAM. THE BEAM CONNECTORS MAY INCLUDE WELDS, FASTENERS (E.G., BOTS AND NUTS, SCREWS, SELF-DRILLING SCREWS, OR THE LIKE), METAL DEFORMATION FOR AN INTERFERENCE CONNECTION (E.G., CLINCHING, PUNCHING, SHEARING, OR THE LIKE CONNECTIONS)
540

ASSEMBLING ONE OR MORE STIFFENERS AND/OR ONE OR MORE SUPPORT MEMBER BRACKETS TO THE COLD-FORMED BEAM. FOR EXAMPLE, ASSEMBLING ONE OR MORE STIFFENERS TO THE UPPER MEMBER, THE LOWER MEMBER, THE WEB, OR THE LIKE, SUCH AS ADJACENT THE ENDS OF THE COLD-FORMED BEAM AND/OR BETWEEN THE ENDS OF THE COLD-FORMED BEAM. IN OTHER EXAMPLES, ASSEMBLING ONE OR MORE SUPPORT MEMBER BRACKETS TO THE ONE OR MORE ENDS OF THE COLD-FORMED BEAM AND/OR THE END STIFFENERS.
550

ASSEMBLING ONE OR MORE SUPPORT SEATS (E.G., A SEAT BRACKET FORMED FROM ONE OR MORE SEAT MEMBERS, SUCH AS L-SHAPED SEAT MEMBERS) TO ONE OR MORE ENDS OF THE COLD-FORMED BEAM, SUCH AS THE END STIFFENERS AND/OR THE ONE OR MORE EXTENSION MEMBERS (E.G., UPPER EXTENSION MEMBERS)
560

FIG. 12

COLD FORMED BEAM FOR STRUCTURES AND METHOD OF FORMING THE COLD FORMED BEAM

PRIORITY CLAIM UNDER 35 U.S.C. § 119

[0001] The present Application for a Patent claims priority to U.S. Provisional Patent Application Ser. No. 63/530,552 entitled "Cold Formed Beam for Structures and Method of Forming the Cold Formed Beam", filed on Aug. 3, 2023, both of which are assigned to the assignee hereof and hereby expressly incorporated by reference herein.

FIELD

[0002] This application relates generally to the field of structural support members for use in structures, such as structural decking systems, roof systems, or other like framing systems, and more particularly, to improvements to the structural support members and manufacturing of the structural support members.

BACKGROUND

[0003] Structures (e.g., buildings, warehouses, plants, or the like) are used in commercial, residential, or industrial construction and may use different types of framing. As such, these structures may utilize structural decking systems, roof systems (e.g., standing seam roofs, or the like), or other like systems, such as wooden framing systems (e.g., wooden studs, plywood floors and walls, or the like). Alternatively, or additionally, structures may utilize other materials and/or substrates to form the structures. These structures all utilize structural support members to distribute loading throughout the structure.

[0004] In some embodiments the structures may include structural decking systems that utilize structural decking panels, which may typically be manufactured from steel sheets that may or may not be coiled. In order to increase the structural strength and the stiffness of the individual steel sheets, structural decking panels with longitudinal profiles are formed from the steel sheets via roll forming, break forming, bending, stamping, or other like processes. The structural decking panels are secured to each other in order to form a portion of the structural steel decking system when installed. These structural decking panels may be used as roof decking, floor decking, or wall panels. As such, corrugated structural decking panels may be used in a variety of building applications. The decking panels are connected to the other load resisting support members of a building, such as joists and/or beams, which are in turn connected to other support members, such as girders (e.g., joist girders, beams, or the like), walls, wall panels, columns (e.g., concrete, steel, or the like, or combinations thereof), or the like in order to create the structural decking systems. When the decking panels are connected to each other and the various support members in a secure manner for roof, floor, or wall applications, the assembled structural steel decking system provides considerable diaphragm (or membrane) strength, which is used to transfer horizontal loads to the vertical and lateral load carrying members of the building.

[0005] Additionally, or alternatively, structures that use roof decking (e.g., standing seam roofing, or the like) are typically large area, open floor steel frame buildings. The buildings typically are pre-engineered and are provided as kits of components for use in a wide range of industries, including agricultural, aircraft hangers, garages, riding arenas, indoor sports fields, warehouses, as well as commercial and governmental buildings. Steel buildings may feature open floor space, referred to as bays, and are commonly but not always, built on poured concrete slabs. These buildings may also include load resisting support members (e.g., columns, beams, rafters, purlins, joists, girts, bracing, or the like), as described above. Vertical columns may be operatively coupled to the concrete slabs and extend from the concrete. The vertical columns may be operatively coupled to and support elongated beams or trusses. Long bay support members (e.g., beams, joists, purlins) may be operatively coupled to the beams or trusses in a transverse orientation. A plurality of roof panels may be operatively coupled to the beams, joists, or purlins with clips, such as standing seam clips. Typically, the clips provide a gap between the beams, purlins, or joists and the roof panels. Frequently, the gap is filled with insulation components and/or other building components to reduce heat transfer through the roof panels.

[0006] Additionally, or alternatively, structures may utilize wooden structural framing and/or other materials, such as through the use of podium designs (e.g., concrete podiums, or the like). These types of wooden and/or concreate structures may provide cost savings, speed of installation, wind and seismic loading benefits, thermal benefits, sustainability, and/or other advantages.

[0007] Regardless of the type of structure and framing, all of these structures may utilize structural support members, such as girders, beams, joists, or other like structural support members to distribute the loading through the structure. There is a need for improved structural support members for these structures.

BRIEF SUMMARY

[0008] Various framing systems (e.g., structural or otherwise) often utilize joists (e.g., joists, girder joists, or the like), beams, and/or other structural support members for supporting studs (e.g., metal, wooden, or the like), steel decking panels, wooden panels, or the like. A joist typically comprises an upper chord, a lower chord, and web(s), which operatively couples the upper chord to the lower chord. The opposing ends of the joist (e.g., a proximal end and a distal end) may include a joist seat (otherwise described as a joist shoe). The upper chord, the lower chord, web(s), and joist seat(s) may be made of one or more components that are operatively coupled together and/or may be formed of any type of shape. The upper chord is operatively coupled to the lower chord and/or the joist seat through the use of one or more web members (e.g., single or multiple bars, rolled members, or the like). The upper chord and the lower chord (and the joist seat) may each be formed from L-shaped members (e.g., otherwise described as angle members, or the like), such as a first member operatively coupled to a second member and spaced apart using a spacer. The upper chord may have an upright T-shape formed from the two L-shaped members, while the lower chord may have an upside-down T-shape formed from the two L-shaped members. Other joists may utilize rolled chords (e.g., having u-shapes, w-shapes, or the like shape), which are coupled to each other through one or more web members (e.g., one or more bars, rolled members, or the like) that are welded and/or fastened to the rolled chords. Instead of and/or in combination with the joists, beams (e.g., I-beams, H-beams, castellated beams, or other like beams) may be used as structural support members. The castellated beam may be an I-beam (or H-beam) that is formed, then separated (e.g., longitudinally along the length of the beam) and reassembled using welding such that apertures are located in the center of the beam.

[0009] While traditional joists and/or beams satisfy various needs during construction, there is a need for alternate types of structural support members. The present disclosure relates to an improved structural support member, in the form of a cold formed beam that may be formed from a single sheet of steel (e.g., rolled, bent, cut, pressed, stamped, or the like from a single sheet of steel in the desired profile). In particular embodiments, as will be discussed herein, the cold formed beam may include an upper member and a lower member (e.g., square, rectangular, other shape) separated by a web. The web may include stamped apertures that strengthen the web, reduce weight, and/or allow building components to pass through the stamped apertures. The cold formed beam may include beam connections that operatively couple the ends of the steel sheet used to form the beam to a portion of the beam (e.g., the web). The beam connections may include deformation of the metal layers (e.g., clinching, or the like), such as two or more layers of the sheet together without having to weld the beam. As such, forming the cold formed beam from a single sheet, stamping of the web, and/or using deformation connections (e.g., clinching, or the like) of the ends of the sheet allows for the pre-coating (e.g., galvanized, painting, or the like) of the sheet before the forming (e.g., rolling, or the like), before stamping, and/or before installing the beam connectors. As will be described in further detail herein, the structure of the cold formed beam of the present disclosure reduces the weight, increases the speed of manufacture, reduces the need for bridging (e.g., between traditional support members), reduces the time to install, improves installation of the decking to the cold formed beam, and/or improves assembly of other building components to the cold formed beam.

[0010] One embodiment of the present disclosure is a cold-formed beam comprising an upper member, a lower member, and a web between the upper member and the lower member. The upper member, the lower member, and the web are formed from forming a sheet.

[0011] In further accord with embodiments, the sheet is a single sheet that is rolled to form the upper member, the lower member, and the web.

[0012] In other embodiments, the upper member comprises an upper web flange that extends over at least a portion of the web.

[0013] In still other embodiments, the lower member comprises a lower web flange that extends over at least a portion of the web.

[0014] In yet other embodiments, the upper web flange is operatively coupled to the web and the lower web flange is operatively coupled to the web through the use of a plurality of beam connectors.

[0015] In other embodiments, the plurality of beam connectors comprise an interference connector formed by deforming a portion of the upper web flange and the web, and a portion of the lower web flange and the web.

[0016] In further accord with embodiments, the plurality of beam connectors comprise welding the upper web flange to the web and the lower web flange to the web, or assembling fasteners through the upper web flange and the web and the lower web flange and the web.

