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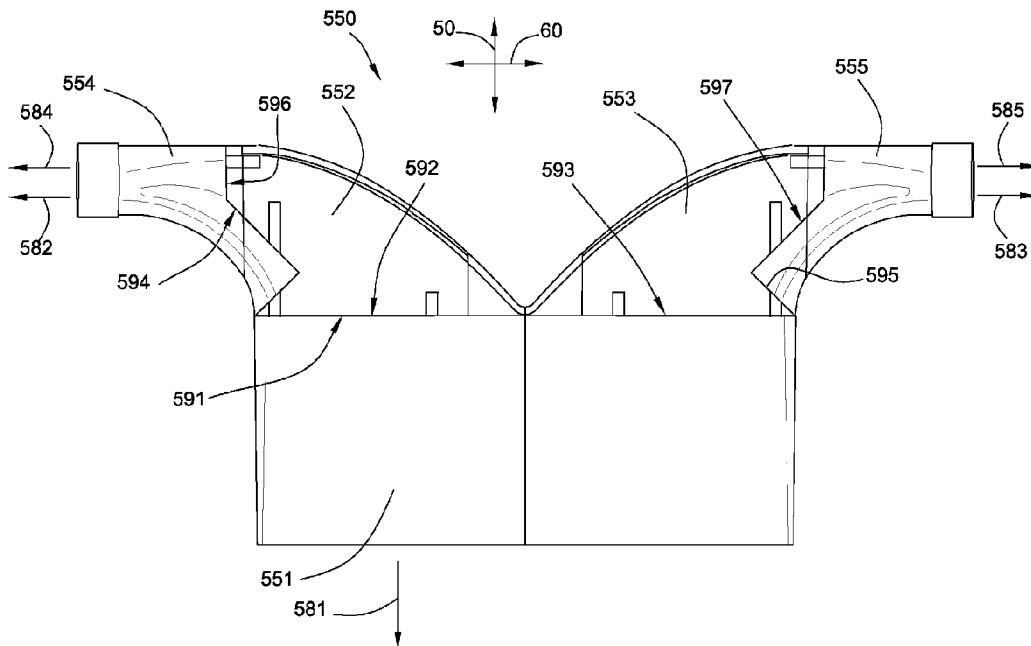
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(54) Titre : MOULE MULTIPIECE ET PROCEDE DE FABRICATION D'UN DISTRIBUTEUR DE BOUE  
 (54) Title: MULTI-PIECE MOLD AND METHOD OF MAKING SLURRY DISTRIBUTOR



(57) **Abrégé/Abstract:**

A multi-piece mold for use in a method for making a slurry distributor includes a plurality of mold segments (551,552,553,554,555) adapted to be removably secured together. The mold segments are configured such that, when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon- Each mold segment (551,552,553,554,555) has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path (581, 582, 583, 584, 585) out of a respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path (581, 582, 583, 584, 585).

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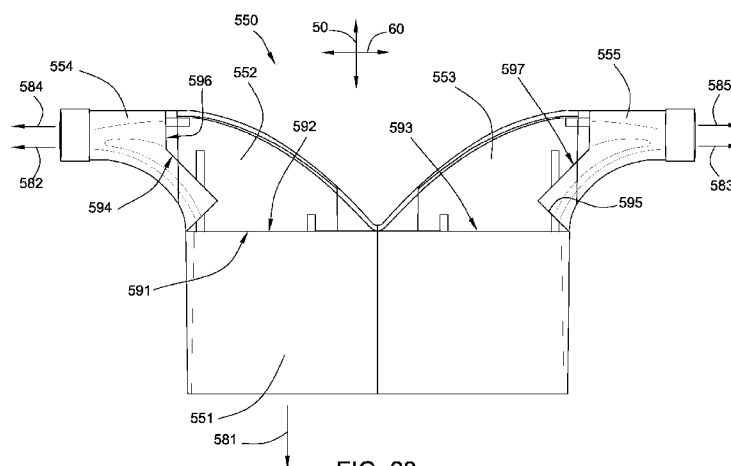


FIG. 23

(57) Abstract: A multi-piece mold for use in a method for making a slurry distributor includes a plurality of mold segments (551,552,553,554,555) adapted to be removably secured together. The mold segments are configured such that, when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon- Each mold segment (551,552,553,554,555) has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path (581, 582, 583, 584, 585) out of a respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path (581, 582, 583, 584, 585).



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**MULTI-PIECE MOLD AND METHOD OF MAKING SLURRY DISTRIBUTOR**

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**BACKGROUND**

**[0002]** The present disclosure relates to continuous board (e.g., wallboard) manufacturing processes and, more particularly, to a mold and a method for making a slurry distributor for the distribution of an aqueous cementitious slurry, such as aqueous calcined gypsum slurry, for example.

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**[0003]** It is well-known to produce gypsum board by uniformly dispersing calcined gypsum (commonly referred to as "stucco") in water to form an aqueous calcined gypsum slurry. The aqueous calcined gypsum slurry is typically produced in a continuous manner by inserting stucco and water and other additives into a mixer which contains means for agitating the contents to form a uniform gypsum slurry. The slurry is continuously directed toward and through a discharge outlet of the mixer and into a discharge conduit connected to the discharge outlet of the mixer. An aqueous foam can be combined with the aqueous calcined gypsum slurry in the mixer and/or in the discharge conduit. The stream of slurry passes through the discharge conduit from which it is continuously deposited onto a moving web of cover sheet material supported by a forming table. The slurry is allowed to spread over the advancing web. A second web of cover sheet material is applied to cover the slurry and form a sandwich structure of a continuous wallboard preform, which is subjected to forming, such as at a conventional forming station, to obtain a desired thickness. The calcined gypsum reacts with the water in the wallboard preform and sets as the wallboard preform moves down a manufacturing line. The wallboard preform is cut into segments at a point along the line where the wallboard preform has set sufficiently, the segments are flipped over, dried (e.g., in a kiln) to drive off excess water, and processed to provide the final wallboard product of desired dimensions.

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**[0004]** Prior devices and methods for addressing some of the operational problems associated with the production of gypsum wallboard are disclosed in commonly-assigned U.S. Patent Nos. 5,683,635; 5,643,510; 6,494,609; 6,874,930; 7,007,914; and 7,296,919.

5 **[0005]** The weight proportion of water relative to stucco that is combined to form a given amount of finished product is often referred to in the art as the “water-stucco ratio” (WSR). A reduction in the WSR without a formulation change will correspondingly increase the slurry viscosity, thereby reducing the ability of the slurry to spread on the forming table. Reducing water usage (i.e., lowering the WSR) in the  
10 gypsum board manufacturing process can yield many advantages, including the opportunity to reduce the energy demand in the process. However, spreading increasingly viscous gypsum slurries uniformly on the forming table remains a great challenge.

**[0006]** Furthermore, in some situations where the slurry is a multi-phase slurry  
15 including air, air-liquid slurry separation can develop in the slurry discharge conduit from the mixer. As WSR decreases, the air volume increases to maintain the same dry density. The degree of air phase separated from the liquid slurry phase increases, thereby resulting in the propensity for larger mass or density variation.

**[0007]** It will be appreciated that this background description has been created by  
20 the inventors to aid the reader and is not to be taken as an indication that any of the indicated problems were themselves appreciated in the art. While the described principles can, in some aspects and embodiments, alleviate the problems inherent in other systems, it will be appreciated that the scope of the protected innovation is defined by the attached claims and not by the ability of any disclosed feature to solve  
25 any specific problem noted herein.

## SUMMARY

**[0008]** in one aspect, the present disclosure is directed to embodiments of a mold  
for use in a method for making a slurry distributor according to principles of the  
30 present disclosure. In one embodiment, a multi-piece mold includes a plurality of mold

segments adapted to be removably secured together. Each mold segment includes an exterior surface configured to define at least a portion of an interior surface of a slurry distributor. The mold segments are configured such that, when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path out of a respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path.

**[0009]** In another aspect of the present disclosure, embodiments of a method of making a slurry distributor are described. A plurality of mold segments of a multi-piece mold is assembled to define an exterior surface of the multi-piece mold. The assembled multi-piece mold is dipped into a solution of flexible material such that at least a portion of the multi-piece mold is submersed in the solution. The multi-piece mold is removed from the solution such that a layer of solution adheres substantially around the exterior surface of the multi-piece mold. The solution is allowed to cure such that an at least partially-solidified molded slurry distributor is formed around the multi-piece mold. The molded slurry distributor has an interior surface defining an interior flow region. The interior surface of the molded slurry distributor is in contacting relationship with the exterior surface of the multi-piece mold. The molded slurry distributor defines at least two openings each in fluid communication with the interior flow region.

**[0010]** The multi-piece mold is disassembled by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor. The

maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path.

5 [0011] In another aspect of the present disclosure, a slurry distributor made following a method using an embodiment of a multi-piece mold according to principles of the present disclosure can include a feed conduit and a distribution conduit in fluid communication therewith. The feed conduit can include a first feed inlet in fluid communication with the distribution conduit and a second feed inlet disposed in spaced relationship with the first feed inlet and in fluid communication with the distribution  
10 conduit. The distribution conduit can extend generally along a longitudinal axis and include an entry portion and a distribution outlet in fluid communication therewith. The entry portion is in fluid communication with the first and second feed inlets of the feed conduit. The distribution outlet extends a predetermined distance along a transverse axis, which is substantially perpendicular to the longitudinal axis.

15 [0012] In another aspect of the present disclosure, a slurry distributor made using an embodiment of a multi-piece mold according to principles of the present disclosure can be placed in fluid communication with a gypsum slurry mixer adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. In still another aspect of the present disclosure, a slurry distributor made using an embodiment of a  
20 multi-piece mold according to principles of the present disclosure can be used in a method of preparing a gypsum product. For example, a slurry distributor can be used to distribute an aqueous calcined gypsum slurry upon an advancing web.

[0013] Further and alternative aspects and features of the disclosed principles will be appreciated from the following detailed description and the accompanying drawings. As  
25 will be appreciated, the slurry distribution systems disclosed herein are capable of being carried out and used in other and different embodiments, and capable of being modified in various respects. Accordingly, it is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and do not restrict the scope of the appended claims.



**[013a]** In a broad aspect, the present invention relates to a multi-piece mold comprising: a plurality of mold segments adapted to be removably secured together, each mold segment including an exterior surface configured to define at least a portion of an interior surface of a slurry distributor, the mold segments  
5 configured such that when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon; wherein each mold segment has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold  
10 segment along a removal path out of a respective opening of the molded slurry distributor, the maximum cross-sectional area of each mold segment being up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path; wherein the exterior surfaces of the assembled mold  
15 segments are configured to define the molded slurry distributor such that the molded slurry distributor includes a feed conduit having a first feed inlet defining one of the openings of the molded slurry distributor and a distribution conduit, the distribution conduit extending generally along a longitudinal axis and including an entry portion and a distribution outlet in fluid communication with the entry portion,  
20 the entry portion in fluid communication with the first feed inlet of the feed conduit, the distribution outlet defining one of the openings of the molded slurry distributor; and wherein at least two mold segments are adapted to be removed from the interior flow region of the molded slurry distributor by following a removal path through the opening of the first feed inlet and at least one mold segment is adapted  
25 to be removed from the interior flow region of the slurry distributor by following a removal path through the opening of the distribution outlet.

**[013b]** In another broad aspect, the present invention relates to a method of making a slurry distributor comprising: assembling a plurality of mold segments of a multi-piece mold according to the present invention to define an exterior surface of  
30 the multi-piece mold; dipping the assembled multi-piece mold into a solution of

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flexible material such that at least a portion of the multi-piece mold is submersed in the solution; removing the multi-piece mold from the solution such that a layer of solution adheres substantially around the exterior surface of the multi-piece mold; allowing the solution to cure such that an at least partially-solidified molded slurry distributor is formed around the multi-piece mold, wherein the molded slurry distributor has an interior surface defining an interior flow region, the interior surface of the molded slurry distributor being in contacting relationship with the exterior surface of the multi-piece mold, and the molded slurry distributor defines at least two openings each in fluid communication with the interior flow region;

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10 disassembling the multi-piece mold by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening; wherein each mold segment has a maximum

15 cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor, the maximum cross-sectional area of each mold segment being up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses

20 when moving along the respective removal path; wherein the slurry distributor includes a feed conduit having a first feed inlet defining one of the openings and a distribution conduit, the distribution conduit extending generally along a longitudinal axis and including an entry portion and a distribution outlet in fluid communication with the entry portion, the entry portion in fluid communication with the first feed

25 inlet of the feed conduit, the distribution outlet defining one of the openings; and wherein at least two mold segments are removed from the interior flow region of the slurry distributor by following a removal path through the opening of the first feed inlet and at least one mold segment is removed from the interior flow region of the slurry distributor by following a removal path through the opening of the distribution

30 outlet.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0014] FIG. 1 is a perspective view of an embodiment of a slurry distributor constructed in accordance with principles of the present disclosure.

5 [0015] FIG. 2 is a perspective view of the slurry distributor of FIG. 1 and a perspective view of an embodiment of a slurry distributor support constructed in accordance with principles of the present disclosure.

[0016] FIG. 3 is a front elevational view of the slurry distributor of FIG. 1 and the slurry distributor support of FIG. 2.

10 [0017] FIG. 4 is a perspective view of an embodiment of a slurry distributor constructed in accordance with principles of the present disclosure that defines an interior geometry that is similar to the slurry distributor of FIG. 1, but that is constructed from a rigid material and has a two-piece construction.

[0018] FIG. 5 is another perspective view of the slurry distributor of FIG. 4 but with a profiling system removed for illustrative purposes.

15 [0019] FIG. 6 is an isometric view of another embodiment of a slurry distributor constructed in accordance with principles of the present disclosure, which includes a first feed inlet and a second feed inlet disposed at about a sixty degree feed angle with respect to a longitudinal axis or machine direction of the slurry distributor.

[0020] FIG. 7 is a top plan view of the slurry distributor of FIG. 6.

20 [0021] FIG. 8 is a rear elevational view of the slurry distributor of FIG. 6.

[0022] FIG. 9 is a top plan view of a first piece of the slurry distributor of FIG. 6, which has a two-piece construction.

[0023] FIG. 10 is a front perspective view of the slurry distributor piece of FIG. 9.

25 [0024] FIG. 11 is an exploded view of the slurry distributor of FIG. 6 and a support system for the slurry distributor constructed in accordance with principles of the present disclosure.

[0025] FIG. 12 is a perspective view of the slurry distributor and the support system of FIG. 11.

**[0026]** FIG. 13 is an exploded view of the slurry distributor of FIG. 6 and another embodiment of a support system constructed in accordance with principles of the present disclosure.

5 **[0027]** FIG. 14 is a perspective view of the slurry distributor and the support system of FIG. 13.

**[0028]** FIG. 15 is a perspective view of an embodiment of a slurry distributor constructed in accordance with principles of the present disclosure that defines an interior geometry that is similar to the slurry distributor of FIG. 6, but that is constructed from a flexible material and has an integral construction.

10 **[0029]** FIG. 16 is a top plan view of the slurry distributor of FIG. 15.

**[0030]** FIG. 17 is an enlarged, perspective view of the interior geometry defined by the slurry distributor of FIG. 15, illustrating progressive cross-sectional flow areas of a portion of the feed conduit thereof.

15 **[0031]** FIG. 18 is an enlarged, perspective view of the interior geometry of the slurry distributor of FIG. 15, illustrating another progressive cross-sectional flow area of the feed conduit.

**[0032]** FIG. 19 is an enlarged, perspective view of the interior geometry of the slurry distributor of FIG. 15, illustrating yet another progressive cross-sectional flow area of the feed conduit which is aligned with a half of an entry portion to a distribution conduit of  
20 the slurry distributor of FIG. 15.

**[0033]** FIG. 20 is a perspective view of the slurry distributor of FIG. 15 and another embodiment of a support system constructed in accordance with principles of the present disclosure.

25 **[0034]** FIG. 21 is a perspective view as in FIG. 20, but with a support frame removed for illustrative purposes to show a plurality of retaining plates in distributed relationship with the slurry distributor of FIG. 15.

**[0035]** FIG. 22 is a perspective view of an embodiment of a multi-piece mold for making a slurry distributor as in FIG. 1 constructed in accordance with principles of the present disclosure.