[0017] In other embodiments, the plurality of beam connectors are formed between a range of 2 inches to 24 inches along the length of the beam.

[0018] In still other embodiments, the upper member or the lower member comprises a square member or a rectangular member.

[0019] In yet other embodiments, the square member or the rectangular member comprises a first flange extending from the web, a second flange extending from the first flange, a third flange extending from the second flange, and a fourth flange extending from the third flange. Moreover, a web flange extends from the fourth flange over at least a portion of the web.

[0020] In other embodiments, the web comprises a plurality of stamped apertures extending through the web.

[0021] In further accord with embodiments, the plurality of stamped apertures comprise circular apertures.

[0022] In other embodiments, the plurality of stamped apertures comprise triangular apertures, square, or diamond apertures.

[0023] In still other embodiments, the plurality of stamped aperture comprise polygonal apertures.

[0024] In yet other embodiments, at least a portion of the web around the plurality of stamped apertures comprise at least one embossment.

[0025] In other embodiments, the upper member comprises and upper extension member on at least one end, wherein the upper extension member extends past the web.

[0026] In other embodiments, the beam further comprises at least one seat support operatively coupled to the at least one upper extension member.

[0027] Another embodiment of the present disclosure is a structural system comprising a plurality of support members and a plurality of cold formed beams. The plurality of cold-formed beams comprise an upper member, a lower member, and a web between the upper member and the lower member. The upper member, the lower member, and the web are formed from forming a sheet. The ends of the plurality of cold formed beams are operatively coupled to two of the plurality of support members.

[0028] In further accord with embodiments, the sheet is a single sheet that is rolled to form the upper member, the lower member, and the web.

[0029] Another embodiments of the present disclosure is method of forming a cold formed beam. The method comprises rolling a steel sheet to form an upper member, a lower member, and a web between the upper member and the lower member. The method further comprises stamping the web to form a plurality of apertures in the web. Moreover, the method comprises forming a plurality of beam connectors between an upper flange and the web and a lower flange and the web.

[0030] To the accomplishment of the foregoing and the related ends, the one or more embodiments of the invention comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth certain illustrative features of the one or more embodiments. These features are indicative, however, of but a few of the various ways in which the principles of various embodiments may be employed, and this description is intended to include all such embodiments and their equivalents.

BRIEF DESCRIPTION OF DRAWINGS

[0031] The accompanying drawings illustrate some of the embodiments of the invention and are not necessarily drawn to scale, wherein:

[0032] FIG. **1**A illustrates a perspective view of a structural decking system utilizing a cold formed beam, in accordance with embodiments of the present disclosure;

[0033] FIG. **1**B illustrates a perspective view of a portion of a structural decking system that may utilize the cold formed beam, in accordance with embodiments of the present disclosure;

[0034] FIG. **1**C illustrates a side view of a portion of a roof system that may utilize the cold formed beam, in accordance with embodiments of the present disclosure;

[0035] FIG. **1**D illustrates a perspective view of a portion of roof system that may utilize the cold formed beam, in accordance with embodiments of the present disclosure;

[0036] FIG. **2**A illustrates a perspective view of a cold formed beam having square shaped upper and lower members, in accordance with embodiments of the present disclosure;

[0037] FIG. **2**B illustrates an enlarged perspective view of an end of the cold formed beam of FIG. **2**A, in accordance with embodiments of the present disclosure;

[0038] FIG. **2**C illustrates an end view of the cold formed beam of FIG. **2**A, in accordance with embodiments of the present disclosure;

[0039] FIG. **3**A illustrates a perspective view of a cold formed beam having rectangular shaped upper and lower members, in accordance with embodiments of the present disclosure;

[0040] FIG. **3**B illustrates an end view of the cold formed beam of FIG. **3**A, in accordance with embodiments of the present disclosure;

[0041] FIG. **4**A illustrates a perspective view of a cold formed beam having rectangular shaped upper and lower members with a rib, in accordance with embodiments of the present disclosure;

[0042] FIG. **4**B illustrates an end view of the cold formed beam of FIG. **4**B, in accordance with embodiments of the present disclosure;

[0043] FIG. **4**C illustrates a perspective view of a cold formed beam having rectangular shaped upper and lower members with multiple ribs, in accordance with embodiments of the present disclosure;

[0044] FIG. **4**D illustrates an end view of the cold formed beam of FIG. **4**C, in accordance with embodiments of the present disclosure;

[0045] FIG. **5**A illustrates a side view of an end a cold formed beam, in accordance with embodiments of the present disclosure;

[0046] FIG. **5**B illustrates an end view of the cold formed beam of FIG. **5**A, in accordance with embodiments of the present disclosure;

[0047] FIG. **5**C illustrates a cross-sectional view of the cold formed beam of FIG. **5**B, in accordance with embodiments of the present disclosure;

[0048] FIG. **6**A illustrates a side view of an end a cold formed beam operatively coupled to a girder support member, in accordance with embodiments of the present disclosure;

[0049] FIG. **6**B illustrates a side view of two ends cold formed beams operatively coupled to a girder support member, in accordance with embodiments of the present disclosure;

[0050] FIG. **6**C illustrates a side view of an end of a cold formed beam operatively coupled to a support member, in accordance with embodiments of the present disclosure;

[0051] FIG. **7**A illustrates a perspective view of a cold formed beam with extension members extending from the upper member and bearing seats attached to the extension members, in accordance with embodiments of the present disclosure;

[0052] FIG. **7**B illustrates a side view and a partial enlarged view of the cold formed beam of FIG. **7**A, in accordance with embodiments of the present disclosure;

[0053] FIG. **7**C illustrates an end view of the cold formed beam of FIG. **7**A, in accordance with embodiments of the present disclosure;

[0054] FIG. **7**D illustrates a perspective view of a cold formed beam with extended extension members extending from the upper member and a coped end with a bearing seat attached to the extension members, in accordance with embodiments of the present disclosure;

[0055] FIG. **7**E illustrates a side view of the cold formed beam of FIG. **7**D, in accordance with embodiments of the present disclosure;

[0056] FIG. **7**F illustrates an end view of the cold formed beam of FIG. **7**D, in accordance with embodiments of the present disclosure;

[0057] FIG. **8**A illustrates a perspective view of a cold formed beam with beam connectors, in accordance with embodiments of the present disclosure;

[0058] FIG. **8**B illustrates an end view of a cold formed beam with beam connectors, in accordance with embodiments of the present disclosure;

[0059] FIG. **9**A illustrates a cross-sectional view of dies and layered sheets of a cold formed beam for forming a clinching beam connection in the cold formed beam, in accordance with embodiments of the present disclosure;

[0060] FIG. **9**B illustrates a cross-sectional view of a first die forming the clinching beam connection in layered sheets of the cold formed beam, in accordance with embodiments of the present disclosure;

[0061] FIG. **9**C further illustrates a cross-sectional view of a second rotating die for forming the clinching beam connection in layered sheets of the cold formed beam, in accordance with embodiments of the present disclosure;

[0062] FIG. **9**D further illustrates a cross-sectional view of the first die retracting from the clinching beam connection in the cold formed beam, in accordance with embodiments of the present disclosure;

[0063] FIG. **9**E further illustrates a cross-sectional view of the cold formed beam and/or the dies moving to a different location of the cold formed beam to form another clinching beam connection, in accordance with embodiments of the present disclosure;

[0064] FIG. **10**A illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0065] FIG. **10**B illustrates a side view of the cold formed beam with cross-bracing of FIG. **10**A, in accordance with embodiments of the present disclosure;

[0066] FIG. **10**C illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0067] FIG. **10**D illustrates a side view of the cold formed beam with cross-bracing of FIG. **10**C, in accordance with embodiments of the present disclosure;

[0068] FIG. **10**E illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0069] FIG. **10**F illustrates a side view of the cold formed beam with cross-bracing of FIG. **10**E, in accordance with embodiments of the present disclosure;

[0070] FIG. **10**G illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0071] FIG. **10**H illustrates a side view of the cold formed beam with cross-bracing of FIG. **10**G, in accordance with embodiments of the present disclosure;

[0072] FIG. **10**I illustrates an end view of cold formed beams with cross-bracing and bearing seats, in accordance with embodiments of the present disclosure;

[0073] FIG. **10**J illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0074] FIG. **10**K illustrates a side view of the cold formed beam with cross-bracing of FIG. **10**J, in accordance with embodiments of the present disclosure;

[0075] FIG. **10**L illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0076] FIG. **10**M illustrates an end view of cold formed beams with cross-bracing, in accordance with embodiments of the present disclosure;

[0077] FIG. **11**A illustrates a side view of an end a cold formed beam having a web with circular stamped apertures, in accordance with embodiments of the present disclosure;

[0078] FIG. **11**B illustrates a side view of an end a cold formed beam having a web with polygonal stamped apertures, in accordance with embodiments of the present disclosure;

[0079] FIG. **11**C illustrates a side view of an end a cold formed beam having a web with square stamped apertures, in accordance with embodiments of the present disclosure;

[0080] FIG. **11**D illustrates a side view of an end a cold formed beam having a web with triangular stamped apertures in a back-to-back configuration, in accordance with embodiments of the present disclosure;

[0081] FIG. **11**E illustrates a side view of an end a cold formed beam having a web with triangular stamped apertures in a clover configuration, in accordance with embodiments of the present disclosure; and