**[0036]** FIGS. 22A-K are various detail views of mold segments of the multi-piece mold of FIG. 22.

**[0037]** FIG. 23 is a top plan view of the mold of FIG. 22.

**[0038]** FIG. 24 is an exploded view of an embodiment of a multi-piece mold for  
5 making a slurry distributor as in FIG. 15 constructed in accordance with principles of the present disclosure.

**[0039]** FIG. 25 is a perspective view of another embodiment of a mold for making a piece of a two-piece slurry distributor constructed in accordance with principles of the present disclosure.

10 **[0040]** FIG. 26 is a top plan view of the mold of FIG. 25.

**[0041]** FIG. 27 is a schematic plan diagram of an embodiment of a gypsum slurry mixing and dispensing assembly including a slurry distributor in accordance with principles of the present disclosure.

**[0042]** FIG. 28 is a schematic plan diagram of another embodiment of a gypsum  
15 slurry mixing and dispensing assembly including a slurry distributor in accordance with principles of the present disclosure.

**[0043]** FIG. 29 is a schematic elevational diagram of an embodiment of a wet end of a gypsum wallboard manufacturing line in accordance with principles of the present disclosure.

20 **[0044]** FIG. 30 is a perspective view of an embodiment of a flow splitter constructed in accordance with principles of the present disclosure suitable for use in a gypsum slurry mixing and dispensing assembly including a slurry distributor.

**[0045]** FIG. 31 is a side elevational view, in section, of the flow splitter of FIG. 30.

**[0046]** FIG. 32 is a side elevational view of the flow splitter of FIG. 30 with an  
25 embodiment of a squeezing apparatus constructed in accordance with principles of the present disclosure mounted thereto.

**[0047]** FIG. 33 is a top plan view of a half portion of a slurry distributor similar to the slurry distributor of FIG. 15.

[0048] FIG. 34 is a plot of the data from Table I of Example 1 showing the dimensionless distance from the feed inlet versus the dimensionless area and the dimensionless hydraulic radius of the half portion of the slurry distributor of FIG. 33.

[0049] FIG. 35 is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless velocity of a flow of modeled slurry moving through the half portion of the slurry distributor of FIG. 33.

[0050] FIG. 36 is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless shear rate in the modeled slurry moving through the half portion of the slurry distributor of FIG. 33.

[0051] FIG. 37 is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless viscosity of the modeled slurry moving through the half portion of the slurry distributor of FIG. 33.

[0052] FIG. 38 is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless shear stress in the modeled slurry moving through the half portion of the slurry distributor of FIG. 33.

[0053] FIG. 39 is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless Reynolds number of the modeled slurry moving through the half portion of the slurry distributor of FIG. 33.

#### DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0054] The present disclosure provides various embodiments of a slurry distribution system that can be used in the manufacture of products, including cementitious products such as gypsum wallboard, for example. Embodiments of a slurry distributor constructed in accordance with principles of the present disclosure can be used in a manufacturing process to effectively distribute a multi-phase slurry, such as one containing air and liquid phases, such as found in an aqueous foamed gypsum slurry,

for example. Embodiments of a method of making a slurry distributor according to principles of the present disclosure can use a multi-piece mold in a dip molding process.

**[0055]** Embodiments of a distribution system constructed in accordance with principles of the present disclosure can be used to distribute a slurry (e.g., an aqueous  
5 calcined gypsum slurry) onto an advancing web (e.g., paper or mat) moving on a conveyor during a continuous board (e.g., wallboard) manufacturing process. In one aspect, a slurry distribution system constructed in accordance with principles of the present disclosure can be used in a conventional gypsum drywall manufacturing process as, or part of, a discharge conduit attached to a mixer adapted to agitate  
10 calcined gypsum and water to form an aqueous calcined gypsum slurry.

**[0056]** Embodiments of a slurry distribution system constructed in accordance with principles of the present disclosure are aimed at accomplishing wider distribution (along the cross-machine direction) of a uniform gypsum slurry. Embodiments of a slurry distribution system of the present disclosure are suitable for use with a gypsum slurry  
15 having a range of WSRs, including WSRs conventionally used to manufacture gypsum wallboard and those that are relatively lower and have a relatively higher viscosity. Furthermore, a gypsum slurry distribution system of the present disclosure can be used to help control air-liquid phase separation, such as, in aqueous foamed gypsum slurry, including foamed gypsum slurry having a very high foam volume. The spreading of the  
20 aqueous calcined gypsum slurry over the advancing web can be controlled by routing and distributing the slurry using a distribution system as shown and described herein.

**[0057]** Embodiments of a method of preparing a gypsum product in accordance with principles of the present disclosure can include distributing an aqueous calcined gypsum slurry upon an advancing web using a slurry distributor constructed in  
25 accordance with principles of the present disclosure. Various embodiments of a method of distributing an aqueous calcined gypsum slurry upon a moving web are described herein.

**[0058]** Turning now to the Figures, there is shown in FIGS. 1-3 an embodiment of a slurry distributor 120 according to principles of the present disclosure, and in FIGS. 4  
30 and 5, another embodiment of a slurry distributor 220 according to principles of the

present disclosure is shown. The slurry distributor 120 shown in FIGS. 1-3 is constructed from a resiliently flexible material, whereas the slurry distributor 220 shown in FIGS. 3 and 4 is made from a relatively rigid material. However, the interior flow geometry of both slurry distributors 120, 220 in FIGS. 1-5 is the same, and reference should also be made to FIG. 5 when considering the slurry distributor 120 of FIGS. 1-3.

5 **[0059]** Referring to FIG. 1, the slurry distributor 120 includes a feed conduit 122, which has first and second feed inlets 124, 125, and a distribution conduit 128, which includes a distribution outlet 130 and is in fluid communication with the feed conduit 128. A profiling system 132 (see FIG. 3) adapted to locally vary the size of the distribution outlet 130 of the distribution conduit 128 can also be provided.

10 **[0060]** Referring to FIG. 1, the feed conduit 122 extends generally along a transverse axis or cross-machine direction 60, which is substantially perpendicular to a longitudinal axis or machine direction 50. The first feed inlet 124 is in spaced relationship with the second feed inlet 125. The first feed inlet 124 and the second feed inlet 125 define respective openings 134, 135 that have substantially the same area. The illustrated openings 134, 135 of the first and second feed inlets 124, 125 both have a circular cross-sectional shape as illustrated in this example. In other embodiments, the cross-sectional shape of the feed inlets 124, 125 can take other forms, depending upon the intended applications and process conditions present.

20 **[0061]** The first and second feed inlets 124, 125 are in opposing relationship to each other along the cross-machine axis 60 such that the first and second feed inlets 124, 125 are disposed at substantially a 90° angle to the machine axis 50. In other embodiments the first and second feed inlets 124, 125 can be oriented in a different manner with respect to the machine direction. For example, in some embodiments, the first and second feed inlets 124, 125 can be at an angle between 0° and about 135° with respect to the machine direction 50.

25 **[0062]** The feed conduit 122 includes first and second entry segments 136, 137 and a bifurcated connector segment 139 disposed between the first and second entry segments 136, 137. The first and second entry segments 136, 137 are generally cylindrical and extend along the transverse axis 60 such that they are substantially

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parallel to a plane 57 defined by the longitudinal axis 50 and the transverse axis 60. The first and second feed inlets 124, 125 are disposed at the distal ends of the first and the second entry segments 136, 137, respectively, and are in fluid communication therewith.

5 **[0063]** In other embodiments the first and second feed inlets 124, 125 and the first and second entry segments 136, 137 can be oriented in a different manner with respect to the transverse axis 60, the machine direction 50, and/or the plane 57 defined by the longitudinal axis 50 and the transverse axis 60. For example, in some embodiments, the first and second feed inlets 124, 125 and the first and second entry segments 136,  
10 137 can each be disposed substantially in the plane 57 defined by the longitudinal axis 50 and the transverse axis 60 at a feed angle  $\theta$  with respect to the longitudinal axis or machine direction 50 which is an angle in a range up to about  $135^\circ$  with respect to the machine direction 50, and in other embodiments in a range from about  $30^\circ$  to about  $135^\circ$ , and in yet other embodiments in a range from about  $45^\circ$  to about  $135^\circ$ , and in still  
15 other embodiments in a range from about  $40^\circ$  to about  $110^\circ$ .

**[0064]** The bifurcated connector segment 139 is in fluid communication with the first and second feed inlets 124, 125 and the first and the second entry segments 136, 137. The bifurcated connector segment 139 includes first and second shaped ducts 141, 143. The first and second feed inlets 124, 125 of the feed conduit 22 are in fluid  
20 communication with the first and second shaped ducts 141, 143, respectively. The first and second shaped ducts 141, 143 of the connector segment 139 are adapted to receive a first flow in a first feed direction 190 and a second flow in a second flow direction 191 of aqueous calcined gypsum slurry from the first and second feed inlets 124, 125, respectively, and to direct the first and second flows 190, 191 of aqueous  
25 calcined gypsum slurry into the distribution conduit 128.

**[0065]** As shown in FIG. 5, the first and second shaped ducts 141, 143 of the connector segment 139 define first and second feed outlets 140, 145 respectively in fluid communication with the first and second feed inlets 124, 125. Each feed outlet 140, 145 is in fluid communication with the distribution conduit 128. Each of the  
30 illustrated first and second feed outlets 140, 145 defines an opening 142 with a

generally rectangular inner portion 147 and a substantially circular side portion 149. The circular side portions 145 are disposed adjacent side walls 151, 153 of the distribution conduit 128.

**[0066]** In embodiments, the openings 142 of the first and second feed outlets 140, 5 145 can have a cross-sectional area that is larger than the cross-sectional area of the openings 134, 135 of the first feed inlet 124 and the second feed inlet 125, respectively. For example, in some embodiments, the cross-sectional area of the openings 142 of the first and second feed outlets 140, 145 can be in a range from greater than to about 300% greater than the cross-sectional area of the openings 134, 135 of the first feed 10 inlet 124 and the second feed inlet 125, respectively, in a range from greater than to about 200% greater in other embodiments, and in a range from greater than to about 150% greater in still other embodiments.

**[0067]** In embodiments, the openings 142 of the first and second feed outlets 140, 145 can have a hydraulic diameter ( $4 \times$  cross-sectional area / perimeter) that is smaller 15 than the hydraulic diameter of the openings 134, 135 of the first feed inlet 124 and the second feed inlet 125, respectively. For example, in some embodiments, the hydraulic diameter of the openings 142 of the first and second feed outlets 140, 145 can be about 80% or less than the hydraulic diameter of the openings 134, 135 of the first feed inlet 124 and the second feed inlet 125, respectively, about 70% or less in other 20 embodiments, and about 50% or less in still other embodiments.

**[0068]** Referring back to FIG. 1, the connector segment 139 is substantially parallel to the plane 57 defined by the longitudinal axis 50 and the transverse axis 60. In other embodiments the connector segment 139 can be oriented in a different manner with respect to the transverse axis 60, the machine direction 50, and/or the plane 57 defined 25 by the longitudinal axis 50 and the transverse axis 60.

**[0069]** The first feed inlet 124, the first entry segment 136, and the first shaped duct 141 are a mirror image of the second feed inlet 125, the second entry segment 137, and the second shaped duct 143, respectively. Accordingly, it will be understood that the description of one feed inlet is applicable to the other feed inlet, the description of one

entry segment is applicable to the other entry segment, and the description of one shaped duct is applicable to the other shaped duct, as well in a corresponding manner.

5 **[0070]** The first shaped duct 141 is fluidly connected to the first feed inlet 124 and the first entry segment 136. The first shaped duct 141 is also fluidly connected to the distribution conduit 128 to thereby help fluidly connect the first feed inlet 124 and the distribution outlet 130 such that the first flow 190 of slurry can enter the first feed inlet 124; travel through the first entry segment 136, the first shaped duct 141, and the distribution conduit 128; and be discharged from the slurry distributor 120 through the distribution outlet 130.

10 **[0071]** The first shaped duct 141 has a front, outer curved wall 157 and an opposing rear, inner curved wall 158 defining a curved guide surface 165 adapted to redirect the first flow of slurry from the first feed flow direction 190, which is substantially parallel to the transverse or cross-machine direction 60, to an outlet flow direction 192, which is substantially parallel to the longitudinal axis or machine direction 50 and substantially perpendicular to the first feed flow direction 190. The first shaped duct 141 is adapted to receive the first flow of slurry moving in the first feed flow direction 190 and redirect the slurry flow direction by a change in direction angle  $\alpha$ , as shown in FIG. 9, such that the first flow of slurry is conveyed into the distribution conduit 128 moving substantially in the outlet flow direction 192.

20 **[0072]** In use, the first flow of aqueous calcined gypsum slurry passes through the first feed inlet 124 in the first feed direction 190, and the second flow of aqueous calcined gypsum slurry passes through the second feed inlet 125 in the second feed direction 191. The first and second feed directions 190, 191 can be symmetrical with respect to each other along the longitudinal axis 50 in some embodiments. The first flow of slurry moving in the first feed flow direction 190 is redirected in the slurry distributor 120 through a change in direction angle  $\alpha$  in a range up to about 135° to the outlet flow direction 192. The second flow of slurry moving in the second feed flow direction 191 is redirected in the slurry distributor 120 through a change in direction angle  $\alpha$  in a range up to about 135° to the outlet flow direction 192. The combined first and second flows 190, 191 of aqueous calcined gypsum slurry discharge from the slurry distributor 120 through the distribution outlet 130.

distributor 120 moving generally in the outlet flow direction 192. The outlet flow direction 192 can be substantially parallel to the longitudinal axis or machine direction 50.

**[0073]** For example, in the illustrated embodiment, the first flow of slurry is redirected from the first feed flow direction 190 along the cross-machine direction 60 through a change in direction angle  $\alpha$  of about ninety degrees about the vertical axis 55 to the outlet flow direction 192 along the machine direction 50. In some embodiments, the flow of slurry can be redirected from a first feed flow direction 190 through a change in direction angle  $\alpha$  about the vertical axis 55 which is in a range up to about 135° to the outlet flow direction 192, and in other embodiments in a range from about 30° to about 135°, and in yet other embodiments in a range from about 45° to about 135°, and in still other embodiments in a range from about 40° to about 110°.

**[0074]** In some embodiments, the shape of the rear curved guide surface 165 can be generally parabolic, which in the illustrated embodiment can be defined by a parabola of the form  $Ax^2+B$ . In alternate embodiments, higher order curves may be used to define the rear curved guide surface 165 or, alternatively, the rear, inner wall 158 can have a generally curved shape that is made up of straight or linear segments that have been oriented at their ends to collectively define a generally curved wall. Moreover, the parameters used to define the specific shape factors of the outer wall can depend on specific operating parameters of the process in which the slurry distributor will be used.

**[0075]** At least one of the feed conduit 122 and the distribution conduit 128 can include an area of expansion having a cross-sectional flow area that is greater than a cross-sectional flow area of an adjacent area upstream from the area of expansion in a direction from the feed conduit 122 toward the distribution conduit 128. The first entry segment 136 and/or the first shaped duct 141 can have a cross section that varies along the direction of flow to help distribute the first flow of slurry moving therethrough. The shaped duct 141 can have a cross sectional flow area that increases in a first flow direction 195 from the first feed inlet 124 toward the distribution conduit 128 such that the first flow of slurry is decelerated as it passes through the first shaped duct 141. In some embodiments, the first shaped duct 141 can have a maximum cross-section flow

area at a predetermined point along the first flow direction 195 and decrease from the maximum cross-sectional flow area at points further along the first flow direction 195.

**[0076]** In some embodiments, the maximum cross-sectional flow area of the first shaped duct 141 is about 200% of the cross-sectional area of the opening 134 of the first feed inlet 124 or less. In yet other embodiments, the maximum cross-sectional flow area of the shaped duct 141 is about 150% of the cross-sectional area of the opening 134 of the first feed inlet 124 or less. In still other embodiments, the maximum cross-sectional flow area of the shaped duct 141 is about 125% of the cross-sectional area of the opening 134 of the first feed inlet 124 or less. In yet other embodiments, the maximum cross-sectional flow area of the shaped duct 141 is about 110% of the cross-sectional area of the opening 134 of the first feed inlet 124 or less. In some embodiments, the cross-sectional flow area is controlled such that the flow area does not vary more than a predetermined amount over a given length to help prevent large variations in the flow regime.