[0082] FIG. **12** illustrates a method of forming a cold-formed beam with stamped apertures, in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0083] Embodiments of the present invention now may be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure may satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0084] The present disclosure relates to an improved structural support member in the form of a cold formed-beam **100** that may be formed from a single sheet of steel (e.g., rolled from a single sheet of steel in the desired profile, or the like). In particular embodiments, as will be discussed herein, the cold formed beam **100** may include an upper member **120** and a lower member **140** (e.g., square, rectangular, other shape) separated by a web **160**. The upper member **120** and the lower member **140** may otherwise be described as an upper chord **120** and a lower chord **140**. The web **160** may include stamped web apertures **170** (otherwise described as punched, pressed, sheared, or the like apertures) that strengthen the web **160**, reduce weight, and/or allow building components to pass through the web apertures **170**. The cold formed beam **100** may include beam connectors **190** (otherwise described as beam connections) that operatively couple the ends of the sheet to a portion of the beam **100** (e.g., a portion of the web **160**, a portion of the upper member **120**, and/or the lower member **140**). The beam connectors **190** may include interference connectors **192** (otherwise described as interference connections) formed by deforming two or more metal layers (e.g., clinching connections, punched, pressed, sheared, or the like connections) in which two or more layers of the sheet within the cold formed beam **100** are deformed together such that welding is not required. As such, the stamping of the web **160** to form the web apertures **170** and/or the deformed metal connections of the ends of the sheet that form the cold formed beam **100** allows for the pre-coating (e.g., galvanized, painting, or the like) of the sheet before forming (e.g., cold rolling, bending, stamping, or the like) and/or before installing the beam connectors **190**. As will be described in further detail herein, the structure of the cold formed beam **100** of the present disclosure reduces the weight, increases the speed of manufacture, reduces the need for bridging (e.g., when compared to traditional structural support members, such as joists, or the like), reduces the time to install, improves installation of the decking (e.g., otherwise described as panels, decking panels, or the like) to the cold formed beam **100**, and/or improves assembly of other building components.

[0085] As illustrated in FIGS. **1**A and **1**B, the cold formed beam **100** may be utilized in structural decking systems **1** (otherwise described as structural panel systems, structural decking panel systems, or the like). The structural decking system **1** of FIG. **1**A comprises vertical support members **2** (e.g., steel beams, concrete columns, structural walls, concrete walls, other support members). In some embodiments, girder support members **4** (e.g., joist girders, or the like) may be operatively coupled between the vertical support members **2**. The cold-formed beam **100** of the present disclose may be operatively coupled between the support members (e.g., vertical support members **2**, girder support members **4**, or the like). Thereafter, decking panels **70** are operatively coupled to the cold-formed beams **100**, as will be described in further detail herein.

[0086] As illustrated in FIG. **1**B, the decking panels **70** of the structural decking system **1** may be operatively coupled to the cold-formed beams **100** through the use of one or more decking connectors **90**. It should be understood that the structural decking panels **70** may have profiles that include top flanges **74** (otherwise described as peaks, upper flanges, outer flanges, or the like), bottom flanges **76** (otherwise described as troughs, lower flanges, inner flanges, or the like), and panel webs **78** (e.g., the portions of the panel that are sloped, perpendicular, or generally perpendicular with the flanges **74**, **76**) that operatively couple the top flanges **74** to the bottom flanges **76**. The combination of top and bottom flanges **74**, **76**, and the panel webs **78** create a flute for the decking panels **2** that may be described as profiles. The profiles may be referred to as "fluted profiles," "hat profiles", "flat-bottomed profiles", "triangular profiles," "trapezoidal profiles," "dovetail profiles," or other like profiles depending on the shape of the profiles. The distance from the top of the top flange **74** and the bottom of the bottom flange **76** may generally range from a ½ inch to 3, 3½, 4, 4½, 5, 5½, or the like inches in depth; however, other ranges of depths within these ranges, overlapping these ranges, or outside of these ranges may be used in the profiles. For example, in some embodiments the distance may range from ½ inch to 12 inches in depth, or the like. The decking panels **70** may or may not include longitudinal ribs, bends, or cutouts that impact the moment of inertia and section modulus of the decking panels **70** (e.g., profile dimensions, ribs, cutouts, or the like that are used to target different performance characteristics, such as but not limited to strength and/or stiffness). Depending on the material thickness, the length and width of the decking panels **70**, and the height of the top flanges **74** and bottom flanges **76**, the decking panels **70** may weigh between 100 and 420 lbs. In other embodiments, the weight of the decking panels **70** may be within, overlap, or be located outside of this range. Each decking panel **70** may be formed (e.g., roll-formed, or the like) into the desired profile.

[0087] Decking edges **79** (e.g., the opposite longer sides of the structural decking panel **70**) may be formed into lips that couple a first decking panel **70** to an adjacent second decking panel **70**. The lips on opposite edges **79** of a decking panel **70** may create sidelaps between the decking panels **70**. The sidelaps may be overlapping in-plane sidelaps, out of plane sidelap seams (e.g., male and female standing lips that create a standing sidelap seam), in-plane nested sidelaps, or the like. The sidelaps may have two, three, four, or more layers, or the like. Decking connectors **90** (connectors may also be described herein as joints, connections, attachments, couplings, or the like) may be formed in the sidelap of the structural decking panels **70** to couple adjacent decking panels **70** to each other. The decking connectors **90** may be fasteners (e.g., bolts, rivets, screws, or the like), welds (e.g., top sidelap welds, side sidelap welds, or the like), interference connections (e.g., clenched cut, sheared, punched, deformed, or the like) in which two of the layers of the edges **79** of adjacent decking panels **70** are deformed, or the like as discussed herein.

[0088] In order to couple two adjacent structural decking panels **70** together, a first edge **79** of a first structural decking panel **70** may receive a second edge **79** of a second structural decking panel **70**. The first edge **79** may be placed over the second edge **79** to create an un-joined sidelap along the length of adjacent structural decking panel edges **79**. The purpose of the sidelap formed after using the connector **90** (e.g., utilizing a fastener, interference clench connection, weld, or the like) is to couple two adjacent structural decking panels **70** securely to each other in order to prevent one decking panel **70** from separating transversely from another decking panel **70** (e.g., lifting vertically off another panel in a horizontal roof or floor installation), preventing in-plane movement (e.g., shifting of the panels **70** along the sidelap) between the adjacent structural panels **70**, and providing the desired shear strength of the structural decking system **1**.

[0089] The structural decking panels **70** may be secured to the cold-formed beams **100**, after the decking panels **70** have been placed over the cold-formed beams **100**, through one or more connectors **90** as previously discussed herein. In some embodiments, it should be understood that connectors **90** may be one or more fasteners (e.g., bolts, rivets, screws, stand-off fasteners, anchors, or the like) that operatively couple the decking **70** to the upper member **120** of the cold formed beams **100** (e.g., upper member connectors). For example, a fastener may extend through the decking **70** (e.g., bottom flange **76** of the decking) and to the upper member **120** of the cold formed beam **100**. Concreate **98** may be placed over the decking panels **70** to create a floor or roof.

[0090] FIGS. **1**C and **1**D illustrate another type of decking system, such as a roof decking system **10** (e.g., standing seam roof systems, or the like). Roof decking systems **10** may be utilized in new construction and/or as retrofitting on current roofs of structures (e.g., buildings, or the like). The roof systems **10** may utilize decking panels **70** that are operatively coupled to beams, such as the cold formed beam **100** described herein, or to purlins that are operatively coupled to beams. The beams may be operatively coupled to beam girders **4**, or directly to vertical support members **2**. The decking panels **70** are typically operatively coupled to the support members (e.g., beams, or the like) through the use of seam clips **30**, as illustrated in Figure **1**C, or through seam clips **30** and a bridge member **40**, as illustrated in FIG. **1**D.

[0091] The seam clips **30** may be installed to the support member (e.g., purlin **6**, cold formed beam **100**, or the like) directly, or through the use of another member **40** (e.g., a bridge member, or other member). The seam clips **30** may comprise a base clip portion and a connector clip portion. The base clip portion and the connector clip portion may move with respect to each other in order to allow the connector clip portion to move with the decking panels **70** as the base clip portion stays static with the support members. As such, the seam clips **30** allow the roof panels to move due to thermal expansion and contraction. The decking panels **70** of the roof systems **10** may be thinner and/or have different profiles than the structural decking panels **70** described with respect to the structural decking systems **1** of FIGS. **1**A and **1**B. In the roof systems **10**, the decking panel edges **79** may be operatively coupled to each other by placing a portion of a folded edge of one panel under an edge of the panel clips **30**, and by placing a folded edge of an adjacent panel over the clip **30** and/or by placing a folded portion of the edge of one panel over the edge of another panel where the clips **30** are not located. Then the edges of the panels **70** and/or the clips **30** (e.g., edge of connector clip portion) where the clips **30** are located are seamed together. The seeming of the edges of the panels **70** (including the clips **30**) may create a watertight seam (or water-resistant seam) in order to resist the flow of water between panels **70**. As such, in some embodiments, portions of the edges **79** of the panels **70** and/or the clips **30** (e.g., connector clip portion edges) are further folded, bent, and/or sheared (e.g., cut, or the like) together in order to operatively couple the panels **70** and the clips **30** to each other. In other embodiments, other connectors may be utilized to operatively couple the adjacent panels edges **79** to each other and/or to the clips **30**. In some embodiments, the seam clips **30** and/or the bridging members **50** may provide space for insulation **50** for the roof systems **10**.

[0092] Alternatively, or additionally, structures may utilize other framing systems (not illustrated), that may utilize wood or other materials for distributing loads throughout the structure. Regardless of the type of structure (e.g., structural decking systems, roof deck systems, standing seam roofing, wooden framing systems, or the like), these structures utilize conventional joists (e.g., chords and/or open webs) and/or beams (e.g., beams that are formed from separate members, such as upper members, lower members, and webs that are formed separately, or from I-beams or H-beams that are spliced and rejoined, machined, or the like to form a beam with apertures therein). Unlike conventional structural support members, the structural support members of present disclosure, as will be described herein, may be formed from a single sheet of steel (e.g., roll forming, or the like) and the edges of the steel sheet are operatively coupled using beam connectors **190**, as will be described in further detail herein. Moreover, web apertures **170** are stamped into the webs **160** of the cold formed beams **100** to reduce the weight, provide additional structural strength, and/or allow for building components (e.g., HVAC ducts, pipes, electrical wiring, networking wires, or the like) to extend through the apertures **170**.

[0093] FIGS. **2**A through **4**D illustrate embodiments of the cold formed beam **100** of the of the present disclosure. As illustrated, the cold formed beam **100** may comprise an upper member **120**, a lower member **140**, and a web **160** formed between the upper member **120** and the lower member **140**. As previously described herein, the upper member **120**, the lower member **140** and the web **160** may be formed by rolling a single sheet of steel into the cold formed beam **100**. For example, a first portion of the steel sheet adjacent a first edge of the steel sheet may become the upper member **120**, while a second portion of the steel sheet adjacent a second edge of the steel sheet may become the second member **140**. Moreover, a central portion of the steel sheet may become the web **160** of the cold formed beam **100**. The cold formed beam **100** may have a first end **102** and a second send **104**, which are used to operatively couple the cold formed beam **100** to other structural support members. In some embodiments, as will be described in further detail herein, the first end **102** and/or second end **104** of the cold formed beam **100** may have stiffeners **200**, brackets **250**, an attachment assembly **40**, and/or the like for operatively coupling with other structural support members.

[0094] The cold formed beam **100** may have a length of 20, 25, 30, 35, 40, 45, 50, 55, 60, or the like feet. Generally, the cold formed beam **100** may range from 30 to 45 feet in length; however, it should be understood that the length of the cold-formed beam **100** may be less than or greater than the values described above, and as such may range in a length that overlaps, falls between, or falls outside of any of the values described above. Furthermore, the depth (or height) of the cold-formed beam **100** may be 10, 12, 14, 15, 16, 18, 20, 22, 24, 25, 26, 28, 30, 32, 34, 35, 36, 38, 40, or the like inches. Generally, the cold-formed beam **100** may have a depth that ranges from 20 to 30 inches; however, it should be understood that the depth of the cold-formed beam **100** may be less than or greater than the values described above, and as such may have a depth that overlaps, falls between, or falls outside of any of the values described above.

[0095] In particular embodiments, the cold formed beam **100** may be formed from a single sheet coil that ranges between 36 to 60 inches wide and/or has an average thickness of 0.089, 0.099, 0.105, 0.120, 0.125, or the like inches. Moreover, the steel sheet used to form the cold formed beam **100**, and thus a single layer of the cold formed beam **100**, may have a thickness of 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19, 0.20, or the like inches. Generally, the sheet used to form the cold-formed beam **100**, and thus a single layer of the cold formed beam **100**, may have a thickness that ranges from 0.06 to 0.125 inches; however, it should be understood that the thickness of a single layer of the cold-formed beam **100** may be less than or greater than the values described above, and as such may range in a thickness that overlaps, falls between, or falls outside of any of the values described above. Moreover, portions of the beam **100**, such as at the locations of the beam connectors **190**, may be formed of two or more layers of the steel sheet, and thus, may comprise two or more layers of the steel sheet, and thus, may have a thickness that is two or more times the thickness of the steel sheet.

[0096] As illustrated in FIGS. **2**C, **3**B, **4**B, and **4**D, the upper member **120** may be formed from a first upper flange **122** extending from the web **160** (e.g., generally perpendicular to the web **160**); a second upper flange **123** extending from the first upper flange **122** (e.g., generally perpendicular to the first upper flange **122** and/or parallel with the web **160**); a third upper flange **124** extending from the second upper flange **123** (e.g., generally perpendicular to the second upper flange **123** and/or the web **160**); a fourth upper flange **125** extending from the third upper flange **124** (e.g., generally perpendicular to the third upper flange **124** and/or parallel with the web **160**); a fifth upper flange **126** extending from the fourth upper flange **125** (e.g., generally perpendicular to the fourth upper flange **125** and/or the web **160**); and an upper web flange **128** extending from the fifth upper flange **126** (e.g., generally perpendicular to the fifth upper flange **126** and/or parallel with the web **160**). As such, the upper member **120** may comprise of a square and/or rectangular shaped member that is formed from a first portion of the steel sheet (e.g., adjacent a first edge of the steel sheet). Moreover, the upper web flange **128** may be operatively coupled to the web **160** using beam connectors **190**, as will be described in further detail herein, in order to secure the portion of the steel sheet adjacent the first edge to the cold formed beam **100**.

[0097] As further illustrated in FIGS. **2**C, **3**B, **4**B, and **4**D, the lower member **140**, lower member **140** may be formed from a first lower flange **142** extending from the web **160** (e.g., generally perpendicular to the web **160**); a second lower flange **143** extending from the first lower flange **142** (e.g., generally perpendicular to the first lower flange **142** and/or parallel with the web **160**); a third lower flange **144** extending from the second lower flange **143** (e.g., generally perpendicular to the second lower flange **143** and/or the web **160**); a fourth lower flange **145** extending from the third lower flange **144** (e.g., generally perpendicular to the third lower flange **144** and/or parallel with the web **160**); a fifth lower flange **146** extending from the fourth lower flange **145** (e.g., generally perpendicular to the fourth lower flange **145**

and/or the web **160**); and a lower web flange **148** extending from the fifth lower flange **146** (e.g., generally perpendicular to the fifth lower flange **146** and/or parallel with the web **160**). As such, the lower member **140**, like the upper member **120**, may comprise of a square and/or rectangular shaped member that is formed from a second portion of the steel sheet (e.g., adjacent a first edge of the steel sheet). Moreover, the lower web flange **148** may be operatively coupled to the web **160** using beam connectors **190**, as will be described in further detail herein, in order to secure the portion of the steel sheet adjacent the second edge to the cold formed beam **100**.

[0098] In some embodiments, the upper member **120** and the lower member **140** have a height of 1, 1.5, 2.0, 2.5, 3, 3.5, 4.0, 4.5, 5, or the like inches, and a width of 2.0, 2.5, 3, 3.5, 4.0, 4.5, 5, 5.5, 6, or the like inches. In some embodiments, the upper member **120** and the lower member **140** may have heights of 3 inches and a widths of 4 inches. In some embodiments, the upper member **120** and the lower member **140** may have heights of 3 inches and a widths of 5 inches. The dimensions of the upper member **120** and the lower member **140** may be the same or different from each other. Moreover, it should be understood that the web flanges **128**, **148** may have lengths of 1, 1.5, 2.0, 2.5, 3, 3.5, 4.0, 4.5, 5 or the like inches, which may be the same or different from each other. In some embodiments, the web flanges **128**, **148** may have lengths of 2.375 inches. It should be understood that the upper member **120** and/or the lower member **140** (including the individual flanges thereof) may have dimensions that may be less than or greater than the values described above, and as such may have ranges of dimensions that overlap, fall between, or fall outside of any of the values described above.

[0099] While the upper member **120** and the lower member **140** may be illustrated as four-sided members (e.g., generally square, rectangular, or the like), it should be understood that the members may have different shapes, such as triangular (e.g., an inverted upper triangle, lower triangle, or the like), any polygonal shape (e.g., 5, 6, 7, 8, 9 sided) shape, T-shape, uniform shape, non-uniform shape, or other like shape. In some embodiments at least a portion of the sheet may be folded back upon itself to create a flange with two or more layers (e.g., three or more layers at the web flanges **128**, **148**). In some embodiments at least a portion of the upper member **120** may require an upper flange (e.g., illustrated as the third flange **124**) that may be parallel with a lower flute **76** of the decking **70** such that the decking connectors **90** may be used to operatively couple the decking panels **70** to the cold-formed beam **100** (e.g., through the lower flute **76** and the upper flange of the upper member **120**).

[0100] Moreover, as illustrated in FIGS. **4**A through **4**D, the upper member **120** and/or the lower member **140** may have chord embossments (e.g., chord ribs, grooves, cuts, punches, louvers, apertures, or the like). As such, one or more flanges of the upper member **120** and/or the lower member **140** may include one or more structural chord embossments (e.g., structural chord ribs, grooves, embossments, cuts, punches, louvers, apertures, or the like) that may provide additional structural strength for the upper member **120** and/or lower member **140**, and thus, the cold formed beam **100**. In the illustrated embodiments, the structural chord embossments are illustrated as one or more chord ribs **180**, such as one or more upper flange chord ribs **182** and/or one or more lower flange chord ribs **184**. While the one or more upper flange chord ribs **182** and/or lower flange chord ribs **184** are illustrated as being located on the outer flanges and/or side flanges, it should be understood that the one or more chord ribs **180** may be located on the flanges of the upper member **120** and lower member **140** adjacent the web **160**. Furthermore, while the chord ribs **180** are illustrated as v-shaped chord ribs **180**, it should be understood that the chord ribs **180** may be any type of shape, such as u-shaped, y-shaped, c-shaped, or other like shaped ribs. Moreover, instead of the chord ribs **180** extending inwardly, the chord ribs **180** may extend outwardly, although inwardly extending upper chord ribs **182** on the upper flange **124** may be preferred due to the decking panels **70** and/or other components being located on top of the upper member **120**. Furthermore, inwardly extending chord ribs **180** may be preferred in the upper member **120** and/or the lower member **140** due to attachment of other components to the side flanges of the upper member **120** and/or the lower member **140**. Additionally, while the chord ribs **180** are illustrated as being continuous along the length of the upper member **120** and/or lower member **140**, the chord ribs **180** may be discontinuous and only extend over a portion (e.g., uniformly or non-uniformly) of the length, width, and/or height of the upper member **120** and/or the lower member **140** (e.g., in any orientation). Finally, while the embossments are illustrated chord ribs **180**, as discussed above, other embossments may replace the chord ribs **180** and/or be utilized along with the chord ribs **180**.