**[0077]** In some embodiments, the first entry segment 136 and/or the first shaped duct 141 can include one or more guide channels 167, 168 that are adapted to help distribute the first flow of slurry toward the outer and/or the inner walls 157, 158 of the feed conduit 122. The guide channels 167, 168 are adapted to increase the flow of slurry around the boundary wall layers of the slurry distributor 120.

**[0078]** Referring to FIGS. 1 and 5, the guide channels 167, 168 can be configured to have a larger cross-sectional area than an adjacent portion 171 of the feed conduit 122 which defines a restriction that promotes flow to the adjacent guide channel 167, 168 respectively disposed at the wall region of the slurry distributor 120. In the illustrated embodiment, the feed conduit 122 includes the outer guide channel 167 adjacent the outer wall 157 and the sidewall 151 of the distribution conduit 128 and the inner guide channel 168 adjacent the inner wall 158 of the first shaped duct 141. The cross-sectional areas of the outer and inner guide channels 167, 168 can become progressively smaller moving in the first flow direction 195. The outer guide channel 167 can extend substantially along the sidewall 151 of the distribution conduit 128 to the distribution outlet 130. At a given cross-sectional location through the first shaped duct

141 in a direction perpendicular to the first flow direction 195, the outer guide channel 167 has a larger cross-sectional area than the inner guide channel 168 to help divert the first flow of slurry from its initial line of movement in the first feed direction 190 toward the outer wall 157.

5 **[0079]** Providing guide channels adjacent wall regions can help direct or guide slurry flow to those regions, which can be areas in conventional systems where “dead spots” of low slurry flow are found. By encouraging slurry flow at the wall regions of the slurry distributor 120 through the provision of guide channels, slurry buildup inside the slurry distributor is discouraged and the cleanliness of the interior of the slurry distributor 120  
10 can be enhanced. The frequency of slurry buildup breaking off into lumps which can tear the moving web of cover sheet material can also be decreased.

**[0080]** In other embodiments, the relative sizes of the outer and inner guide channels 167, 168 can be varied to help adjust the slurry flow to improve flow stability and reduce the occurrence of air-liquid slurry phase separation. For example, in applications using  
15 a slurry that is relatively more viscous, at a given cross-sectional location through the first shaped duct 141 in a direction perpendicular to the first flow direction 195, the outer guide channel 167 can have a smaller cross-sectional area than the inner guide channel 168 to help urge the first flow of slurry toward the inner wall 158.

**[0081]** The inner curved walls 158 of the first and second shaped ducts 141, 142  
20 meet to define a peak 175 adjacent an entry portion 152 of the distribution conduit 128. The peak 175 effectively bifurcates the connector segment 139. Each feed outlet 140, 145 is in fluid communication with the entry portion 152 of the distribution conduit 128.

**[0082]** The location of the peak 175 along the longitudinal axis 50 can vary in other embodiments. For example, the inner curved walls 158 of the first and second shaped  
25 ducts 141, 142 can be less curved in other embodiments such that the peak 175 is further away from the distribution outlet 130 along the longitudinal axis 50 than as shown in the illustrated slurry distributor 120. In other embodiments, the peak 175 can be closer to the distribution outlet 130 along the longitudinal axis 50 than as shown in the illustrated slurry distributor 120.

**[0083]** The distribution conduit 128 is substantially parallel to the plane 57 defined by the longitudinal axis 50 and the transverse axis 60 and is adapted to urge the combined first and second flows of aqueous calcined gypsum slurry from the first and second shaped ducts 141, 142 into a generally two-dimensional flow pattern for enhanced stability and uniformity. The distribution outlet 130 has a width that extends a predetermined distance along the transverse axis 60 and a height that extends along a vertical axis 55, which is mutually perpendicular to the longitudinal axis 50 and the transverse axis 60. The height of the distribution outlet 130 is small relative to its width. The distribution conduit 128 can be oriented relative to a moving web of cover sheet upon a forming table such that the distribution conduit 128 is substantially parallel to the moving web.

**[0084]** The distribution conduit 128 extends generally along the longitudinal axis 50 and includes the entry portion 152 and the distribution outlet 130. The entry portion 152 is in fluid communication with the first and second feed inlets 124, 125 of the feed conduit 122. Referring to FIG. 5, the entry portion 152 is adapted to receive both the first and the second flows of aqueous calcined gypsum slurry from the first and second feed inlets 124, 125 of the feed conduit 122. The entry portion 152 of the distribution conduit 128 includes a distribution inlet 154 in fluid communication with the first and second feed outlets 140, 145 of the feed conduit 122. The illustrated distribution inlet 154 defines an opening 156 that substantially corresponds to the openings 142 of the first and second feed outlets 140, 145. The first and second flows of aqueous calcined gypsum slurry combine in the distribution conduit 128 such that the combined flows move generally in the outlet flow direction 192 which can be substantially aligned with the line of movement of a web of cover sheet material moving over a forming table in a wallboard manufacturing line.

**[0085]** The distribution outlet 130 is in fluid communication with the entry portion 152 and thus the first and second feed inlets 124, 125 and the first and second feed outlets 140, 145 of the feed conduit 122. The distribution outlet 130 is in fluid communication with the first and second shaped ducts 141, 143 and is adapted to discharge the

combined first and second flows of slurry therefrom along the outlet flow direction 192 upon a web of cover sheet material advancing along the machine direction 50.

5 **[0086]** Referring to FIG. 1, the illustrated distribution outlet 130 defines a generally rectangular opening 181 with semi-circular narrow ends 183, 185. The semi-circular ends 183, 185 of the opening 181 of the distribution outlet 130 can be the terminating end of the outer guide channels 167 disposed adjacent the side walls 151, 153 of the distribution conduit 128.

**[0087]** The opening 181 of the distribution outlet 130 has an area which is greater than the sum of the areas of the openings 134, 135 of the first and second feed inlets 10 124, 125 and is smaller than the area of the sum of the openings 142 of the first and second feed outlets 140, 145 (i.e., the opening 156 of the distribution inlet 154). Accordingly, the cross-sectional area of the opening 156 of the entry portion 152 of the distribution conduit 128 is greater than the cross-sectional area of the opening 181 of the distribution outlet 130.

15 **[0088]** For example, in some embodiments, the cross-sectional area of the opening 181 of the distribution outlet 130 can be in a range from greater than to about 400% greater than the sum of the cross-sectional areas of the openings 134, 135 of the first and second feed inlets 124, 125, in a range from greater than to about 200% greater in other embodiments, and in a range from greater than to about 150% greater in still other 20 embodiments. In other embodiments, the ratio of the sum of the cross-sectional areas of the openings 134, 135 of the first and second feed inlets 124, 125 to the cross-sectional area of the opening 181 of the distribution outlet 130 can be varied based upon one or more factors, including the speed of the manufacturing line, the viscosity of the slurry being distributed by the distributor 120, the width of the board product being 25 made with the distributor 120, etc. In some embodiments, the cross-sectional area of the opening 156 of the entry portion 152 of the distribution conduit 128 can be in a range from greater than to about 200% greater than the cross-sectional area of the opening 181 of the distribution outlet 130, in a range from greater than to about 150% greater in other embodiments, and in a range from greater than to about 125% greater 30 in still other embodiments.



**[0089]** The distribution outlet 130 extends substantially along the transverse axis 60. The opening 181 of the distribution outlet 130 has a width  $W_1$  of about twenty-four inches along the transverse axis 60 and a height  $H_1$  of about one inch along the vertical axis 55 (see FIG. 3, also). In other embodiments, the size and shape of the opening  
5 181 of the distribution outlet 130 can be varied.

**[0090]** The distribution outlet 130 is disposed intermediately along the transverse axis 60 between the first feed inlet 124 and the second feed inlet 125 such that the first feed inlet 124 and the second feed inlet 125 are disposed substantially the same distance  $D_1$ ,  $D_2$  from a transverse central midpoint 187 of the distribution outlet 130 (see  
10 FIG. 3, also). The distribution outlet 130 can be made from a resiliently flexible material such that its shape is adapted to be variable along the transverse axis 60, such as by the profiling system 32, for example.

**[0091]** It is contemplated that the width  $W_1$  and/or height  $H_1$  of the opening 181 of the distribution outlet 130 can be varied in other embodiments for different operating  
15 conditions. In general, the overall dimensions of the various embodiments for slurry distributors as disclosed herein can be scaled up or down depending on the type of product being manufactured (for example, the thickness and/or width of manufactured product), the speed of the manufacturing line being used, the rate of deposition of the slurry through the distributor, the viscosity of the slurry, and the like. For example, the  
20 width  $W_1$ , along the transverse axis 60, of the distribution outlet 130 for use in a wallboard manufacturing process, which conventionally is provided in nominal widths no greater than fifty-four inches, can be within a range from about eight to about fifty-four inches in some embodiments, and in other embodiments within a range from about eighteen inches to about thirty inches. In other embodiments, the ratio of the width  $W_1$ ,  
25 along the transverse axis 60, of the distribution outlet 130 to the maximum nominal width of the panel being produced on the manufacturing system using the slurry distributor constructed according to principles of the present disclosure can be in a range from about 1/7 to about 1, in a range from about 1/3 to about 1 in other  
embodiments, in a range from about 1/3 to about 2/3 in yet other embodiments, and in a  
30 range from about 1/2 to about 1 in still other embodiments.

**[0092]** The height of the distribution outlet can be within a range from about 3/16 inch to about two inches in some embodiments, and in other embodiments between about 3/16 inch and about an inch. In some embodiments including a rectangular distribution outlet, the ratio of the rectangular width to the rectangular height of the outlet opening can be about 4 or more, in other embodiments about 8 or more, in some 5 embodiments from about 4 to about 288, in other embodiments from about 9 to about 288, in other embodiments from about 18 to about 288, and in still other embodiments from about 18 to about 160.

**[0093]** The distribution conduit 128 includes a converging portion 182 in fluid 10 communication with the entry portion 152. The height of the converging portion 182 is less than the height at the maximum cross-sectional flow area of the first and second shaped ducts 141, 143 and less than the height of the opening 181 of the distribution outlet 130. In some embodiments, the height of the converging portion 182 can be about half the height of the opening 181 of the distribution outlet 130.

**[0094]** The converging portion 182 and the height of the distribution outlet 130 can 15 cooperate together to help control the average velocity of the combined first and second flows of aqueous calcined gypsum being distributed from the distribution conduit 128. The height and/or width of the distribution outlet 130 can be varied to adjust the average velocity of the combined first and second flows of slurry discharging from the slurry 20 distributor 120.

**[0095]** In some embodiments, the outlet flow direction 192 is substantially parallel to the plane 57 defined by the machine direction 50 and the transverse cross-machine direction 60 of the system transporting the advancing web of cover sheet material. In other embodiments, the first and second feed directions 190, 191 and the outlet flow 25 direction 192 are all substantially parallel to the plane 57 defined by the machine direction 50 and the transverse cross-machine direction 60 of the system transporting the advancing web of cover sheet material. In some embodiments, the slurry distributor can be adapted and arranged with respect to the forming table such that the flow of slurry is redirected in the slurry distributor 120 from the first and second feed directions

190, 191 to the outlet flow direction 192 without undergoing substantial flow redirection by rotating about the cross-machine direction 60.

**[0096]** In some embodiments, the slurry distributor can be adapted and arranged with respect to the forming table such that the first and second flows of slurry are  
5 redirected in the slurry distributor from the first and second feed directions 190, 191 to the outlet flow direction 192 by redirecting the first and second flows of slurry by rotating about the cross-machine direction 60 over an angle of about forty-five degrees or less. Such a rotation can be accomplished in some embodiments by adapting the slurry distributor such that the first and second feed inlets 124, 125 and the first and second  
10 feed directions 190, 191 of the first and second flows of slurry are disposed at a vertical offset angle  $\omega$  with respect to the vertical axis 55 and the plane 57 formed by the machine axis 50 and the cross-machine axis 60. In embodiments, the first and second feed inlets 124, 125 and the first and second feed directions 190, 191 of the first and second flows of slurry can be disposed at a vertical offset angle  $\omega$  within a range from  
15 zero to about sixty degrees such that the flow of slurry is redirected about the machine axis 50 and moves along the vertical axis 55 in the slurry distributor 120 from the first and second feed directions 190, 191 to the outlet flow direction 192. In embodiments, at least one of the respective entry segment 136, 137 and the shaped ducts 141, 143 can be adapted to facilitate the redirection of the slurry about the machine axis 50 and  
20 along the vertical axis 55. In embodiments, the first and second flows of slurry can be redirected from the first and second feed directions 190, 191 through a change in direction angle  $\alpha$  about an axis substantially perpendicular to vertical offset angle  $\omega$  and/or one or more other rotational axes within a range of about forty-five degrees to about one hundred fifty degrees to the outlet flow direction 192 such that the outlet flow  
25 direction 192 is generally aligned with the machine direction 50.

**[0097]** In use, first and second flows of aqueous calcined gypsum slurry pass through the first and second feed inlets 124, 125 in converging first and second feed directions 190, 191. The first and second shaped ducts 141, 143 redirect the first and second flows of slurry from the first feed direction 190 and the second feed direction  
30 191 so that the first and second flows of slurry move over a change in direction angle  $\alpha$

from both being substantially parallel to the transverse axis 60 to both being substantially parallel to the machine direction 50. The distribution conduit 128 can be positioned such that it extends along the longitudinal axis 50 which substantially coincides with the machine direction 50 along which a web of cover sheet material  
5 moves in a method making a gypsum board. The first and second flows of aqueous calcined gypsum slurry combine in the slurry distributor 120 such that the combined first and second flows of aqueous calcined gypsum slurry pass through the distribution outlet 130 in the outlet flow direction 192 generally along the longitudinal axis 50 and in the direction of the machine direction.

10 **[0098]** Referring to FIG. 2, a slurry distributor support 100 can be provided to help support the slurry distributor 120, which in the illustrated embodiment is made from a flexible material, such as PVC or urethane, for example. The slurry distributor support 100 can be made from a suitable rigid material to help support the flexible slurry distributor 120. The slurry distributor support 100 can include a two-piece construction.  
15 The two pieces 101, 103 can be pivotally movable with respect to each other about a hinge 105 at the rear end thereof to allow for ready access to an interior 107 of the support 100. The interior 107 of the support 100 can be configured such that the interior 107 substantially conforms to the exterior of the slurry distributor 120 to help limit the amount of movement the slurry distributor 120 can undergo with respect to the support 100 and/or to help define the interior geometry of the slurry distributor 120  
20 through which a slurry will flow.

**[0099]** Referring to FIG. 3, in some embodiments, the slurry distributor support 100 can be made from a suitable resiliently flexible material that provides support and is able to be deformed in response to the profiling system 132 mounted to the support  
25 100. The profiling system 132 can be mounted to the support 100 adjacent the distribution outlet 130 of the slurry distributor 120. The profiling system 132 so installed can act to vary the size and/or shape of the distribution outlet 130 of the distribution conduit 128 by also varying the size and/or shape of the closely conforming support 100, which in turn, influences the size and/or shape of the distribution outlet 130.

**[00100]** Referring to FIG. 3, the profiling system 132 can be adapted to selectively change the size and/or shape of the opening 181 of the distribution outlet 130. In some embodiments, the profiling system can be used to selectively adjust the height  $H_1$  of the opening 181 of the distribution outlet 130.

5 **[00101]** The illustrated profiling system 132 includes a plate 90, a plurality of mounting bolts 92 securing the plate to the distribution conduit 128, and a series of adjustment bolts 94, 95 threadingly secured thereto. The mounting bolts 92 are used to secure the plate 90 to the support 100 adjacent the distribution outlet 130 of the slurry distributor 120. The plate 90 extends substantially along the transverse axis 60. In the illustrated  
10 embodiment, the plate 90 is in the form of a length of angle iron. In other embodiments, the plate 90 can have different shapes and can comprise different materials. In still other embodiments, the profiling system can include other components adapted to selectively change the size and/or shape of the opening 181 of the distribution outlet 130.

15 **[00102]** The illustrated profiling system 132 is adapted to locally vary along the transverse axis 60 the size and/or shape of the opening 181 of the distribution outlet 130. The adjustment bolts 94, 95 are in regular, spaced relationship to each other along the transverse axis 60 over the distribution outlet 130. The adjustment bolts 94, 95 are independently adjustable to locally vary the size and/or shape of the distribution  
20 outlet 130.