[0101] As further illustrated in FIGS. **2**A through **4**D, the web **160** may include a plurality of web apertures **170**. The plurality of web apertures **170** may be formed in the steel sheet before forming the upper member **120** and/or the lower member **140**, and/or may be formed in the web **160** during or after the forming of the upper member **120** and/or the lower member **140**. As illustrated in FIGS. **2**A through **4**D, at least a portion of the web **160** around the plurality of web apertures **170** may have at least one web embossment **172** (or may have a web embossment **172** that extends around the entirety of the web apertures **170**). As such, at least a portion of the web embossment **172** may end in a lip **174** that defines the web apertures **170**. The one or more web embossments **172** may provide additional structural support to the web **160**. While FIGS. **2**A through **4**D illustrate a single web embossment **170**, as illustrated in FIGS. **10**A through **10**E, and as will be described in further detail herein, in some embodiments multiple web embossments **172** may be formed in the web **160** around at least a portion of the web apertures **170**, which may provide additional structural strength for the web **160**, and thus, the cold formed beam **100**. The multiple web embossments **170** may be progressive web embossments **172**, such that each progressive embossment **172** is further away from the plane of the web **160**.

[0102] In some embodiments, the plurality of apertures **170** may have an opening that is 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 26, 28, 30, 35, 40, or the like inches in height, width, diagonal, and/or diameter. Generally, the plurality of web apertures **170** have a diameter of 8, 9, 10, 12, 14, 16, 18, 20, or the like inches; however, it should be understood that the plurality of web apertures **170** may have dimensions that may be less than or greater than the values described above, and as such, may have a range that overlaps, falls between, or falls outside of any of the values described above.

[0103] The plurality of web apertures **170** (e.g., a center of a web aperture, a center point within a group of two or more apertures **170** as illustrated in FIGS. **11**D or **11**E, or the like) within the web **160** may be spaced every 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 36, 48, 60, or the like inches (e.g., center-to-center). Generally, the plurality of web apertures **170** are spaced 15, 20, or 30 inches (e.g., on center) apart; however, it should be understood that the spacing of the plurality of web apertures **170** may be less than or greater than the values described above, and as such may have a range that overlaps, falls between, or falls outside of any of the values described above. The plurality of web apertures **170** reduce the weight, provide additional structural strength, and/or allow for budling components (e.g., HVAC ducts, pipes, electrical wiring, networking wires, or the like) to extend through the apertures **170**.

[0104] As further illustrated in FIGS. **5**A through **5**C, one or more stiffeners **200** may be utilized to provide additional structural strength to the cold-formed beam **100** and/or provide a location adjacent the ends (e.g., at or near the ends **102**, **104**) of the cold formed beam **100** in order to provide a location for operatively coupling the cold formed beam **100** to other support members of the decking systems described herein. In other embodiments, the stiffeners **200** may be located between adjacent web apertures **170** and/or extend at least partially over a web aperture **170** (e.g., on the flat side of the web **160**, or the like). In some embodiments, the stiffener **200** may be a rectangular stiffener as illustrated in the cross-sectional view in FIG. **5**C. However, it should be understood that the stiffener **200** may be any type of stiffener **200** having any shape, such as square, circular, oval, triangular, any polygonal shape, I-shaped, H-shaped, T-shaped, uniform, non-uniform, hollow, solid, or the like. As Illustrated in FIGS. **6**A and **6**B, the stiffeners **200** may be one or more end stiffeners **210**. The end stiffeners **210** may include first end stiffeners **212**, such as two first end stiffeners located on each side adjacent the first end **102** of the cold formed beam **100**. Moreover, the end stiffeners **210** may be one or more second end stiffeners **214**, such as two second end stiffeners **214** located on each side adjacent the second end **104** of the cold formed beam **100**.

[0105] The one or more stiffeners **200** may be utilized to provide additional strength to the cold-formed beam **100**; however, additionally or alternatively, it should be understood that the one or more stiffeners **200** may be used to provide a location for operatively coupling the cold-formed beam **100** to another support member (e.g., a vertical support member, horizontal support member, or the like). For example, as illustrated in FIGS. **6**A and **6**B, the cold formed beam **100** may utilize a bracket **250** (e.g., hanger bracket, or the like) that may be used to operatively couple the cold-formed beam **100** to another support member (e.g., illustrated in FIGS. **6**A and **6**B as an I-beam). In some embodiments, the hanger bracket **252** may extend around the lower member **140**, around at least a portion of the end stiffeners **210**, such as the one or more first end stiffeners **212** or second end stiffeners **214**. The hanger bracket **252** may comprise a base hanger flange **254** that extends around the lower flange of the lower member **140**. The base flange **254** may be operatively coupled to side hanger flanges **256**, **258** that extend around the side flanges of the lower member **140** and/or the one or more end stiffeners **200**. The side hanger flanges **256**, **258** may be operatively coupled to a support hanger flange **260**. The support hanger flange **260** may extend over the support member, as illustrated in FIGS. **6**A and **6**B. In other embodiments (not illustrated), the side hanger flanges **256**, **258** may be operatively coupled to a flange of the upper members **120**. It should be understood that the base flange **254** and/or the side hanger flanges **256**, **258** may be operatively coupled to the lower member **140**, the end stiffeners **210**, and/or the upper member **120** through the use of bracket connectors **290** (e.g., welds, deformation the metal layers, fasteners, such as bolts and nuts, screws, self-drilling screws, rivets, or the like). Moreover, the support hanger flange **260** may also be operatively coupled to the support member using bracket connectors **290**.

[0106] In some embodiments, two adjacent cold-formed beams **100** may be operatively coupled to a support member and/or each other, as illustrated in FIG. **6**B. For example, a first cold-formed beam **106** may be operatively coupled to the support member through the use of first ends stiffeners **212** and a first hanger bracket **262**, while a second cold-formed beam **108** may be operatively coupled the support member adjacent the first cold formed beam **106** through the use of second end stiffeners **214** and a second hanger bracket **264**. Moreover, the first cold formed beam **106** and the second cold-formed beam **108** may be operatively coupled together through the use of a tie bracket **270**. For example, the upper member **120** (e.g., the first upper member) of the first cold formed beam **106** may be operatively coupled to the upper member **120** (e.g., second upper member) of the second cold formed beam **108** through the use of the tie bracket **270**. The tic bracket **270** may have any type of shape that has channel having a web **272** and one or more flanges **274**. The tie bracket **270** may have any type of shape, such a U-shape, C-shape, hat-shape, or other like shape. The channel of the tie bracket **270** may extend around the first upper member **120** of the first cold formed beam **106** and the second upper member **120** of the second cold formed beam **108**. The tic bracket **270** may be operatively coupled to the first upper member **120** and the second upper member **120** through the use of bracket connectors **290** (e.g., tie bracket connectors).

[0107] FIG. **6**C illustrates an alternate embodiment of the stiffener **200** and/or the bracket **250**. As illustrated in FIG. **6**C, in some embodiments the stiffener **200** may be a stiffener bracket **220**, such as L-shaped stiffener bracket **222**. The stiffener bracket **200** may be utilized to provide additional strength to cold-formed beam **100**, as well as to allow for operatively coupling with another support member. It should be understood that any type of traditional or non-traditional connection may be used between the cold-formed beam **100** and an adjacent support member, such as, but not limited to any framed or seated connection, such as any shear stiffener attachment, bearing, or the like, as will be described in further detail herein.

[0108] It should be understood that the one or more stiffeners **200**, the one or more stiffener brackets **220**, the one or more hanger brackets **250**, and/or the one or more tie brackets **270** may have one or more stiffener and/or bracket embossments that are the same as or similar to the one or more chord embossments previously discussed herein. As such, these components may be configured to nest, or otherwise be operatively coupled to, the embossments within the adjacent upper members **120**.

[0109] In some embodiments, the cold-formed beam **100** may be operatively coupled to other support members through the use of one more mounting apertures, such as one or more web mounting apertures **162** located in the web **160** adjacent the first end **102** and/or second end **104** of the cold-formed beam **100**, as illustrated in FIGS. **3**A, **4**A, and/or **4**C. It should be understood that the one or more web mounting apertures **162** may have any type of pattern, such as, one or more columns and/or rows of apertures having 1, 2, 3, 4, 5, 6, 7, 8, or the like apertures in a column and/or row depending on the size of the cold-formed beam **100**. In the illustrated embodiment, the web mounting apertures **162** include two columns of apertures located in the same plane (i.e., not offset), each column including three web mounting apertures **162**. In other embodiments (not illustrated), each of the two columns may include four, five, or six web mounting apertures **162** in each column.