**[00103]** The profiling system 132 can be used to locally vary the distribution outlet 130 so as to alter the flow pattern of the combined first and second flows of aqueous calcined gypsum slurry being distributed from the slurry distributor 120. For example, the mid-line adjustment bolt 95 can be tightened down to constrict the transverse central  
25 midpoint 187 of the distribution outlet 130 to increase the edge flow angle away from the longitudinal axis 50 to facilitate spreading in the cross-machine direction 60 and to improve the slurry flow uniformity in the cross-machine direction 60.

**[00104]** The profiling system 132 can be used to vary the size of the distribution outlet 130 along the transverse axis 60 and maintain the distribution outlet 130 in the new  
30 shape. The plate 90 can be made from a material that is suitably strong such that the

plate 90 can withstand opposing forces exerted by the adjustment bolts 94, 95 in response to adjustments made by the adjustment bolts 94, 95 in urging the distribution outlet 130 into a new shape. The profiling system 132 can be used to help even out variations in the flow profile of the slurry (for example, as a result of different slurry densities and/or different feed inlet velocities) being discharged from the distribution outlet 130 such that the exit pattern of the slurry from the distribution conduit 128 is more uniform.

**[00105]** In other embodiments, the number of adjustment bolts can be varied such that the spacing between adjacent adjustment bolts changes. In other embodiments, such as where the width  $W_1$  of the distribution outlet 130 is different, the number of adjustment bolts can also be varied to achieve a desired adjacent bolt spacing. In yet other embodiments, the spacing between adjacent bolts can vary along the transverse axis 60, for example to provide greater locally-varying control at the side edges 183, 185 of the distribution outlet 130.

**[00106]** A slurry distributor constructed in accordance with principles of the present disclosure can comprise any suitable material. In some embodiments, a slurry distributor can comprise any suitable substantially rigid material which can include a suitable material which can allow the size and shape of the outlet to be modified using a profile system, for example. For example, a suitably rigid plastic, such as ultra-high molecular weight (UHMW) plastic, or metal can be used. In other embodiments, a slurry distributor constructed in accordance with principles of the present disclosure can be made from a flexible material, such as a suitable flexible plastic material, including poly vinyl chloride (PVC) or urethane, for example. In some embodiments, a slurry distributor constructed in accordance with principles of the present disclosure can include a single feed inlet, entry segment, and shaped duct which is in fluid communication with a distribution conduit.

**[00107]** A gypsum slurry distributor constructed in accordance with principles of the present disclosure can be used to help provide a wide cross machine distribution of aqueous calcined gypsum slurry to facilitate the spreading of high viscous/lower WSR gypsum slurries on a web of cover sheet material moving over a forming table. The

gypsum slurry distribution system can be used to help control air-slurry phase separation, as well.

**[00108]** In accordance with another aspect of the present disclosure, a gypsum slurry mixing and dispensing assembly can include a slurry distributor constructed in accordance with principles of the present disclosure. The slurry distributor can be placed in fluid communication with a gypsum slurry mixer adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. In one embodiment, the slurry distributor is adapted to receive a first flow and a second flow of aqueous calcined gypsum slurry from the gypsum slurry mixer and distribute the first and second flows of aqueous calcined gypsum slurry onto an advancing web.

**[00109]** The slurry distributor can comprise a part of, or act as, a discharge conduit of a conventional gypsum slurry mixer (e.g., a pin mixer) as is known in the art. The slurry distributor can be used with components of a conventional discharge conduit. For example, the slurry distributor can be used with components of a gate-canister-boot arrangement as known in the art or of the discharge conduit arrangements described in U.S. Patent Nos. 6,494,609; 6,874,930; 7,007,914; and 7,296,919.

**[00110]** A slurry distributor constructed in accordance with principles of the present disclosure can advantageously be configured as a retrofit in an existing wallboard manufacturing system. The slurry distributor preferably can be used to replace a conventional single or multiple-branch boot used in conventional discharge conduits. This gypsum slurry distributor can be retrofitted to an existing slurry discharge conduit arrangement, such as that shown in U.S. Patent No. 6,874,930 or 7,007,914, for example, as a replacement for the distal dispensing spout or boot. However, in some embodiments, the slurry distributor may, alternatively, be attached to one or more boot outlet(s).

**[00111]** Referring to FIGS. 4 and 5, the slurry distributor 220 is similar to the slurry distributor 120 of FIGS. 1-3, except that it is constructed from a substantially rigid material. The interior geometry 207 of the slurry distributor 220 of FIGS. 4 and 5 is similar to that of the slurry distributor 120 of FIGS. 1-3, and like reference numerals are used to indicate like structure. The interior geometry 207 of the slurry distributor 207 is

adapted to define a flow path for the gypsum slurry traveling therethrough which is of the manner of a streamline flow, undergoing reduced or substantially no air-liquid slurry phase separation and substantially without undergoing a vortex flow path.

5 [00112] In some embodiments, the slurry distributor 220 can comprise any suitable substantially rigid material which can include a suitable material which can allow the size and shape of the outlet 130 to be modified using a profile system, for example. For example, a suitably rigid plastic, such as UHMW plastic, or metal can be used.

[00113] Referring to FIG. 4, the slurry distributor 220 has a two-piece construction. An upper piece 221 of the slurry distributor 220 includes a recess 227 adapted to  
10 receive a profiling system 132 therein. The two pieces 221, 223 can be pivotally movable with respect to each other about a hinge 205 at the rear end thereof to allow for ready access to an interior 207 of the slurry distributor 220. Mounting holes 229 are provided to facilitate the connection of the upper piece 221 and its mating lower piece 223.

15 [00114] Referring to FIGS. 6-8, another embodiment of a slurry distributor 320 constructed in accordance with principles of the present disclosure is shown which is constructed from a rigid material. The slurry distributor 320 of FIGS. 6-8 is similar to the slurry distributor 220 of FIGS. 4 and 5 except that the first and second feed inlets 324, 325 and the first and second entry segments 336, 337 of the slurry distributor 320 of  
20 FIGS. 6-8 are disposed at a feed angle  $\theta$  with respect to the longitudinal axis or machine direction 50 of about  $60^\circ$  (see FIG. 7).

[00115] The slurry distributor 320 has a two-piece construction including an upper piece 321 and its mating lower piece 323. The two pieces 321, 323 of the slurry distributor 320 can be secured together using any suitable technique, such as by using  
25 fasteners through a corresponding number of mounting holes 329 provided in each piece 321, 323, for example. The upper piece 321 of the slurry distributor 320 includes a recess 327 adapted to receive a profiling system 132 therein. The slurry distributor 320 of FIGS. 6-8 is similar in other respects to the slurry distributor 220 of FIGS. 4 and 5.



**[00116]** Referring to FIGS. 9 and 10, the lower piece 323 of the slurry distributor 320 of FIG. 6 is shown. The lower piece 323 defines a first portion 331 of the interior geometry 307 of the slurry distributor 320 of FIG. 6. The upper piece 323 defines a symmetrical second portion of the interior geometry 307 such that when the upper and lower pieces 321, 323 are mated together, as shown in FIG. 6, they define the complete interior geometry 307 of the slurry distributor 320 of FIG. 6.

**[00117]** Referring to FIG. 9, the first and second shaped ducts 341, 343 are adapted to receive the first and second flows of slurry moving in the first and second feed flow directions 390, 391 and redirect the slurry flow direction by a change in direction angle  $\alpha$  such that the first and second flows of slurry are conveyed into the distribution conduit 328 moving substantially in the outlet flow direction 392, which is aligned with the machine direction or longitudinal axis 50.

**[00118]** FIGS. 11 and 12 depict another embodiment of a slurry distributor support 300 for use with the slurry distributor 320 of FIG. 6. The slurry distributor support 300 can include a top and bottom support plate 301, 302 constructed from a suitably rigid material, such as metal, for example. The support plates 301, 302 can be secured to the distributor through any suitable means. In use, the support plates 301, 302 can help support the slurry distributor 320 in place over a machine line including a conveyor assembly supporting and transporting a moving cover sheet. The support plates 301, 302 can be mounted to appropriate uprights placed on either side of the conveyor assembly.

**[00119]** FIGS. 13 and 14 depict yet another embodiment of a slurry distributor support 310 for use with the slurry distributor 320 of FIG. 6, which also includes top and bottom support plates 311, 312. Cutouts 313, 314, 318 in the top support plate 311 can make the support 310 lighter than it would otherwise be and provide access to portions of the slurry distributor 320, such as those portions accommodating mounting fasteners, for example. The slurry distributor support 310 of FIGS. 13 and 14 can be similar in other respects to the slurry distributor support 300 of FIGS. 11 and 12.

**[00120]** FIGS. 15-19 illustrate another embodiment of a slurry distributor 420, which is similar to the slurry distributor 320 of FIGS. 6-8, except that it is constructed from a

substantially flexible material. The slurry distributor 420 of FIGS. 15-19 also includes first and second feed inlets 324, 325 and first and second entry segments 336, 337 which are disposed at a feed angle  $\theta$  with respect to the longitudinal axis or machine direction 50 of about  $60^\circ$  (see FIG. 7). The interior geometry 307 of the slurry distributor 5 420 of FIGS. 15-19 is similar to that of the slurry distributor 320 of FIGS. 6-8, and like reference numerals are used to indicate like structure.

**[00121]** FIGS. 17-19 progressively depict the interior geometry of the second entry segment 337 and the second shaped duct 343 of the slurry distributor 420 of FIGS. 15 and 16. The cross-sectional areas 411, 412, 413, 414 of the outer and inner guide 10 channels 367, 368 can become progressively smaller moving in a second flow direction 397 toward the distribution outlet 330. The outer guide channel 367 can extend substantially along the outer wall 357 of the second shaped duct 343 and along the sidewall 353 of the distribution conduit 328 to the distribution outlet 330. The inner guide channel 368 is adjacent the inner wall 358 of the second shaped duct 343 and 15 terminates at the peak 375 of the bisected connector segment 339. The slurry distributor 420 of FIGS. 15-19 is similar in other respects to the slurry distributor 120 of FIG. 1 and the slurry distributor 320 of FIG. 6.

**[00122]** Referring to FIGS. 20 and 21, the illustrated embodiment of the slurry distributor 420 is made from a flexible material, such as PVC or urethane, for example. 20 A slurry distributor support 400 can be provided to help support the slurry distributor 420. The slurry distributor support 400 can include a support member, which in the illustrated embodiment is in the form of a bottom support tray 401 filled with a suitable supporting medium 402 which defines a supporting surface 404. The supporting surface 404 is configured to substantially conform to at least a portion of an exterior of 25 at least one of the feed conduit 322 and the distribution conduit 328 to help limit the amount of relative movement between the slurry distributor 420 and the support tray 401. In some embodiments, the supporting surface 404 can also help maintain the interior geometry of the slurry distributor 420 through which a slurry will flow.

**[00123]** The slurry distributor support 400 can also include a movable support 30 assembly 405 disposed in spaced relationship to bottom support tray 401. The movable

support assembly 405 can be positioned above the slurry distributor 420 and adapted to be placed in supporting relationship with the slurry distributor 420 to help maintain the interior geometry 307 of the slurry distributor in a desired configuration.

5 **[00124]** The movable support assembly 405 can include a support frame 407 and a plurality of support segments 415, 416, 417, 418, 419 which are movably supported by the support frame 407. The support frame 407 can be mounted to at least one of the bottom support tray 401 or a suitably arranged upright or uprights to retain the support frame 407 in fixed relationship to the bottom support tray 401.

10 **[00125]** In embodiments, at least one support segment 415, 416, 417, 418, 419 is independently movable relative to another support segment 415, 416, 417, 418, 419. In the illustrated embodiment, each support segment 415, 416, 417, 418, 419 can be independently movable relative to the support frame 407 over a predetermined range of travel. In embodiments, each support segment 415, 416, 417, 418, 419 is movable over  
15 a range of travel such that each support segment is in a range of positions over which the respective support segment 415, 416, 417, 418, 419 is in increasing compressive engagement with a portion of at least one of the feed conduit 322 and the distribution conduit 328.

**[00126]** The position of each support segment 415, 416, 417, 418, 419 can be adjusted to place the support segments 415, 416, 417, 418, 419 in compressive  
20 engagement with at least a portion of the slurry distributor 420. Each support segment 415, 416, 417, 418, 419 can be independently adjusted to place each support segment 415, 416, 417, 418, 419 either in further compressive engagement with at least a portion of the slurry distributor 420, thereby locally compressing the interior of the slurry distributor 420, or in reduced compressive engagement with at least a portion of the  
25 slurry distributor 420, thereby allowing the interior of the slurry distributor 420 to expand outwardly, such as in response to aqueous gypsum slurry flowing therethrough.

**[00127]** In the illustrated embodiment, each of the support segments 415, 416, 417 is movable over a range of travel along the vertical axis 55. In other embodiments, at least one of the support segments can be movable along a different line of action.

**[00128]** The movable support assembly 405 includes a clamping mechanism 408 associated with each support segment 415, 416, 417, 418, 419. Each clamping mechanism 408 can be adapted to selectively retain the associated support segment 415, 416, 417, 418, 419 in a selected position relative to the support frame 407.

5 **[00129]** In the illustrated embodiment, a rod 409 is mounted to each support segment 415, 416, 417, 418, 419 and extends upwardly through a corresponding opening in the support frame 407. Each clamping mechanism 408 is mounted to the support frame 407 and is associated with one of the rods 409 projecting from a respective support segment 415, 416, 417, 418, 419. Each clamping mechanism 408 can be adapted to  
10 selectively retain the associated rod 409 in fixed relationship to the support frame 407. The illustrated clamping mechanisms 408 are conventional lever-actuated clamps which encircle the respective rod 409 and allow for infinitely variable adjustment between the clamping mechanism 408 and the associated rod 409.

**[00130]** As one skilled in the art will appreciate, any suitable clamping mechanism 408  
15 can be used in other embodiments. In some embodiments, each associated rod 409 can be moved via a suitable actuator (either hydraulic or electric, e.g.) which is controlled via a controller. The actuator can function as a clamping mechanism by retaining the associated support segment 415, 416, 417, 418, 419 in a fixed position relative to the support frame 407.

20 **[00131]** Referring to FIG. 21, the support segments 415, 416, 417, 418, 419 can each include a contacting surface 501, 502, 503, 504, 505 which is configured to substantially conform to a surface portion of the desired geometric shape of at least one of the feed conduit 322 and the distribution conduit 328 of the slurry distributor 420. In the  
25 illustrated embodiment, a distributor conduit support segment 415 is provided which includes a contacting surface 501 which conforms to the exterior and interior shape of a portion of the distributor conduit 328 over which the distributor conduit support segment 415 is disposed. A pair of shaped duct support segments 416, 417 is provided which respectively include a contacting surface 502, 503 which conforms to the exterior and  
30 interior shape of a portion of the first and the second shaped ducts 341, 343, respectively, over which the shaped duct support segments 416, 417 are disposed. A

pair of entry support segments 418, 419 is provided which respectively include a contacting surface 504, 505 which conforms to the exterior and interior shape of a portion of the first and the second entry segments 336, 337, respectively, over which the shaped duct support segments 418, 419 are disposed. The contacting surfaces 501, 502, 503, 504, 505 are adapted to be placed in contacting relationship with a selected portion of the slurry distributor 420 to help maintain the contacted portion of the slurry distributor 420 in position to help define the interior geometry 307 of the slurry distributor 420.

**[00132]** In use, the movable support assembly 405 can be operated to place each support segment 415, 416, 417, 418, 419 independently in a desired relationship with the slurry distributor 420. The support segments 415, 416, 417, 418, 419 can help maintain the interior geometry 307 of the slurry distributor 420 to promote the flow of slurry therethrough and to help ensure the volume defined by the interior geometry 307 is substantially filled with slurry during use. The location of the particular contacting surface of a given support segment 415, 416, 417, 418, 419 can be adjusted to modify locally the interior geometry of the slurry distributor 420. For example, the distributor conduit support segment 415 can be moved along the vertical axis 55 closer to the bottom support tray 401 to decrease the height of the distribution conduit 328 in an area over which the distributor conduit support segment 415 is.

**[00133]** In other embodiments, the number of support segments can be varied. In still other embodiments, the size and/or shape of a given support segment can be varied.

**[00134]** Any suitable technique for making a slurry distributor constructed in accordance with principles of the present disclosure can be used. For example, in embodiments where the slurry distributor is made from a flexible material, such as PVC or urethane, a multi-piece mold can be used. In some embodiments, the mold piece areas are about 150% or less than the area of the molded slurry distributor through which the mold piece is being pulled during removal, about 125% or less in other embodiments, about 115% or less in still other embodiments, and about 110% or less in yet other embodiments.