[0110] In other embodiments, the cold formed beam **100** may have a first end **102** and/or a second **104** in which the upper member **120** and/or the lower member **140** extends past the web **160** of the cold-formed beam **100**. As such, the first end **102** and/or the second end **104** may have an upper member **120** and/or a lower member **120** that has an overhanging portion and/or web **160** having a recessed portion. As illustrated in FIGS. **7**A through **7**F, the overhanging portion of the upper member **120** may be described and illustrated as one or more upper extension members **130**, such as a first upper extension member **132** and a second upper extension member **134**. The upper extension members **130** may have the same or different shape as the rest of the upper member **120** (or lower member **140** with respect to a lower extension member). However, in the illustrated embodiments the upper extension members **130** may have the same shape as the upper member **120**. In some embodiments, the upper extension member **130** may further comprise an extension web **164** comprising a web flange **166**, a web transition **168** from the web **160** to the web flange **166**, and/or an upper extension member flange **138** (e.g., that may be the same as or different than the upper web flange **128**). The web transition **168** may comprise a radius web transition (otherwise described as coped web transition) that extends into the extension web **164**. The radiused web transition **168** between the web **160** on the first end **102** and second end **104** of the cold-formed beam **100** and into the extension web **164** may improve the structural support between the upper member **120** and the web **160** and/or reduce the chance for defects located between the upper extension members **130**, the web extensions **164**, the upper member **120** and/or the web **160**.

[0111] The upper extension members **130** may be configured for operative coupling with a support seat **400** (otherwise described as a bearing seat, beam seat, or the like). The support seat **400** may comprise a seat bracket **410** (otherwise described as a bearing seat bracket, or the like) having any type of shape and/or configuration. In some embodiments, as illustrated in FIGS. **7**A and **7**B, the cold-formed beam **100** comprises a first seat bracket **412** on a first end **102** and a second seat bracket **414** on a second end **104**. In the illustrated embodiments, the seat bracket **410** is formed from one or more seat members **420**, such as a first seat member **422** and a second seat member **424**. The seat members **420** may be L-shaped members (otherwise described as angle members), which may be operatively coupled to the web **160** and/or upper members **120**, such as through the upper extension member **130** and/or the extension web **164** thereof. For example, the seat bracket **410** (e.g., the members **420**, such as L-shaped members, or the like) may comprise one or more seat apertures **428** through which seat connectors **430** (e.g., welds, clips, clamps, fasteners, such as bolts **432**, nuts **434**, screws, self-drilling fasteners, rivets, pins, or other like fasteners, or other like connectors) are used to operatively couple the seat bracket **410** to the upper member **120** (e.g., through the web **160** and/or upper web flange **128**) and/or the upper member extension **130** thereof (e.g., through the extension web **164**, such as the web flange **166** and/or upper extension member flange **138**). As such, in the illustrated embodiments, the upper portions of the two L-shaped members **412**, **414** (e.g., vertical portions) are operatively coupled to the extension web **164**, and the lower portions of the two L-shaped members **412**, **414** (e.g., horizontal portions) are configured for operative coupling with another support member (e.g., upper portion of an I-beam, or the like). It should be understood that in some embodiments the end of the seat bracket **410** and the end of the upper extension member **130** may be in-line with each other (e.g., in the same plane). However, in some embodiments, end of the seat bracket **410** may extend past the end of the upper extension member **130**. In still other embodiments, as illustrated in FIGS. **7**C and **7**D, the end of the upper extension member **130** may extend past the end of the seat bracket **410**. The end of the upper extension members **130** may be utilized to support the caves of the roof (e.g., which may run perpendicular to the cold-formed beams **100**).

[0112] Regardless of the alignment and/or connection of the seat bracket **410** and the extension member **130** and/or cold-formed beam **100** thereof, it should be understood that the support seat **400**, such as the seat bracket **410**, may be any type of shape made up of one or more seat members **420**. For example, the seat support **400** (e.g., the seat bracket **410**) and/or the seat members **412**, **414** thereof, may be V-shaped, C-shaped, u-shaped, n-shaped, w-shaped, x-shaped, y-shaped, z-shaped, hat-shaped, or the like shaped.

[0113] FIGS. **8**A and **8**B illustrate the cold formed beam **100** with the beam connectors **190**. As previously discussed herein, the beam connectors **190** operatively couple the upper web flange **128** to the web **160** and/or the lower web flange **148** to the web **160** of the cold formed beam **100**. In some embodiments, the beam connectors **190** may comprise welds, fasteners, interference connections (e.g., deformed metal connectors as previously described herein), or the like connections. The beam connectors **190** may be located any distance apart; however, in some embodiments the beam connectors **190** may be spaced apart 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 20, 24 inches, or the like. Alternatively, the beam connectors **190** may be spaced apart at a range of 2 to 10 inches, and in particular 4 to 8 inches. However, it should be understood that the beam connectors **190** may be spaced apart a range between, overlapping, or outside of any of the values discussed above.

[0114] As previously discussed, the beam connectors **190** may be formed through interference connectors by deforming the metal layer of the web flanges **128**, **148** and/or the upper extension member flange **138**, and the web **160**. FIGS. **9**A through **9**E illustrate one embodiment, wherein one or more dies **310** are used to deform the metal layers to create an example interference connection. In particular, FIGS. **9**A through **9**E illustrate a cross-sectional view of the dies **310**

and metal layers that are being deformed in order to form the beam connectors **190**. The dies illustrated in FIGS. **9**A through **9**E, are used to form a circular clinched interference connection; however, it should be understood that the interference connection may be any size and shape (e.g., generally square, rectangular, triangular, any polygonal, or other like shape).

[0115] In some embodiments, the clinching system **300** illustrated in FIGS. **9**A through **9**E may utilize one or more dies **310**, such as a first die set **320** and a second die set **330**. In some embodiments the first die set **320** may include a first actuating die **322** and a first stationary die **322**. Moreover, the second die set **330** may include a second stationary die **332** and one or more second moving dies **334** (e.g., one or more rotating dies). As illustrated in FIG. **9**A, the two or more metal layers, such as the upper web flange **128** or lower web flange **148** and the web **160** may be located between the first die set **320** and the second die set **330**. As illustrated in FIG. **9**B, the first die set **320** and/or the second die set **330** may move closer to each other, and the first actuating die **322** of the first die set **320** may extend to deform at least a portion of the upper web flange **128** layer or the lower web flange **148** layer (or the upper extension member flange **138**) and the web **160** layer into a second die cavity formed in the second die set **330** (e.g., formed by the second stationary die **332** and the one or more second moving dies **334**). As illustrated in FIG. **9**C as the first actuating die **322** deforms the upper web flange **128** layer or the lower web flange **148** (or the upper extension member flange **138**) and the web **160** layer, the one or more second moving dies **334** (e.g., one or more rotating dies) move outwardly (e.g., rotate, or the like) such that the upper web flange **128** layer and the lower web flange **148** (or the upper extension member flange **138**) are pushed outwardly to form the circular clinching connection. Thereafter, as illustrated in FIG. **9**D, the first actuating die **322** is retracted. Moreover, the first die set **320** and/or the second die set **330** are moved away from each other and/or the formed interference connector **192** (e.g., the clinch connection). Furthermore, as illustrated in FIG. **9**E, the second moving die **334** is moved back into place, and the opposing die sets **320**, **330** and/or the metal layers are moved into another position in order to form another clinching connection **192**.

[0116] As previously discussed, the interference connector **192** (e.g., the clinched connection) may be illustrated as a circular clinched connection; however, the clinched connection may be another type of shape, such as rectangular, square, triangular, any polygonal shape, or any other shape. Moreover, while the interference connector **192** is illustrated as being deformed, it should be further understood that a connection aperture (e.g., punch, cut, sheared, or the like aperture) may be formed in the interference connector **192**. Furthermore, as previously discussed herein, instead of using an interference connector **192**, other types of beam connectors **190** may be used to operatively couple the layers of the beam (e.g., fasteners, or the like)

[0117] FIGS. **10**A through **10**M illustrate different types of cross-bracing systems **350** having different types of cross-bracing **360** that may be used between adjacent cold-form beams **100** in a roof and/or floor system. As illustrated in FIGS. **10**A and **10**B, the cross-bracing system **350** may comprise one or more lower horizontal cross-braces **362** that operatively couple a first lower member **140** of a first cold-formed beam **100** and a second lower member **140** of a second cold-formed beam **100**. It should be understood that in some embodiments, the one or more lower horizontal cross-braces **362** may operatively couple more than two cold-formed beams **100** (e.g., 3, 4, 5, 6, or the like cold-formed beams **100**). In the illustrated embodiment, the one or more lower horizontal cross-braces **362** may be operatively coupled to lower members **140** at the third lower flange **144** (e.g., outer flanges of the lower members **140**). It should be understood that the cross-bracing **360** of the cross-bracing system **350** may be operatively coupled to the lower and/or upper members **120**, **140** through the use of bracing connectors **370** (e.g., fasteners, such as bolts, nuts, screws, self-drilling fasteners, powder driven fasteners, pins, rivets, or the like, welds, interference connections, or the like). In some embodiments, the bracing connectors **370** may be operatively coupled through the use of bracing apertures **380**, located in the upper and lower members **120**, **140** and/or the bracing members **360**.