**[00135]** Referring to FIGS. 22 and 23, an embodiment of a multi-piece mold 550 suitable for use in making the slurry distributor 120 of FIG. 1 from a flexible material, such as PVC or urethane is shown. The illustrated multi-piece mold 550 includes five mold segments 551, 552, 553, 554, 555. The mold segments 551, 552, 553, 554, 555 of the multi-piece mold 550 can be made from any suitable material, such as aluminum, for example.

**[00136]** Each mold segment 551, 552, 553, 554, 555 includes an exterior surface configured to define at least a portion of an interior surface of a slurry distributor. The mold segments 551, 552, 553, 554, 555 are configured such that when the mold segments 551, 552, 553, 554, 555 are assembled together to form the multi-piece mold 550, the assembled mold segments define a substantially continuous exterior surface 580 adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon, in this case the slurry distributor 120 of FIG. 1.

**[00137]** Each mold segment 551, 552, 553, 554, 555 has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path out of a respective opening of the molded slurry distributor 120 which is in overlying relationship to the mold 550 when being made. The maximum cross-sectional area of each mold segment 551, 552, 553, 554, 555 is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor 120 through which the respective mold segment 551, 552, 553, 554, 555 traverses when moving along the respective removal path.

**[00138]** In embodiments, the maximum cross-sectional area of each mold segment 551, 552, 553, 554, 555 is up to about 125% of the smallest area of the interior flow region of the molded slurry distributor 120 through which the respective mold segment 551, 552, 553, 554, 555 traverses when moving along the respective removal path, in a range from greater than to about 150% of the smallest area of the interior flow region of the molded slurry distributor 120 through which the respective mold segment 551, 552, 553, 554, 555 traverses when moving along the respective removal path in other embodiments, about 115% or less in still other embodiments, and about 110% or less in yet other embodiments.

5 **[00139]** In the illustrated embodiment, the distributor conduit mold segment 551 is configured to define the interior flow geometry of the distributor conduit 128. The first and second shaped duct mold segments 552, 553 are configured to define the interior flow geometry of the first and the second shaped ducts 141, 143. The first and second entry mold segments 554, 555 define the interior flow geometry of the first entry segment 136 and the first feed inlet 124 and of the second entry segment 137 and the second feed inlet 125, respectively. In other embodiments, the multi-piece mold can include a different number of mold segments and/or the mold segments can have different shapes and/or sizes.

10 **[00140]** FIGS. 22A-E depict various views of the first entry mold segment 554. It should be understood that the second entry mold segment 555 is substantially a mirror image of the first entry mold segment 554. FIGS. 22F-I depict various views of the first shaped duct mold segment 552. It should be understood that the second shaped duct mold segment 553 is substantially a mirror image of the first shaped duct mold segment 15 552. FIGS. 22J and K show additional views of the distributor conduit mold segment 551.

**[00141]** Referring to FIG. 23, the distributor conduit mold segment 551 has a removal path 581 which is substantially aligned with the longitudinal axis 50. The distributor conduit mold segment 551 can be removed from the interior flow region of the slurry distributor 120 molded upon it by disassembling the distributor conduit mold segment 20 551 from the first and second shaped duct mold segments 552, 553 and the first and second entry mold segments 554, 555 and moving the distributor conduit mold segment 551 from its assembled position, shown in FIG. 23, along the removal path 581 out of the opening 181 of the discharge outlet 130.

25 **[00142]** The first shaped duct mold segment 552 and the first entry mold segment 554 each has a removal path 582, 584, respectively, which is substantially aligned with the transverse axis 60. The first entry mold segment 554 can be removed from the interior flow region of the slurry distributor 120 molded upon it by disassembling the first entry mold segment 554 from the first shaped duct mold segment 552 and the distributor 30 conduit mold segment 551 and moving the first entry mold segment 554 from its

assembled position, shown in FIG. 23, along the removal path 584 out of the opening 134 of the first feed inlet 124. Once the first entry mold segment 554 is removed, the first shaped duct mold segment 552 can be removed from the interior flow region of the slurry distributor 120 molded upon it by disassembling the first shaped duct mold segment 552 from the distributor conduit mold segment 551 and moving the first shaped duct mold segment 552 from its assembled position, shown in FIG. 23, along the removal path 582 out of the opening 134 of the first feed inlet 124.

5 [00143] The second shaped duct mold segment 553 and the second entry mold segment 555 each has a removal path 583, 585, respectively, which is substantially aligned with the transverse axis 60. The second entry mold segment 555 can be removed from the interior flow region of the slurry distributor 120 molded upon it by disassembling the second entry mold segment 555 from the second shaped duct mold segment 553 and the distributor conduit mold segment 551 and moving the second entry mold segment 555 from its assembled position, shown in FIG. 23, along the removal path 585 out of the opening 135 of the second feed inlet 125. Once the second entry mold segment 555 is removed, the second shaped duct mold segment 553 can be removed from the interior flow region of the slurry distributor 120 molded upon it by disassembling the second shaped duct mold segment 553 from the distributor conduit mold segment 551 and moving the second shaped duct mold segment 553 from its assembled position, shown in FIG. 23, along the removal path 583 out of the opening 135 of the second feed inlet 125.

15 [00144] In embodiments, at least two mold segments 551, 552, 553, 554, 555 define a respective passage therein where the passages are configured to be aligned with each other when the respective mold segments 551, 552, 553, 554, 555 are disposed in an assembled position so that the mold segment is disposed to define at least a portion of the interior surface of the slurry distributor. Suitable connecting rods adapted to be inserted through the aligned passages can be provided to interconnect the mold segments 551, 552, 553, 554, 555. In embodiments, at least three mold segments 551, 552, 553, 554, 555 can be interconnected with a suitable connecting rod.

25



**[00145]** Referring to FIG. 22, connecting bolts 571, 572, 573 can be inserted through passages in two or more mold segments to interlock and align the mold segments 551, 552, 553, 554, 555 such that a substantially continuous exterior surface 580 of the multi-piece mold 550 is defined. In some embodiments, a distal portion 575 of the  
5 connecting bolts 571, 572, 573 includes an external thread that is configured to threadingly engage one of the mold segments 551, 552, 553, 554, 555 to interconnect at least two of the mold segments 551, 552, 553, 554, 555.

**[00146]** Each of the outer distributor conduit connecting bolts 571 extends through aligned passages in the distributor conduit mold segment 551 and respectively through  
10 a shoulder portion 588, 589 of the first and second entry mold segments 554, 555 and the first and second shaped duct mold segments 552, 553. Each of the inner distributor conduit connecting bolts 572 extends through aligned passages in the distributor conduit mold segment 551 and respectively through the first and second shaped duct mold segments 552, 553. The first feed conduit connecting bolt 573 extends through  
15 aligned passages in the first entry mold segment 554 and the first shaped duct mold segment 552. The second feed conduit connecting bolt 573 extends through aligned passages in the second entry mold segment 555 and the second shaped duct mold segment 553.

**[00147]** Referring to FIG. 23, each mold segment 551, 552, 553, 554, 555 includes at  
20 least one mating surface 591, 592, 593, 594, 595, 596, 597 configured to have a shape that is complementary to a shape of the mating surface 591, 592, 593, 594, 595, 596, 597 of at least one other mold segment 551, 552, 553, 554, 555. In this way pairs of mating surfaces 591, 592, 593, 594, 595, 596, 597 can be joined together to place the mold segments 551, 552, 553, 554, 555 in the assembled position, as shown in FIG. 23.

**[00148]** In the illustrated embodiment, the mating surface 591 of the distributor  
25 conduit mold segment 551 matingly complements and is adjoined with the first mating surfaces 592, 593 of the first and second shaped duct mold segments 552, 553, respectively. The mating surface 594 of the first entry mold segment 554 matingly complements and is adjoined with the second mating surface 596 of the first shaped  
30 duct mold segment 552. The mating surface 595 of the second entry mold segment

555 matingly complements and is adjoined with the second mating surface 597 of the second shaped duct mold segment 553.

**[00149]** The exterior surface 580 of the multi-piece mold 550 is configured to define the interior geometry of the molded slurry distributor 120 so that flashing at the joints is reduced. The assembled multi-piece mold 550 can be dipped into a solution of flexible material, such as PVC or urethane, such that the mold 550 is completely submerged in the solution. The mold 550 can then be removed from the dipped material. An amount of the solution can adhere to the exterior surface 580 of the multi-piece mold 550 which will constitute the molded slurry distributor 120 once the solution changes to a solid form. In embodiments, the multi-piece mold 550 can be used in any suitable dipping process to form the molded piece.

**[00150]** The connecting bolts 571, 572, 573 can be removed to disassemble the multi-piece mold 550 during removal of the mold 550 from the interior of the molded slurry distributor 120. Access to the connecting bolts 571, 572, 573 can be provided through the respective openings 130, 143, 135 of the slurry distributor which are in fluid communication with the interior flow region of the slurry distributor 120.

**[00151]** By making the mold 550 out of multiple separate aluminum pieces — in the illustrated embodiment, five pieces — that have been designed to fit together to provide the desired interior flow geometry, the mold segments 551, 552, 553, 554, 555 can be disengaged from each other and pulled out from the solution once it has begun to set but while it is still warm. At sufficiently-high temperatures, the flexible material is pliable enough to pull larger calculated areas of the aluminum mold pieces 551, 552, 553, 554, 555 through the smaller calculated areas of the molded slurry distributor 120 without tearing it. In some embodiments, the largest mold piece area is up to about 150% of the smallest area of the molded slurry distributor cavity area through which the particular mold piece traverses transversely during the removal process, up to about 125% in other embodiments, up to about 115% in still other embodiments, and up to about 110% in yet other embodiments.

**[00152]** Referring to FIG. 24, an embodiment of a multi-piece mold 650 suitable for use in making the slurry distributor 320 of FIG. 6 from a flexible material, such as PVC

or urethane is shown. The illustrated multi-piece mold 650 includes five mold segments 651, 652, 653, 654, 655. The mold segments 651, 652, 653, 654, 655 of the multi-piece mold 550 can be made from any suitable material, such as aluminum, for example. The mold segments 651, 652, 653, 654, 655 are shown in a disassembled condition in FIG.

5 24.

**[00153]** Connecting bolts can be used to removably connect the mold segments 651, 652, 653, 654, 655 together to assemble the mold 650 such that a substantially continuous exterior surface of the multi-piece mold 650 is defined. The exterior surface of the multi-piece mold 650 defines the internal flow geometry of the slurry distributor 10 220 of FIG. 6. The mold 650 can be similar in construction to the mold 550 of FIGS. 22 and 23 in that each piece of the mold 650 of FIG. 24 is constructed such that its area is within a predetermined amount of the smallest area of the molded slurry distributor 220 through which the mold piece must traverse when it is being removed (e.g., greater than the smallest area of the molded slurry distributor cavity area through which the 15 particular mold piece traverses transversely during the removal process in some embodiments up to about 150% in other embodiments, up to about 150% of the smallest area of the molded slurry distributor cavity area through which the particular mold piece traverses transversely during the removal process in some embodiments, up to about 125% in other embodiments, up to about 115% in still other embodiments, and 20 up to about 110% in yet other embodiments). The multi-piece mold 650 of FIG. 24 can be similar in other respects to the multi-piece mold 550 of FIGS. 22 and 23 in other respects.

**[00154]** Various embodiments of a method of making a slurry distributor can be practiced using an embodiment of a multi-piece mold according to principles of the 25 present disclosure. In one embodiment, a plurality of mold segments of a multi-piece mold is assembled to define an exterior surface of the multi-piece mold. The assembled multi-piece mold is dipped into a solution of flexible material such that at least a portion of the multi-piece mold is submersed in the solution. The multi-piece mold is removed from the solution such that a layer of solution adheres substantially around the exterior 30 surface of the multi-piece mold. The solution is allowed to cure such that an at least

partially-solidified molded slurry distributor is formed around the multi-piece mold. The molded slurry distributor has an interior surface defining an interior flow region. The interior surface of the molded slurry distributor is in contacting relationship with the exterior surface of the multi-piece mold. The molded slurry distributor defines at least two openings each in fluid communication with the interior flow region.

5 [00155] The multi-piece mold is disassembled by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path. In 10 15 embodiments, at least a portion of the interior surface of the molded slurry distributor is substantially a negative image of at least a portion of the exterior surface of the multi-piece mold.

[00156] In embodiments, at least two mold segments can be assembled together by aligning a respective passage defined in the mold segments and inserting a connecting rod through the aligned passages to interconnect the mold segments. In some 20 25 embodiments, at least three mold segments are assembled together by inserting a connecting rod through aligned passages defined therein. In embodiments, each passage can be aligned with at least one respective opening of the molded slurry distributor to allow for the removal of the associated connecting rod from the passage.

[00157] In embodiments, at least one mold segment can be removed from the flow region of the slurry distributor through a different opening of the molded slurry distributor than at least one other mold segment. At least two mold segments can be removed from the interior flow region of the slurry distributor by following a removal path through the opening of the first feed inlet, and at least one mold segment can be removed from 30

the interior flow region of the slurry distributor by following a removal path through the opening of the distribution outlet.

**[00158]** Referring to FIGS. 25 and 26, an embodiment of a mold 750 for use in making one of the pieces 221, 223 of the two-piece slurry distributor 220 of FIG. 4 is shown. Referring to FIG. 25, mounting bore-defining elements 852 can be included to define mounting bores in the piece of the two-piece slurry distributor 220 of FIG. 34 being made to facilitate its connection with the other piece.

**[00159]** Referring to FIGS. 25 and 26, the mold 750 includes a mold surface 754 projecting from a bottom surface 756 of the mold 750. A boundary wall 756 extends along the vertical axis and defines the depth of the mold. The mold surface 754 is disposed within the boundary wall 756. The boundary wall 756 is configured to allow the volume of a cavity 758 defined within the boundary wall to be filled with molten mold material such that the mold surface 754 is immersed. The mold surface 754 is configured to be a negative image of the interior flow geometry defined by the particular piece of the two-piece distributor being molded.

**[00160]** In use, the cavity 758 of the mold 750 can be filled with a molten material such that the mold surface is immersed and the cavity 758 is filled with molten material. The molten material can be allowed to cool and removed from the mold 750. Another mold can be used to form the mating piece of the slurry distributor 220 of FIG. 4.

**[00161]** Referring to FIG. 27, an embodiment of a gypsum slurry mixing and dispensing assembly 810 includes a gypsum slurry mixer 912 in fluid communication with a slurry distributor 820 similar to the slurry distributor 320 shown in FIG. 6. The gypsum slurry mixer 812 is adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. Both the water and the calcined gypsum can be supplied to the mixer 812 via one or more inlets as is known in the art. Any suitable mixer (e.g., a pin mixer) can be used with the slurry distributor.

**[00162]** The slurry distributor 820 is in fluid communication with the gypsum slurry mixer 812. The slurry distributor 820 includes a first feed inlet 824 adapted to receive a first flow of aqueous calcined gypsum slurry from the gypsum slurry mixer 812 moving in a first feed direction 890, a second feed inlet 825 adapted to receive a second flow of

aqueous calcined gypsum slurry from the gypsum slurry mixer 812 moving in a second feed direction 891, and a distribution outlet 830 in fluid communication with both the first and the second feed inlets 824, 825 and adapted such that the first and second flows of aqueous calcined gypsum slurry discharge from the slurry distributor 820 through the distribution outlet 830 substantially along a machine direction 50.

5 [00163] The slurry distributor 820 includes a feed conduit 822 in fluid communication with a distribution conduit 828. The feed conduit includes the first feed inlet 824 and the second feed inlet 825 disposed in spaced relationship to the first feed inlet 824, which are both disposed at a feed angle  $\theta$  of about  $60^\circ$  with respect to the machine direction 10 50. The feed conduit 822 includes structure therein adapted to receive the first and second flows of slurry moving in the first and second feed flow direction 890, 891 and redirect the slurry flow direction by a change in direction angle  $\alpha$  (see FIG. 9) such that the first and second flows of slurry are conveyed into the distribution conduit 828 moving substantially in the outlet flow direction 892, which is substantially aligned with 15 the machine direction 50. The first and second feed inlets 824, 825 each has an opening with a cross-sectional area, and the entry portion 852 of the distribution conduit 828 has an opening with a cross-sectional area which is greater than the sum of the cross-sectional areas of the openings of the first and second feed inlets 824, 825.

[00164] The distribution conduit 828 extends generally along the longitudinal axis or 20 machine direction 50, which is substantially perpendicular to a transverse axis 60. The distribution conduit 828 includes an entry portion 852 and the distribution outlet 830. The entry portion 852 is in fluid communication with the first and second feed inlets 824, 825 of the feed conduit 822 such that the entry portion 852 is adapted to receive both the first and the second flows of aqueous calcined gypsum slurry therefrom. The 25 distribution outlet 830 is in fluid communication with the entry portion 852. The distribution outlet 830 of the distribution conduit 828 extends a predetermined distance along the transverse axis 60 to facilitate the discharge of the combined first and second flows of aqueous calcined gypsum slurry in the cross-machine direction or along the transverse axis 60. The slurry distributor 820 can be similar in other respects to the 30 slurry distributor 320 of FIG. 6.

**[00165]** A delivery conduit 814 is disposed between and in fluid communication with the gypsum slurry mixer 812 and the slurry distributor 820. The delivery conduit 814 includes a main delivery trunk 815, a first delivery branch 817 in fluid communication with the first feed inlet 824 of the slurry distributor 820, and a second delivery branch 818 in fluid communication with the second feed inlet 825 of the slurry distributor 820. The main delivery trunk 815 is in fluid communication with both the first and second delivery branches 817, 818. In other embodiments, the first and second delivery branches 817, 818 can be in independent fluid communication with the gypsum slurry mixer 812.

**[00166]** The delivery conduit 814 can be made from any suitable material and can have different shapes. In some embodiments, the delivery conduit 814 can comprise a flexible conduit.

**[00167]** An aqueous foam supply conduit 821 can be in fluid communication with at least one of the gypsum slurry mixer 812 and the delivery conduit 814. An aqueous foam from a source can be added to the constituent materials through the foam supply conduit 821 at any suitable location downstream of the mixer 812 and/or in the mixer 812 itself to form a foamed gypsum slurry that is provided to the slurry distributor 220. In the illustrated embodiment, the foam supply conduit 821 is disposed downstream of the gypsum slurry mixer 812. In the illustrated embodiment, the aqueous foam supply conduit 821 has a manifold-type arrangement for supplying foam to an injection ring or block associated with the delivery conduit 814 as described in U.S. Patent No. 6,874,930, for example.

**[00168]** In other embodiments, one or more foam supply conduits can be provided that are in fluid communication with the mixer 812. In yet other embodiments, the aqueous foam supply conduit(s) can be in fluid communication with the gypsum slurry mixer alone. As will be appreciated by those skilled in the art, the means for introducing aqueous foam into the gypsum slurry in the gypsum slurry mixing and dispensing assembly 810, including its relative location in the assembly, can be varied and/or optimized to provide a uniform dispersion of aqueous foam in the gypsum slurry to produce board that is fit for its intended purpose.

**[00169]** Any suitable foaming agent can be used. Preferably, the aqueous foam is produced in a continuous manner in which a stream of the mix of foaming agent and water is directed to a foam generator, and a stream of the resultant aqueous foam leaves the generator and is directed to and mixed with the calcined gypsum slurry.

5 Some examples of suitable foaming agents are described in U.S. Patent Nos. 5,683,635 and 5,643,510, for example.

**[00170]** When the foamed gypsum slurry sets and is dried, the foam dispersed in the slurry produces air voids therein which act to lower the overall density of the wallboard. The amount of foam and/or amount of air in the foam can be varied to adjust the dry  
10 board density such that the resulting wallboard product is within a desired weight range.

**[00171]** One or more flow-modifying elements 823 can be associated with the delivery conduit 814 and adapted to control the first and the second flows of aqueous calcined gypsum slurry from the gypsum slurry mixer 812. The flow-modifying element(s) 823 can be used to control an operating characteristic of the first and second flows of  
15 aqueous calcined gypsum slurry. In the illustrated embodiment of FIG. 27, the flow-modifying element(s) 823 is associated with the main delivery trunk 815. Examples of suitable flow-modifying elements include volume restrictors, pressure reducers, constrictor valves, canisters, etc., including those described in U.S. Pat. Nos. 6,494,609; 6,874,930; 7,007,914; and 7,296,919, for example.

20 **[00172]** The main delivery trunk 815 can be joined to the first and second delivery branches 817, 818 via a suitable Y-shaped flow splitter 819. The flow splitter 819 is disposed between the main delivery trunk 815 and the first delivery branch 817 and between the main delivery trunk 815 and the second delivery branch 818. In some embodiments, the flow splitter 819 can be adapted to help split the first and second  
25 flows of gypsum slurry such that they are substantially equal. In other embodiments, additional components can be added to help regulate the first and second flows of slurry.

**[00173]** In use, an aqueous calcined gypsum slurry is discharged from the mixer 812. The aqueous calcined gypsum slurry from the mixer 812 is split in the flow splitter 819  
30 into the first flow of aqueous calcined gypsum slurry and the second flow of aqueous



calcined gypsum slurry. The aqueous calcined gypsum slurry from the mixer 812 can be split such that the first and second flows of aqueous calcined gypsum slurry are substantially balanced.

5 **[00174]** Referring to FIG. 28, another embodiment of a gypsum slurry mixing and dispensing assembly 910 is shown. The gypsum slurry mixing and dispensing assembly 910 includes a gypsum slurry mixer 912 in fluid communication with a slurry distributor 920. The gypsum slurry mixer 912 is adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. The slurry distributor 920 can be similar in construction and function to the slurry distributor 320 of FIG. 6.

10 **[00175]** A delivery conduit 914 is disposed between and in fluid communication with the gypsum slurry mixer 912 and the slurry distributor 920. The delivery conduit 914 includes a main delivery trunk 915, a first delivery branch 917 in fluid communication with the first feed inlet 924 of the slurry distributor 920, and a second delivery branch 918 in fluid communication with the second feed inlet 925 of the slurry distributor 920.

15 **[00176]** The main delivery trunk 915 is disposed between and in fluid communication with the gypsum slurry mixer 912 and both the first and the second delivery branches 917, 918. An aqueous foam supply conduit 921 can be in fluid communication with at least one of the gypsum slurry mixer 912 and the delivery conduit 914. In the illustrated embodiment, the aqueous foam supply conduit 921 is associated with the main delivery  
20 trunk 915 of the delivery conduit 914.

**[00177]** The first delivery branch 917 is disposed between and in fluid communication with the gypsum slurry mixer 912 and the first feed inlet 924 of the slurry distributor 920. At least one first flow-modifying element 923 is associated with the first delivery branch 917 and is adapted to control the first flow of aqueous calcined gypsum slurry from the  
25 gypsum slurry mixer 912.

**[00178]** The second delivery branch 918 is disposed between and in fluid communication with the gypsum slurry mixer 912 and the second feed inlet 925 of the slurry distributor 920. At least one second flow-modifying element 927 is associated with the second delivery branch 918 and is adapted to control the second flow of  
30 aqueous calcined gypsum slurry from the gypsum slurry mixer 912.

**[00179]** The first and second flow-modifying elements 923, 927 can be operated to control an operating characteristic of the first and second flows of aqueous calcined gypsum slurry. The first and second flow-modifying elements 923, 927 can be independently operable. In some embodiments, the first and second flow-modifying elements 923, 927 can be actuated to deliver first and second flows of slurries that alternate between a relatively slower and relatively faster average velocity in opposing fashion such that at a given time the first slurry has an average velocity that is faster than that of the second flow of slurry and at another point in time the first slurry has an average velocity that is slower than that of the second flow of slurry.

**[00180]** As one of ordinary skill in the art will appreciate, one or both of the webs of cover sheet material can be pre-treated with a very thin relatively denser layer of gypsum slurry (relative to the gypsum slurry comprising the core), often referred to as a skim coat in the art, and/or hard edges, if desired. To that end, the mixer 912 includes a first auxiliary conduit 929 that is adapted to deposit a stream of dense aqueous calcined gypsum slurry that is relatively denser than the first and second flows of aqueous calcined gypsum slurry delivered to the slurry distributor (i.e., a "face skim coat/hard edge stream"). The first auxiliary conduit 929 can deposit the face skim coat/hard edge stream upon a moving web of cover sheet material upstream of a skim coat roller 931 that is adapted to apply a skim coat layer to the moving web of cover sheet material and to define hard edges at the periphery of the moving web by virtue of the width of the roller 931 being less than the width of the moving web as is known in the art. Hard edges can be formed from the same dense slurry that forms the thin dense layer by directing portions of the dense slurry around the ends of the roller used to apply the dense layer to the web.

**[00181]** The mixer 912 can also include a second auxiliary conduit 933 adapted to deposit a stream of dense aqueous calcined gypsum slurry that is relatively denser than the first and second flows of aqueous calcined gypsum slurry delivered to the slurry distributor (i.e., a "back skim coat stream"). The second auxiliary conduit 933 can deposit the back skim coat stream upon a second moving web of cover sheet material upstream (in the direction of movement of the second web) of a skim coat roller 937 that

is adapted to apply a skim coat layer to the second moving web of cover sheet material as is known in the art (see FIG. 29 also).

5 [00182] In other embodiments, separate auxiliary conduits can be connected to the mixer to deliver one or more separate edge streams to the moving web of cover sheet material. Other suitable equipment (such as auxiliary mixers) can be provided in the auxiliary conduits to help make the slurry therein denser, such as by mechanically breaking up foam in the slurry and/or by chemically breaking down the foam through use of a suitable de-foaming agent.

10 [00183] In yet other embodiments, first and second delivery branches can each include a foam supply conduit therein which are respectively adapted to independently introduce aqueous foam into the first and second flows of aqueous calcined gypsum slurry delivered to the slurry distributor. In still other embodiments, a plurality of mixers can be provided to provide independent streams of slurry to the first and second feed inlets of a slurry distributor constructed in accordance with principles of the present disclosure. It will be appreciated that other embodiments are possible.

15 [00184] The gypsum slurry mixing and dispensing assembly 910 of FIG. 28 can be similar in other respects to the gypsum slurry mixing and dispensing assembly 810 of FIG. 27. It is further contemplated that other slurry distributors constructed in accordance with principles of the present disclosure can be used in other embodiments of a gypsum slurry mixing and dispensing assembly as described herein.

20 [00185] Referring to FIG. 29, an exemplary embodiment of a wet end 1011 of a gypsum wallboard manufacturing line is shown. The wet end 1011 includes a gypsum slurry mixing and dispensing assembly 1010 having a gypsum slurry mixer 1012 in fluid communication with a slurry distributor 1020 similar in construction and function to the slurry distributor 320 of FIG. 6, a hard edge/face skim coat roller 1031 disposed upstream of the slurry distributor 1020 and supported over a forming table 1038 such that a first moving web 1039 of cover sheet material is disposed therebetween, a back skim coat roller 1037 disposed over a support element 1041 such that a second moving web 1043 of cover sheet material is disposed therebetween, and a forming station 1045 adapted to shape the preform into a desired thickness. The skim coat rollers 1031,

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1037, the forming table 1038, the support element 1041, and the forming station 1045 can all comprise conventional equipment suitable for their intended purposes as is known in the art. The wet end 1011 can be equipped with other conventional equipment as is known in the art.

5 [00186] In another aspect of the present disclosure, a slurry distributor constructed in accordance with principles of the present disclosure can be used in a variety of manufacturing processes. For example, in one embodiment, a slurry distribution system can be used in a method of preparing a gypsum product. A slurry distributor can be used to distribute an aqueous calcined gypsum slurry upon the first advancing  
10 web 1039.

[00187] Water and calcined gypsum can be mixed in the mixer 1012 to form the first and second flows 1047, 1048 of aqueous calcined gypsum slurry. In some embodiments, the water and calcined gypsum can be continuously added to the mixer in a water-to-calcined gypsum ratio from about 0.5 to about 1.3, and in other  
15 embodiments of about 0.75 or less.

[00188] Gypsum board products are typically formed "face down" such that the advancing web 1039 serves as the "face" cover sheet of the finished board. A face skim coat/hard edge stream 1049 (a layer of denser aqueous calcined gypsum slurry relative to at least one of the first and second flows of aqueous calcined gypsum slurry)  
20 can be applied to the first moving web 1039 upstream of the hard edge/face skim coat roller 1031, relative to the machine direction 1092, to apply a skim coat layer to the first web 1039 and to define hard edges of the board.

[00189] The first flow 1047 and the second flow 1048 of aqueous calcined gypsum slurry are respectively passed through the first feed inlet 1024 and the second feed inlet  
25 1025 of the slurry distributor 1020. The first and second flows 1047, 1048 of aqueous calcined gypsum slurry are combined in the slurry distributor 1020. The first and second flows 1047, 1048 of aqueous calcined gypsum slurry move along a flow path through the slurry distributor 1020 in the manner of a streamline flow, undergoing minimal or substantially no air-liquid slurry phase separation and substantially without  
30 undergoing a vortex flow path.

**[00190]** The first moving web 1039 moves along the longitudinal axis 50. The first flow 1047 of aqueous calcined gypsum slurry passes through the first feed inlet 1024, and the second flow 1048 of aqueous calcined gypsum slurry passes through the second feed inlet 1025. The distribution conduit 1028 is positioned such that it extends  
5 along the longitudinal axis 50 which substantially coincides with the machine direction 1092 along which the first web 1039 of cover sheet material moves. Preferably, the central midpoint of the distribution outlet 1030 (taken along the transverse axis / cross-machine direction 60) substantially coincides with the central midpoint of the first moving cover sheet 1039. The first and second flows 1047, 1048 of aqueous calcined  
10 gypsum slurry combine in the slurry distributor 1020 such that the combined first and second flows 1051 of aqueous calcined gypsum slurry pass through the distribution outlet 1030 in a distribution direction 1093 generally along the machine direction 1092.

**[00191]** In some embodiments, the distribution conduit 1028 is positioned such that it is substantially parallel to the plane defines by the longitudinal axis 50 and the  
15 transverse axis 60 of the first web 1039 moving along the forming table. In other embodiments, the entry portion of the distribution conduit can be disposed vertically lower or higher than the distribution outlet 1030 relative to the first web 1039.

**[00192]** The combined first and second flows 1051 of aqueous calcined gypsum slurry are discharged from the slurry distributor 1020 upon the first moving web 1039. The  
20 face skim coat/hard edge stream 1049 can be deposited from the mixer 1012 at a point upstream, relative to the direction of movement of the first moving web 1039 in the machine direction 1092, of where the first and second flows 1047, 1048 of aqueous calcined gypsum slurry are discharged from the slurry distributor 1020 upon the first moving web 1039. The combined first and second flows 1047, 1048 of aqueous  
25 calcined gypsum slurry can be discharged from the slurry distributor with a reduced momentum per unit width along the cross-machine direction relative to a conventional boot design to help prevent "washout" of the face skim coat/hard edge stream 1049 deposited on the first moving web 1039 (i.e., the situation where a portion of the deposited skim coat layer is displaced from its position upon the moving web 339 in  
30 response to the impact of the slurry being deposited upon it).

**[00193]** The first and second flows 1047, 1048 of aqueous calcined gypsum slurry respectively passed through the first and second feed inlets 1024, 1025 of the slurry distributor 1020 can be selectively controlled with at least one flow-modifying element 1023. For example, in some embodiments, the first and second flows 1047, 1048 of aqueous calcined gypsum slurry are selectively controlled such that the average velocity of the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 and the average velocity of the second flow 1048 of aqueous calcined gypsum slurry passing through the second feed inlet 1025 are substantially the same.

**[00194]** In embodiments, the first flow 1047 of aqueous calcined gypsum slurry is passed at an average first feed velocity through the first feed inlet 1024 of the slurry distributor 1020. The second flow 1048 of aqueous calcined gypsum slurry is passed at an average second feed velocity through the second feed inlet 1025 of the slurry distributor 1020. The second feed inlet 1025 is in spaced relationship to the first feed inlet 1024. The first and second flows 1051 of aqueous calcined gypsum slurry are combined in the slurry distributor 1020. The combined first and second flows 1051 of aqueous calcined gypsum slurry are discharged at an average discharge velocity from a distribution outlet 1030 of the slurry distributor 1020 upon the web 1039 of cover sheet material moving along a machine direction 1092. The average discharge velocity is less than the average first feed velocity and the average second feed velocity.