[0118] As illustrated in FIGS. **10**C and **10**D, the cross-bracing system **350** may comprise one or more lower horizontal cross-braces **362** and one or more upper horizontal cross-braces **364**. The one or more lower horizontal cross-braces **362** may operatively couple a first lower member **140** of a first cold-formed beam **100** and a second lower member **140** of a second cold-formed beam **100**. Alternatively, or additionally, the one or more upper horizontal cross-braces **364** may operatively couple a first upper member **120** of the first cold-formed beam **100** and a second upper member **120** of the second cold-formed beam **100**. In the illustrated embodiments, the one or more lower horizontal cross-braces **362** are operatively coupled between the first lower member **140** and the second lower member **140** using a second lower flange **143** (e.g., side flange) and a fourth lower flange **145** (e.g., side flange) of the lower members **140**, respectively (e.g., side flanges). Moreover, in the illustrated embodiments, the one or more upper horizontal cross-braces **364** are operatively coupled between the first upper member **120** and the second upper member **120** using a second upper flange **123** (e.g., side flange) and a fourth upper flange **125** (e.g., side flange) of the upper members **120**, respectively. It should be understood that the cross-bracing **360** of the cross-bracing system **350** may be operatively coupled to the lower and/or upper members **120**, **130** in the same or similar way as described above with respect to FIGS. **10**A and **10**B (e.g., bracing connectors **370** and/or bracing apertures **380**).

[0119] FIGS. **10**E and **10**F illustrate that the cross-bracing system **350** may comprise one or more diagonal cross-braces **366**. The one or more diagonal cross-braces **366** may operatively couple a first lower member **140** of a first cold-formed beam **100** to a second upper member **120** of a second cold-formed beam **100**. Additionally, or alternatively, the one or more diagonal cross-braces **366** operatively couples a first upper member **120** of the first cold-formed beam **100** and a second lower member **140** of the second cold-formed beam **100**. Furthermore, as illustrated in FIG. **10**F, the two-diagonal cross-braces **366** may be operatively coupled to each other at a location at which the two-diagonal cross-braces **366** cross (e.g., back-to-back L-shaped members, or the like). In the illustrated embodiments, the two-diagonal cross-braces **366** are operatively coupled between the side flanges of the upper and lower members **120**, **140**, as previously discussed herein. Furthermore, as illustrated in FIGS. **10**E and **10**F, one or more lower cross-braces **362** may also be used between two or more adjacent lower cross-braces **362**, as previously discussed with respect to FIGS. **10**A and **10**B.

[0120] Moreover, FIGS. **10**G and **10**H, further illustrate that the cross-bracing system **350** may utilize both upper and lower cross-bracing **362**, **364** and diagonal cross-bracing **366**, as previously discussed with respect to FIGS. **10**C and **10**D, and FIGS. **10**E and **10**F. In this configuration, the upper members **120** and the lower members **140** may each have three bracing apertures **380**, to allow for the connection of the upper and lower cross-bracing **362**, **364** and diagonal cross-bracing **366** between the upper and lower members **120**, **140**, as illustrated in FIG. **10**H (e.g., to allow any cold-form beam **100** to be connected using any of the cross-bracing systems **350**).

[0121] FIG. **10**I illustrates cross-bracing similar to FIG. **10**A. As such, the cross-bracing system **350** may comprise one or more lower horizontal cross-braces **362** that operatively couple a first lower member **140** of a first cold-formed beam **100** and a second lower member **140** of a second cold-formed beam **100**. In the illustrated embodiment, the one or more lower horizontal cross-braces **362** may be operatively coupled to lower members **140** at the first lower flange **142** and/or fifth lower flange **146** (e.g., one or more lower inner flanges of the lower members **140**).

[0122] FIGS. **10**J and **10**K illustrate cross-bracing similar to FIGS. **10**C and **10**D. As illustrated in FIGS. **10**J and **10**K, the cross-bracing system **350** may comprise one or more lower horizontal cross-braces **362** and one or more upper horizontal cross-braces **364**. The one or more lower horizontal cross-braces **362** may operatively couple a first lower member **140** of a first cold-formed beam **100** and a second lower member **140** of a second cold-formed beam **100**, as previously described with respect to FIG. **10**I. The one or more upper horizontal cross-braces **364** may operatively couple a first upper member **120** of the first cold-formed beam **100** and a second upper member **120** of the second cold-formed beam **100**. In the illustrated embodiments, the one or more upper horizontal cross-braces **364** are operatively coupled between the first upper flange **122** and/or the fifth upper flange **126** (e.g., one or more upper inner flanges of the upper members **120**).

[0123] FIG. **10**L illustrates cross-bracing between three or more beams **100**. As illustrated in FIG. **10**L, the cross-bracing **360** may comprise one or more lower horizontal cross-braces **362**, one or more upper horizontal cross-braces **364**, and one or more diagonal cross-braces **366**. The one or more upper horizontal cross-braces **364** and the one or more lower horizontal cross-braces **362** may be operatively coupled to the upper and lower members **120**, **140** as previously described with respect to FIGS. **10**J and **10**K. Additionally, the one or more diagonal cross-braces **366** may operatively couple a first lower member **140** of a first cold-formed beam **100** to a second upper member **120** of a second cold-formed beam **100**, as previously described herein. However, as illustrated in FIG. **10**L, the diagonal cross-braces **366** may be operatively coupled to the upper horizontal cross-braces **364** and/or lower horizontal cross-braces **362** through the use of one or more bracing connectors **370** and/or one or more bracing apertures **380** (e.g., in the cross-bracing **360**).

[0124] FIG. **10**M illustrates cross-bracing **360** between three or more beams **100**. As illustrated in FIG. **10**M, the cross-bracing **360** may comprise one or more lower horizontal cross-braces **362**, one or more upper horizontal cross-braces **364**, one or more diagonal cross-braces **366**, and/or one or more vertical cross-braces **368**. The one or more upper horizontal cross-braces **362**, the one or more lower horizontal cross-braces **364**, and/or the one or more diagonal cross-braces **366** may be operatively coupled to the upper and lower members **120**, **140**, and/or each other as previously discussed with respect to FIG. **10**L. It should be understood that the one or more vertical cross-braces **368** may be operatively coupled to the upper member **120**, lower member **140**, and/or the upper horizontal cross-braces **364** and/or the lower horizontal cross-braces **362** through the use of one or be more bracing connectors **370** and/or one or more bracing apertures **380** (e.g., in the cross-bracing **360** or the upper and/or lower members **120**, **140**). As illustrated in FIG. **10**M, the vertical cross-braces **368** may be operatively coupled to a first upper flange **122** and/or a fifth upper flange **126** and/or a first lower flange **142** and/or a fifth lower flange **146**. However, it should be understood that the vertical cross-braces **368** may be operatively coupled to any of the flanges of the upper and/or lower members **120**, **140** and/or other cross-bracing **360**.

[0125] In the illustrated embodiments, the cross-bracing **360** utilizes L-shaped cross-bracing members (otherwise described as angle cross-bracing members). However, it should be understood that the cross-bracing **360** may be any shape (e.g., u-shaped, c-shaped, x-shaped, y-shaped, n-shaped, w-shaped, m-shaped, circular, oval, uniform, non-uniform, or the like shaped). Moreover, it should be understood that while specific cross-bracing systems **350** are illustrated, other types of cross-bracing systems **350** may be utilized. Depending on the configuration, the cross-bracing systems **350** may be categorized as different types of cross-bracing such as horizontal, vertical, diagonal, uplift, termination, or the like cross-bracing systems **350**.

[0126] FIGS. **11**A through **11**E illustrate other embodiments of the cold formed beam **100**, which have apertures **170** of different shapes and/or multiple embossments **172**. FIG. **10**A illustrates one embodiment in which the apertures **170** are circular and have multiple embossments **172** in the web **160** of the cold-formed beam **100**. FIG. **11**B illustrates one embodiment in which the apertures **170** are polygonal (e.g., having eight sides) and have multiple embossments **172** in the web **160** of the cold-formed beam **100**. FIG. **11**C illustrates one embodiment in which the apertures **170** are square or diamond shaped and have multiple embossments **172** in the web **160** of the cold-formed beam **100**. FIGS. **11**D and **11**E illustrate embodiments in which the apertures **170** are triangular (e.g., two back-to-back triangular apertures as illustrated in FIG. **11**D, and four triangular apertures with the points directed towards each other as illustrated in FIG. **11**E) and have multiple embossments **172** in the web **160** of the cold formed beam **100**.

[0127] FIG. **12** illustrates a process flow for forming the cold formed beams **100** discussed herein. As illustrated in block **510** of FIG. **12**, a steel sheet is procured (e.g., manufactured, purchased, or the like). Depending on the beam connectors **190** that will be used to form the cold formed beam **100**, it should be understood that the steel sheet may already be coated (e.g., galvanized, painted, or coated with another material), or it may be coated before being formed into the cold formed beam **100**. As such, the interference connectors **192** may be formed in the coated steel sheets, whereas welded connectors may not be able to be formed and/or would require additional coating after welding.

[0128] Block **520** of FIG. **12** illustrates that the steel sheet is formed into the cold formed beam **100** through rolling, pressing, bending, or other like forming operation. In particular embodiments, the cold formed beam **100** may be created by rolling the steel sheet through one or more sets of opposing dies (e.g., rolling dies) to form the portions of the steel sheet adjacent the edges of the steel sheet into the multiple flanges in order to create the upper member **120**, lower member **140**, and/or extension member(s) **130** of the cold formed beam **100** described herein.

[0129] FIG. **12** further illustrates in block **530** that that the apertures **170** are formed in the web **160** of the cold formed beam **100**. It should be understood that the apertures **170** may be formed in the web **160** before, during, or after the upper and lower members **120**, **140** are formed as described in block **520**. Regardless of when the apertures **170** are formed, in some embodiments the apertures **170** are formed through a stamping process. The stamping process may include using one or more sets of dies to punch out the material in the web **160** in the desired shape and/or create the one or more embossments **172** around at least a portion of the web **160** surrounding the apertures **170**. While the apertures **170** may be formed through a stamping process, it should be understood that in other embodiments, the apertures **170** may be formed by other processes (e.g., laser cutting, water cutting, plasma cutting, or the like).