**[00195]** In some embodiments, the average discharge velocity is less than about 90% of the average first feed velocity and the average second feed velocity. In some embodiments, the average discharge velocity is less than about 80% of the average first feed velocity and the average second feed velocity.

**[00196]** The combined first and second flows 1051 of aqueous calcined gypsum slurry are discharged from the slurry distributor 1020 through the distribution outlet 1030. The opening of the distribution outlet 1030 has a width extending along the transverse axis 60 and sized such that the ratio of the width of the first moving web 1039 of cover sheet material to the width of the opening of the distribution outlet 1030 is within a range including and between about 1:1 and about 6:1. In some embodiments, the ratio of the

average velocity of the combined first and second flows 1051 of aqueous calcined gypsum slurry discharging from the slurry distributor 1020 to the velocity of the moving web 1039 of cover sheet material moving along the machine direction 1092 can be about 2:1 or less in some embodiments, and from about 1:1 to about 2:1 in other  
5 embodiments.

**[00197]** The combined first and second flows 1051 of aqueous calcined gypsum slurry discharging from the slurry distributor 1020 form a spread pattern upon the moving web 1039. At least one of the size and shape of the distribution outlet 1030 can be adjusted, which in turn can change the spread pattern.

10 **[00198]** Thus, slurry is fed into both feed inlets 1024, 1025 of the feed conduit 1022 and then exits through the distribution outlet 1030 with an adjustable gap. A converging portion 1082 can provide a slight increase in the slurry velocity so as to reduce unwanted exit effects and thereby further improve flow stability at the free surface. Side-to-side flow variation and/or any local variations can be reduced by performing  
15 cross-machine (CD) profiling control at the discharge outlet 1030 using the profiling system. This distribution system can help prevent air-liquid slurry separation in the slurry resulting in a more uniform and consistent material delivered to the forming table 1038.

**[00199]** A back skim coat stream 1053 (a layer of denser aqueous calcined gypsum  
20 slurry relative to at least one of the first and second flows 1047, 1048 of aqueous calcined gypsum slurry) can be applied to the second moving web 1043. The back skim coat stream 1053 can be deposited from the mixer 1012 at a point upstream, relative to the direction of movement of the second moving web 1043, of the back skim coat roller 1037.

25 **[00200]** In other embodiments, the average velocity of the first and second flows 1047, 1048 of aqueous calcined gypsum slurry are varied. In some embodiments, the slurry velocities at the feed inlets 1024, 1025 of the feed conduit 1022 can oscillate periodically between relatively higher and lower average velocities (at one point in time one inlet has a higher velocity than the other inlet, and then at a predetermined point in  
30 time vice versa) to help reduce the chance of buildup within the geometry itself.

**[00201]** In embodiments, the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 has a shear rate that is lower than the shear rate of the combined first and second flows 1051 discharging from the distribution outlet 1030, and the second flow 1048 of aqueous calcined gypsum slurry passing through the second feed inlet 1025 has a shear rate that is lower than the shear rate of the combined first and second flows 1051 discharging from the distribution outlet 1030. In embodiments, the shear rate of the combined first and second flows 1051 discharging from the distribution outlet 1030 can be greater than about 150% of the shear rate of the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 and/or the second flow 1048 of aqueous calcined gypsum slurry passing through the second feed inlet 1025, greater than about 175% in still other embodiments, and about double or greater in yet other embodiments. It should be understood that the viscosity of the first and second flows 1047, 1048 of aqueous calcined gypsum slurry and the combined first and second flows 1051 can be inversely related to the shear rate present at a given location such that as the shear rate goes up, the viscosity decreases.

**[00202]** In embodiments, the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 has a shear stress that is lower than the shear stress of the combined first and second flows 1051 discharging from the distribution outlet 1030, and the second flow 1048 of aqueous calcined gypsum slurry passing through the second feed inlet 1025 has a shear stress that is lower than the shear stress of the combined first and second flows 1051 discharging from the distribution outlet 1030. In embodiments, the shear stress of the combined first and second flows 1051 discharging from the distribution outlet 1030 can be greater than about 110% of the shear rate of the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 and/or the second flow 1048 of aqueous calcined gypsum slurry passing through the second feed inlet 1025.

**[00203]** In embodiments, the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 has a Reynolds number that is higher than the Reynolds number of the combined first and second flows 1051 discharging from the distribution outlet 1030, and the second flow 1048 of aqueous calcined gypsum slurry



passing through the second feed inlet 1025 has a Reynolds number that is higher than the Reynolds number of the combined first and second flows 1051 discharging from the distribution outlet 1030. In embodiments, the Reynolds number of the combined first and second flows 1051 discharging from the distribution outlet 1030 can be less than about 90% of the Reynolds number of the first flow 1047 of aqueous calcined gypsum slurry passing through the first feed inlet 1024 and/or the second flow 1048 of aqueous calcined gypsum slurry passing through the second feed inlet 1025, less than about 80% in still other embodiments, and less than about 70% in still other embodiments.

**[00204]** Referring to FIG. 30, an embodiment of a Y-shaped flow splitter 1100 suitable for use in a gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure is shown. The flow splitter 1100 can be placed in fluid communication with a gypsum slurry mixer and a slurry distributor such that the flow splitter 1100 receives a single flow of aqueous calcined gypsum slurry from the mixer and discharges two separate flows of aqueous calcined gypsum slurry therefrom to the first and second feed inlets of the slurry distributor. One or more flow-modifying elements can be disposed between the mixer and the flow splitter 1100 and/or between one or both of the delivery branches leading between the splitter 1100 and the associated slurry distributor.

**[00205]** The flow splitter 1100 has a substantially circular inlet 1102 disposed in a main branch 1103 adapted to receive a single flow of slurry and a pair of substantially circular outlets 1104, 1106 disposed respectively in first and second outlet branches 1105, 1107 that allow two flows of slurry to discharge from the splitter 1100. The cross-sectional areas of the openings of the inlet 1102 and the outlets 1104, 1106 can vary depending on the desired flow velocity. In embodiments where the cross-sectional areas of the openings of outlet 1104, 1106 are each substantially equal to cross-sectional area of the opening of the inlet 1102, the flow velocity of the slurry discharging from each outlet 1104, 1106 can be reduced to about 50% of the velocity of the single flow of slurry entering the inlet 1102 where the volumetric flow rate through the inlet 1102 and both outlets 1104, 1106 is substantially the same.

**[00206]** In some embodiments, the diameter of the outlets 1104, 1106 can be made smaller than the diameter of the inlet 1102 in order to maintain a relatively high flow velocity throughout the splitter 1100. In embodiments where the cross-sectional areas of the openings of the outlets 1104, 1106 are each smaller than the cross-sectional area of the opening of the inlet 1102, the flow velocity can be maintained in the outlets 1104, 1106 or at least reduced to a lesser extent than if the outlets 1104, 1106 and the inlet 1102 all have substantially equal cross-sectional areas. For example, in some embodiments, the flow splitter 1100 has the inlet 1102 has an inner diameter ( $ID_1$ ) of about 3 inches, and each outlet 1104, 1106 has an  $ID_2$  of about 2.5 inches (though other inlet and outlet diameters can be used in other embodiments). In an embodiment with these dimensions at a line speed of 350 fpm, the smaller diameter of the outlets 1104, 1106 causes the flow velocity in each outlet to be reduced by about 28% of the flow velocity of the single flow of slurry at the inlet 1102.

**[00207]** The flow splitter 1100 can include a central contoured portion 1114 and a junction 1120 between the first and second outlet branches 1105, 1107. The central contoured portion 1114 creates a restriction 1108 in the central interior region of the flow splitter 1100 upstream of the junction 1120 that helps promote flow to the outer edges 1110, 1112 of the splitter to reduce the occurrence of slurry buildup at the junction 1120. The shape of the central contoured portion 1114 results in guide channels 1111, 1113 adjacent the outer edges 1110, 1112 of the flow splitter 1100. The restriction 1108 in the central contoured portion 1114 has a smaller height  $H_2$  than the height  $H_3$  of the guide channels 1111, 1113. The guide channels 1111, 1113 have a cross-sectional area that is larger than the cross-sectional area of the central restriction 1108. As a result, the flowing slurry encounters less flow resistance through the guide channels 1111, 1113 than through the central restriction 1108, and flow is directed toward the outer edges of the splitter junction 1120.

**[00208]** The junction 1120 establishes the openings to the first and second outlet branches 1105, 1107. The junction 1120 is made up of a planar wall surface 1123 that is substantially perpendicular to an inlet flow direction 1125.

**[00209]** Referring to FIG. 32, in some embodiments, an automatic device 1150 for squeezing the splitter 1100 at adjustable and regular time intervals can be provided to prevent solids building up inside the splitter 1100. In some embodiments, the squeezing apparatus 1150 can include a pair of plates 1152, 1154 disposed on  
5 opposing sides 1142, 1143 of the central contoured portion 1114. The plates 1152, 1154 are movable relative to each other by a suitable actuator 1160. The actuator 1160 can be operated either automatically or selectively to move the plates 1152, 1154 together relative to each other to apply a compressive force upon the splitter 1100 at the central contoured portion 1114 and the junction 1120.

10 **[00210]** When the squeezing apparatus 1150 squeezes the flow splitter, the squeezing action applies compressive force to the flow splitter 1100, which flexes inwardly in response. This compressive force can help prevent buildup of solids inside the splitter 1100 which may disrupt the substantially equally split flow to the slurry distribution through the outlets 1104, 1106. In some embodiments, the squeezing  
15 apparatus 1150 is designed to automatically pulse through the use of a programmable controller operably arranged with the actuators. The time duration of the application of the compressive force by the squeezing apparatus 1150 and/or the interval between pulses can be adjusted. Furthermore, the stroke length that the plates 1152, 1154 travel with respect to each other in a compressive direction can be adjusted.

20 **[00211]** Embodiments of a slurry distributor, a gypsum slurry mixing and dispensing assembly, and methods of using the same are provided herein which can provide many enhanced process features helpful in manufacturing gypsum wallboard in a commercial setting. A slurry distributor constructed in accordance with principles of the present disclosure can facilitate the spreading of aqueous calcined gypsum slurry upon a  
25 moving web of cover sheet material as it advances past a mixer at the wet end of the manufacturing line toward a forming station.

**[00212]** A gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure can split a flow of aqueous calcined gypsum slurry from a mixer into two separate flows of aqueous calcined gypsum slurry which  
30 can be recombined downstream in a slurry distributor constructed in accordance with

principles of the present disclosure to provide a desired spreading pattern. The design of the dual inlet configuration and the distribution outlet can allow for wider spreading of more viscous slurry in the cross-machine direction over the moving web of cover sheet material. The slurry distributor can be adapted such that the two separate flows of aqueous calcined gypsum slurry enter a slurry distributor along feed inlet directions which include a cross-machine direction component, are re-directed inside the slurry distributor such that the two flows of slurry are moving in substantially a machine direction, and are recombined in the distributor in a way to enhance the cross-direction uniformity of the combined flows of aqueous calcined gypsum slurry being discharged from the distribution outlet of the slurry distributor to help reduce mass flow variation over time along the transverse axis or cross machine direction. Introducing the first and second flows of aqueous calcined gypsum slurry in first and second feed directions that include a cross-machine directional component can help the re-combined flows of slurry discharge from the slurry distributor with a reduced momentum and/or energy.

**[00213]** The interior flow cavity of the slurry distributor can be configured such that each of the two flows of slurry move through the slurry distributor in a streamline flow. The interior flow cavity of the slurry distributor can be configured such that each of the two flows of slurry move through the slurry distributor with minimal or substantially no air-liquid slurry phase separation. The interior flow cavity of the slurry distributor can be configured such that each of the two flows of slurry move through the slurry distributor substantially without undergoing a vortex flow path.

**[00214]** A gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure can include flow geometry upstream of the distribution outlet of the slurry distributor to reduce the slurry velocity in one or multiple steps. For example, a flow splitter can be provided between the mixer and the slurry distributor to reduce the slurry velocity entering the slurry distributor. As another example, the flow geometry in the gypsum slurry mixing and dispensing assembly can include areas of expansion upstream and within the slurry distributor to slow down the slurry so it is manageable when it is discharged from the distribution outlet of the slurry distributor.

[00215] The geometry of the distribution outlet can also help control the discharge velocity and momentum of the slurry as it is being discharged from the slurry distributor upon the moving web of cover sheet material. The flow geometry of the slurry distributor can be adapted such that the slurry discharging from the distribution outlet is maintained in substantially a two-dimensional flow pattern with a relatively small height in comparison to the wider outlet in the cross-machine direction to help improve stability and uniformity.

[00216] The relatively wide discharge outlet yields a momentum per unit width of the slurry being discharged from the distribution outlet that is lower than the momentum per unit width of a slurry discharged from a conventional boot under similar operating conditions. The reduced momentum per unit width can help prevent washout of a skim coat of a dense layer applied to the web of cover sheet material upstream from the location where the slurry is discharged from the slurry distributor upon the web.

[00217] In the situation where a conventional boot outlet is 6 inches wide and 2 inches thick is used, the average velocity of the outlet for a high volume product can be about 761 ft/min. In embodiments where the slurry distributor constructed in accordance with principles of the present disclosure includes a distribution outlet having an opening that is 24 inches wide and 0.75 inches thick, the average velocity can be about 550 ft/min. The mass flow rate is the same for both devices at 3,437 lb/min. The momentum of the slurry (mass flow rate\*average velocity) for both cases would be ~2,618,000 and 1,891,000 lb-ft/min<sup>2</sup> for the conventional boot and the slurry distributor, respectively. Dividing the respective calculated momentum by the widths of the conventional boot outlet and the slurry distributor outlet, the momentum per unit width of the slurry discharging from the convention boot is 402,736 (lb-ft/min<sup>2</sup>)/(inch across boot width), and the momentum per unit width of the slurry discharging from the slurry distributor constructed in accordance with principles of the present disclosure is 78,776 (lb-ft/min<sup>2</sup>)/(inch across slurry distributor width). In this case, the slurry discharging from the slurry distributor has about 20% of the momentum per unit width compared to the conventional boot.

**[00218]** A slurry distributor constructed in accordance with principles of the present disclosure can achieve a desired spreading pattern while using an aqueous calcined gypsum slurry over a broad range of water-stucco ratios, including a relatively low WSR or a more conventional WSR, such as, a water-to-calcined gypsum ratio from about 0.4 to about 1.2, for example, below 0.75 in some embodiments, and between about 0.4 and about 0.8 in other embodiments. Embodiments of a slurry distributor constructed in accordance with principles of the present disclosure can include internal flow geometry adapted to generate controlled shear effects upon the first and second flows of aqueous calcined gypsum slurry as the first and second flows advance from the first and second feed inlets through the slurry distributor toward the distribution outlet. The application of controlled shear in the slurry distributor can selectively reduce the viscosity of the slurry as a result of being subjected to such shear. Under the effects of controlled shear in the slurry distributor, slurry having a lower water-stucco ratio can be distributed from the slurry distributor with a spread pattern in the cross-machine direction comparable to slurries having a conventional WSR.

**[00219]** The interior flow geometry of the slurry distributor can be adapted to further accommodate slurries of various water-stucco ratios to provide increase flow adjacent the boundary wall regions of the interior geometry of the slurry distributor. By including flow geometry features in the slurry distributor adapted to increase the degree of flow around the boundary wall layers, the tendency of slurry to re-circulate in the slurry distributor and/or stop flowing and set therein is reduced. Accordingly, the build up of set slurry in the slurry distributor can be reduced as a result.

**[00220]** A slurry distributor constructed in accordance with principles of the present disclosure can include a profile system mounted adjacent the distribution outlet to alter a cross machine velocity component of the combined flows of slurry discharging from the distribution outlet to selectively control the spread angle and spread width of the slurry in the cross machine direction on the substrate moving down the manufacturing line toward the forming station. The profile system can help the slurry discharged from the distribution outlet achieve a desired spread pattern while being less sensitive to slurry viscosity and WSR. The profile system can be used to change the flow dynamics

of the slurry discharging from the distribution outlet of the slurry distributor to guide slurry flow such that the slurry has more uniform velocity in the cross-machine direction. Using the profile system can also help a gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure be used in a gypsum wallboard manufacturing setting to produce wallboard of different types and volumes.