[0130] Block **540** of FIG. **12** further illustrates that a plurality of beam connectors **190** are formed in the in the cold formed beam **100**. For example, the beam connectors **190** may be formed between the web flanges (e.g., first web flange **128**, second web flange **148**, an upper extension member flange **138**) and the web **160** (e.g., the metal web layer). As previously described herein, the beam connectors **190** may include welds, fasteners, and/or metal deformation connector, such as the interference connectors **192** (e.g., clinching connections, or the like) as previously described herein. It should be understood that when welding is described herein, the welding may be any type of welding, such as but not limited to MIG, stick, TIG, plasma arc, electron beam, laser, gas, or the like welding.

[0131] FIG. **12** further illustrates in block **550** that one or more stiffeners **200** and/or one or more support member brackets **250** may be operatively coupled to the cold-formed beam **100**. For example, the one or more stiffeners **200** may be assembled to the cold formed beam **100**. For example, end stiffeners **210** may be assembled on each end **102**, **104** of the cold formed beam **100** using one or more stiffener connectors (e.g., as described with respect to other connectors). The stiffeners **200** may be operatively coupled to the upper member **120**, the lower member **140**, and/or the web **160** of the cold formed beam **160** using the stiffener connectors.

Moreover, one or more support member brackets **250** may be assembled to the ends of the cold-formed beam **100**, such as to the stiffeners **200**. In some embodiments, the support member brackets **250** and/or the stiffeners **200** may be pre-assembled before assembly to the cold-formed beam **100**. Alternatively, or additionally, the support member brackets **250** and/or the stiffeners **200** may be an integral component, such as a combined stiffener bracket **220**.

[0132] FIG. **12** further illustrates in block **560** that one or more support member seats **400** may be operatively coupled at the ends of the cold formed beam **100**, such as to the stiffeners **200** discussed with respect to block **550** and/or to one or more of the extension members **130** previously discussed herein. For example, a seat bracket **410** may be operatively coupled to the ends of the cold-formed beam **100**, such as a seat bracket **410** that is formed of two L-shaped seat members that are operatively coupled back-to-back around a portion of an extension member **130**.

[0133] The cold-formed beam **100** may support at least the following loading or more, a dead load of 4 sf+self-weight of the beam **100**; a live load of 20 psf, a snow load of 30 psf; an uplift wind load of 60 psf; a downward wind load of 20 psf; live load deflection limit of L/180; and/or a dead plus live load deflection limit of L/150. The structural support performance of the cold-formed beam **100** may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25, 30, 40, 45, 50, 60, 70, 80, 90, 100 or the like percent higher or lower than these values.

[0134] The cold formed beam **100** of the present disclosure may be a unitary cold formed beam **100** formed form a single steel sheet, and in particular, the cold form beam **100** is a long-span cold-formed beam **100** (e.g., greater than 30 feet in length) that has a reduced weight due to the thickness of the steel sheet and/or the plurality of apertures **170** in the web **160**. The beam is generally described herein as being a cold-formed beam **100**, such that the beam is formed without having to heat the beam above its recrystallization temperature. It should be understood that the steel sheet used to form the cold-formed beam **100** may be any type of steel made from any process.

[0135] The configuration of the cold-formed beam **100** may allow for the reduction and/or elimination of bridging between parallel cold-formed beams **100**, which reduces costs and time associated with installing the amount of traditional bridging that is required in traditional long-span beams. However, as previously described herein, the cold-formed beam **100** may be used with any type of bridging system **350**.

[0136] Furthermore, due to the configuration (e.g., shape, thickness, or the like) of the upper member **120** (e.g., the upper flange thereof) the upper member **120** allows for the case of installation of the standing seem clips **30**, bridging members **40**, decking panels **70**, wooden nailer and/or wooden panels (not illustrated) and/or other components of structural framing systems into the upper member **120** of the cold formed beams **100**. Moreover, the plurality of apertures **170** allow for components to be easily passed through and installed across multiple cold formed beams **100**.

[0137] Furthermore, the cold formed beams **100** of the present invention, depending on the type of connectors, reduce (e.g. lower or eliminate) the need for welding the cold formed beam **100**, which reduces safety issues around welding (e.g., wire pokes, or the like), allows for the use of pre-coated steel sheets that have the desired finishes, and/or reduces the carbon footprint and other use of gases associated with welding. Moreover, in some embodiments a footprint of the manufacturing equipment used to form the cold formed beam **100** can be reduced since the cold formed beam **100** can be rolled, stamped, and mended to form the interference connectors in a single location and does not require sending to beam to a different location for welding.

[0138] Finally, it should be understood that the cold formed beam **100** may be formed within 5, 4, 3, 2, or the like minutes, which may be about half the time it takes for traditional long-span beams to be formed (e.g., open web joists, castellated beams, or the like).

[0139] It should be understood that "operatively coupled," when used herein, means that the components may be formed integrally with each other, or may be formed separately and coupled together. Furthermore, "operatively coupled" means that the components may be formed directly to each other, or to each other with one or more components located between the components that are operatively coupled together. Furthermore, "operatively coupled" may mean that the components are detachable from each other, or that they are permanently coupled together.

[0140] Also, it will be understood that, where possible, any of the advantages, features, functions, devices, and/or operational aspects of any of the embodiments of the present invention described and/or contemplated herein may be included in any of the other embodiments of the present invention described and/or contemplated herein, and/or vice versa. In addition, where possible, any terms expressed in the singular form herein are meant to also include the plural form and/or vice versa, unless explicitly stated otherwise. Accordingly, the terms "a" and/or "an" shall mean "one or more."

[0141] Certain terminology is used herein for convenience only and is not to be taken as a limiting, unless such terminology is specifically described herein for specific embodiments. For example, words such as "top", "bottom", "upper", "lower", or the like may merely describe the configurations shown in the figures and described herein for some embodiments of the invention. Indeed, the components may be oriented in any direction and the terminology, therefore, should be understood as encompassing such variations unless specified otherwise. The terminology includes the words specifically mentioned above, derivatives thereof and words of similar import.

[0142] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other changes, combinations, omissions, modifications and substitutions, in addition to those set forth in the above paragraphs, are possible. Those skilled in the art will appreciate that various adaptations, modifications, and combinations of the just described embodiments can be configured without departing from the scope and spirit of the invention. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

What is claimed is:

1. A cold-formed beam comprising:
an upper member;
a lower member; and
a web between the upper member and the lower member;
wherein the upper member, the lower member, and the web are formed from forming a sheet.

2. The beam of claim **1**, wherein the sheet is a single sheet that is rolled to form the upper member, the lower member, and the web.

3. The beam of claim **1**, wherein upper member comprises an upper web flange that extends over at least a portion of the web.

4. The beam of claim **3**, wherein the lower member comprises a lower web flange that extends over at least a portion of the web.

5. The beam of claim **4**, wherein the upper web flange is operatively coupled to the web and the lower web flange is operatively coupled to the web through the use of a plurality of beam connectors.

6. The beam of claim **5**, wherein the plurality of beam connectors comprise:
an interference connector formed by deforming a portion of the upper web flange and the web, and a portion of the lower web flange and the web.

7. The beam of claim **5**, wherein the plurality of beam connectors comprise:
welding the upper web flange to the web and the lower web flange to the web, or assembling fasteners through the upper web flange and the web and the lower web flange and the web.

8. The beam of claim **5**, wherein the plurality of beam connectors are formed between a range of 2 inches to 24 inches along the length of the beam.

9. The beam of claim **1**, wherein the upper member or the lower member comprises:
a square member or a rectangular member.

10. The beam of claim **9**, wherein the square member or the rectangular member comprises:
a first flange extending from the web;
a second flange extending from the first flange;
a third flange extending from the second flange; and
a fourth flange extending from the third flange;
wherein a web flange extends from the fourth flange over at least a portion of the web.

11. The beam of claim **1**, wherein the web comprises:
a plurality of stamped apertures extending through the web.

12. The beam of claim **11**, wherein the plurality of stamped apertures comprise circular apertures.

13. The beam of claim **11**, wherein the plurality of stamped apertures comprise triangular apertures, square, or diamond apertures.

14. The beam of claim **11**, wherein the plurality of stamped aperture comprise polygonal apertures.

15. The beam of claim **11**, wherein at least a portion of the web around the plurality of stamped apertures comprise at least one embossment.

16. The beam of claim **1**, wherein the upper member comprises and upper extension member on at least one end, wherein the upper extension member extends past the web.

17. The beam of claim **16**, further comprising:
at least one seat support operatively coupled to the at least one upper extension member.

18. A structural system, the system comprising:
a plurality of support members;
a plurality of cold formed beams, wherein the plurality of cold-formed beams comprise:
an upper member;
a lower member; and
a web between the upper member and the lower member;
wherein the upper member, the lower member, and the web are formed from forming a sheet;

wherein ends of the plurality of cold formed beams are operatively coupled to two of the plurality of support members.

19. The structural decking system of claim **18**, wherein the sheet is a single sheet that is rolled to form the upper member, the lower member, and the web.

20. A method of forming a cold formed beam, the method comprising:

rolling a steel sheet to form an upper member, a lower member, and a web between the upper member and the lower member;

stamping the web to form a plurality of apertures in the web; and

forming a plurality of beam connectors between an upper flange and the web and a lower flange and the web.

* * * * *