### EXAMPLES

[00221] Referring to FIG. 33, in these Examples the geometry and flow characteristics of a slurry distributor constructed in accordance with principles of the present disclosure were evaluated. A top plan view of a half portion 1205 of a slurry distributor is shown in FIG. 33. The half portion 1205 of the slurry distributor includes a half portion 1207 of a feed conduit 320 and a half portion 1209 of a distribution conduit 328. The half portion 1207 of the feed conduit 322 includes a second feed inlet 325 defining a second opening 335, a second entry segment 337, and a half portion 1211 of a bifurcated connector segment 339. The half portion 1209 of the distribution conduit 328 includes a half portion 1214 of an entry portion 352 of the distribution conduit 328 and a half portion 1217 of a distribution outlet 330.

[00222] It should be understood that another half portion of a slurry distributor, which is a mirror image of the half portion 1205 of FIG. 33, can be integrally joined and aligned with the half portion 1205 of FIG. 33 at a transverse central midpoint 387 of the distribution outlet 330 to form a slurry distributor which is substantially similar to the slurry distributor 420 of FIG. 15. Accordingly, the geometry and flow characteristics described below are equally applicable to the mirror image half portion of the slurry distributor as well.

### EXAMPLE 1

[00223] In this Example and referring to FIG. 33, the particular geometry of the half portion 1205 of the slurry distributor was evaluated at sixteen different locations  $L_{1-16}$  between a first location  $L_1$  at the second feed inlet 325 and a sixteenth location  $L_{16}$  at a half portion 1207 of the distribution outlet 330. Each location  $L_{1-16}$  represents a cross-sectional slice of the half portion 1205 of the slurry distributor as indicated by the

corresponding line. A flow line 1212 along the geometric center of each cross-sectional slice was used to determine the distance between adjacent locations  $L_{1-16}$ . The eleventh location  $L_{11}$  corresponds to the half portion 1214 of the entry portion 352 of the distribution conduit 328 which corresponds to an opening 342 of a second feed outlet 345 of the half portion 1207 of the feed conduit 320. Accordingly, the first through the tenth locations  $L_{1-10}$  are taken in the half portion 1207 of the feed conduit 320, and the eleventh through the sixteenth locations are taken in the half portion 1209 of the distribution conduit 328.

**[00224]** For each location  $L_{1-16}$ , the following geometric values of were determined:

10 the distance along the flow line 1212 between the second feed inlet 325 and the particular location  $L_{1-16}$ ; the cross-sectional area of the opening at the location  $L_{1-16}$ ; the perimeter of the location  $L_{1-16}$ ; and the hydraulic diameter of the location  $L_{1-16}$ . The hydraulic diameter was calculated using the following formula:

$$D_{\text{hyd}} = 4 \times A / P \quad (\text{Eq. 1})$$

15 where  $D_{\text{hyd}}$  is the hydraulic diameter,

A is the area of the particular location  $L_{1-16}$ , and

P is the perimeter of the particular location  $L_{1-16}$ .

Using the inlet conditions, the dimensionless values for each location  $L_{1-16}$  can be determined to describe the interior flow geometry, as shown in Table 1. Curve-fit

20 equations were used to describe the dimensionless geometry of the half portion 1205 of the slurry distributor in FIG. 34, which shows the dimensionless distance from inlet versus the dimensionless area and the hydraulic diameter.

**[00225]** The analysis of the dimensionless values for each location  $L_{1-16}$  shows that the cross sectional flow area increases from the first location  $L_1$  at the second feed inlet

25 325 to the eleventh location  $L_{11}$  at the half portion 1214 of the entry portion 352 (also the opening 342 of the second feed outlet 345). In the exemplary embodiment, the cross-sectional flow area at the half portion 1214 of the entry portion 352 is about 1/3 larger than the cross-sectional flow area at the second feed inlet 325. Between the first location  $L_1$  and the eleventh location  $L_{11}$ , the cross-sectional flow area of the second entry segment 337 and the second shaped duct 339 varies from location to location  $L_1$ .

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11. In this region, at least two adjacent locations  $L_6$ ,  $L_7$  are configured such that the location  $L_7$  located further from the second feed inlet 325 has a cross sectional flow area that is smaller than the adjacent location  $L_6$  that is closer to the second feed inlet 325.

5 **[00226]** Between the first location  $L_1$  and the eleventh location  $L_{11}$ , in the half portion 1207 of the feed conduit 322 there is an area of expansion (e.g.,  $L_{4,6}$ ) having a cross-sectional flow area that is greater than a cross-sectional flow area of an adjacent area (e.g.,  $L_3$ ) upstream from the area of expansion in a direction from the second inlet 335 toward the half portion 1217 of the distribution outlet 330. The second entry segment  
10 337 and the second shaped duct 341 have a cross section that varies along the direction of flow 1212 to help distribute the second flow of slurry moving therethrough.

**[00227]** The cross sectional area decreases from the eleventh location  $L_{11}$  at the half portion 1214 of the entry portion 352 of the distribution conduit 328 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution  
15 conduit 328. In the exemplary embodiment, the cross-sectional flow area of the half portion 1214 of an entry portion 352 is about 95% of that of the half portion 1217 of the distribution outlet 330.

**[00228]** The cross-sectional flow area at the first location  $L_1$  at the second feed inlet 325 is smaller than the cross-sectional flow area at the sixteenth location  $L_{16}$  at the half  
20 portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the exemplary embodiment, the cross-sectional flow area at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 is about 1/4 larger than the cross-sectional flow area at the second feed inlet 325.

**[00229]** The hydraulic diameter decreases from the first location  $L_1$  at the second feed  
25 inlet 325 to the eleventh location  $L_{11}$  at the half portion 1214 of the entry portion 352 of the distribution conduit 328. In the exemplary embodiment, the hydraulic diameter at the half portion 1214 of the entry portion 352 of the distribution conduit 328 is about  $\frac{1}{2}$  the hydraulic diameter at the second feed inlet 325.

**[00230]** The hydraulic diameter decreases from the eleventh location  $L_{11}$  at the half  
30 portion 1214 of an entry portion 352 of the distribution conduit 328 to the sixteenth

location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the exemplary embodiment, the hydraulic diameter of the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 is about 95% of that of the half portion 1214 of the entry portion 352 of the distribution conduit 328.

- 5 **[00231]** The hydraulic diameter at the first location  $L_1$  at the second inlet 326 is larger than the hydraulic diameter at the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the exemplary embodiment, the hydraulic diameter at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 is less than about half of that of the second feed inlet 325.

<b>TABLE I — GEOMETRY</b>				
<b>Location</b>	<b>Dimensionless</b>			
	<b>Distance From Inlet</b>	<b>Area</b>	<b>Perimeter</b>	<b>Hydraulic Dia.</b>
L1	0.00	1.00	1.00	1.00
L2	0.07	1.00	1.00	1.00
L3	0.14	0.91	0.98	0.93
L4	0.20	1.01	1.07	0.94
L5	0.27	1.18	1.24	0.95
L6	0.34	1.25	1.45	0.87
L7	0.41	1.16	1.68	0.69
L8	0.47	1.13	1.93	0.59
L9	0.54	1.23	2.20	0.56
L10	0.61	1.35	2.47	0.55
L11	0.68	1.33	2.73	0.49
L12	0.75	1.28	2.70	0.47
L13	0.81	1.27	2.68	0.48
L14	0.88	1.26	2.67	0.47
L15	0.95	1.26	2.67	0.47
L16	1.00	1.26	2.67	0.47

**EXAMPLE 2**

[00232] In this Example, the half portion 1205 of the slurry distributor of FIG. 33 was used to model the flow of gypsum slurry therethrough under different flow conditions. For all flow conditions, the density ( $\rho$ ) of the aqueous gypsum slurry was set at 1,000 kg/m<sup>3</sup>. Aqueous gypsum slurry is a shear-thinning material such that as shear is applied to it, its viscosity can decrease. The viscosity ( $\mu$ ) Pa.s of the gypsum slurry was calculated using the Power Law Fluid Model which has the following equation:

$$\mu = K\dot{\gamma}^{n-1} \quad (\text{Eq. 2})$$

where,

10 K is a constant,

$\dot{\gamma}$  is the shear rate, and

n is a constant equal to 0.133 in this case.

[00233] In a first flow condition, the gypsum slurry has a viscosity K factor of 50 in the Power Law model and enters the second feed inlet 325 at 2.5 m/s. A computational fluid dynamics technique with a finite volume method was used to determine flow characteristics in the distributor. At each location L<sub>1-16</sub>, the following flow characteristics were determined: area-weighted average velocity (U), area-weighted average shear rate ( $\dot{\gamma}$ ), viscosity calculated using the Power Law Model (Eq. 2), shear stress, and Reynolds Number (Re).

20 [00234] The shear stress was calculated using the following equation:

$$\text{Shear stress} = \mu \times \dot{\gamma} \quad (\text{Eq. 3})$$

where

$\mu$  is the viscosity calculated using the Power Law Model (Eq. 2), and

$\dot{\gamma}$  is the shear rate.

25

[00235] The Reynolds Number was calculated using the following equation:

$$Re = \rho \times U \times D_{hyd} / \mu \quad (\text{Eq. 4})$$

where

$\rho$  is the density of the gypsum slurry,

5  $U$  is the area-weighted average velocity,

$D_{hyd}$  is the hydraulic diameter, and

$\mu$  is the viscosity calculated using the Power Law Model (Eq. 2).

[00236] In a second flow condition case, the feed velocity of the gypsum slurry into the second feed inlet 325 was increased to 3.55 m/s. All other conditions were the same as in the first flow condition of this Example. The dimensional values for the mentioned flow characteristics at each location  $L_{1-16}$  for both the first flow condition where the inlet velocity is 2.5 m/s and the second flow condition where the inlet velocity is 3.55 m/s were modeled. Using the inlet conditions, dimensionless values of the flow characteristics for each location  $L_{1-16}$  were determined, as shown in Table II.

15 [00237] For both flow conditions where  $K$  was set equal to 50, the average velocity was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the average velocity was reduced by about 1/5.

20 [00238] For both flow conditions, the shear rate increased from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the shear rate approximately doubled from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328, as shown in FIG. 36.

25 [00239] For both flow conditions, the calculated viscosity was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the calculated viscosity was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the

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distribution outlet 330 of the distribution conduit 328 by about half, as illustrated in FIG. 37.

**[00240]** For both flow conditions in FIG. 38, the shear stress increased from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 5 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the shear stress increased by about 10% from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328.

**[00241]** For both flow conditions, the Reynolds number in FIG. 39 was reduced from 10 the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the Reynolds number was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 by about 1/3. For both flow 15 conditions, the Reynolds number at the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 is in the laminar region.

**TABLE II — DIMENSIONLESS FLOW CHARACTERISTICS (K = 50)**

Location	Inlet Velocity = 2.50 m/s						Inlet Velocity = 3.55 m/s					
	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re	Re	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re	
L1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
L2	1.00	1.18	0.87	1.02	1.15	1.15	1.00	1.20	0.85	1.03	1.17	
L3	1.10	1.36	0.77	1.04	1.33	1.33	1.10	1.40	0.75	1.05	1.36	
L4	1.00	1.30	0.80	1.04	1.18	1.18	0.99	1.32	0.79	1.04	1.19	
L5	0.86	1.19	0.86	1.02	0.96	0.96	0.86	1.22	0.84	1.03	0.98	
L6	0.83	1.23	0.83	1.03	0.86	0.86	0.83	1.28	0.81	1.03	0.89	
L7	0.90	1.65	0.65	1.07	0.96	0.96	0.90	1.73	0.62	1.08	0.99	
L8	0.90	1.73	0.62	1.08	0.85	0.85	0.90	1.80	0.60	1.08	0.88	
L9	0.82	1.67	0.64	1.07	0.72	0.72	0.82	1.74	0.62	1.08	0.74	
L10	0.77	1.63	0.65	1.07	0.64	0.64	0.77	1.73	0.62	1.08	0.68	
L11	0.76	1.83	0.59	1.08	0.62	0.62	0.76	1.93	0.57	1.09	0.65	
L12	0.78	1.84	0.59	1.08	0.63	0.63	0.78	1.92	0.57	1.09	0.65	
L13	0.78	1.88	0.58	1.09	0.64	0.64	0.78	1.93	0.57	1.09	0.65	
L14	0.78	1.88	0.58	1.09	0.64	0.64	0.78	1.95	0.56	1.09	0.66	
L15	0.78	1.85	0.59	1.09	0.63	0.63	0.78	1.92	0.57	1.09	0.65	
L16	0.79	1.89	0.58	1.09	0.65	0.65	0.79	1.98	0.55	1.09	0.67	

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**EXAMPLE 3**

[00242] In this Example, the half portion 1205 of the slurry distributor of FIG. 33 was used to model the flow of gypsum slurry therethrough under flow conditions similar to those in Example 2 except that the value for the coefficient K in the Power Law Model (Eq. 2) was set at 100. The flow conditions were similar to those in Example 2 in other respects.

[00243] Again, the flow characteristics were evaluated both for a feed velocity of the gypsum slurry into the second feed inlet 325 of 2.50 m/s and of 3.55 m/s. At each location  $L_{1-16}$ , the following flow characteristics were determined: area-weighted average velocity (U), area-weighted average shear rate ( $\dot{\gamma}$ ), viscosity calculated using the Power Law Model (Eq. 2), shear stress (Eq. 3), and Reynolds Number (Re) (Eq. 4). Using the inlet conditions, dimensionless values of the flow characteristics for each location  $L_{1-16}$  were determined, as shown in Table III.

[00244] For both flow conditions where K was set equal to 100, the average velocity was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the average velocity was reduced by about 1/5. The results for average velocity, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. 35.

[00245] For both flow conditions, the shear rate increased from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the shear rate approximately doubled from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. The results for shear rate, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. 36.

[00246] For both flow conditions, the calculated viscosity was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the calculated viscosity was reduced from the first location  $L_1$  at the



second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 by about half. The results for the calculated viscosity, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. 37.

5 **[00247]** For both flow conditions, the shear stress increased from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated embodiment, the shear stress increased by about 10% from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. The results for the shear stress, on a dimensionless basis,  
10 were substantially the same as those in Example 2 and FIG. 38.

**[00248]** For both flow conditions, the Reynolds number was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328. In the illustrated  
15 embodiment, the Reynolds number was reduced from the first location  $L_1$  at the second feed inlet 325 to the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 by about 1/3. For both flow conditions, the Reynolds number at the sixteenth location  $L_{16}$  at the half portion 1217 of the distribution outlet 330 of the distribution conduit 328 is in the laminar region. The results for the  
20 Reynolds number, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. 39.

**[00249]** FIGS. 34-38 are graphs of the flow characteristics computed for the different flow conditions of Examples 2 and 3. Curve-fit equations were used to describe the change in the flow characteristics over the distance between the feed inlet to the half  
25 portion of the distribution outlet. Accordingly, the Examples show that the flow characteristics are consistent over variations in inlet velocity and/or viscosity.

**TABLE III — DIMENSIONLESS FLOW CHARACTERISTICS (K = 100)**

Location	Inlet Velocity = 2.50 m/s						Inlet Velocity = 3.65 m/s					
	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re	Re	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re	
L1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
L2	1.00	1.16	0.88	1.02	1.13	1.13	1.00	1.21	0.85	1.03	1.18	
L3	1.10	1.35	0.77	1.04	1.32	1.32	1.10	1.39	0.75	1.04	1.35	
L4	1.00	1.28	0.80	1.03	1.17	1.17	1.00	1.35	0.77	1.04	1.22	
L5	0.87	1.15	0.88	1.02	0.94	0.94	0.86	1.23	0.84	1.03	0.99	
L6	0.83	1.18	0.87	1.02	0.83	0.83	0.83	1.27	0.81	1.03	0.88	
L7	0.90	1.60	0.66	1.06	0.93	0.93	0.90	1.70	0.63	1.07	0.98	
L8	0.90	1.70	0.63	1.07	0.84	0.84	0.90	1.77	0.61	1.08	0.87	
L9	0.82	1.61	0.66	1.07	0.69	0.69	0.82	1.71	0.63	1.07	0.73	
L10	0.77	1.57	0.68	1.06	0.62	0.62	0.77	1.67	0.64	1.07	0.66	
L11	0.76	1.76	0.61	1.08	0.60	0.60	0.76	1.88	0.58	1.09	0.64	
L12	0.78	1.79	0.60	1.08	0.61	0.61	0.78	1.90	0.57	1.09	0.64	
L13	0.78	1.81	0.60	1.08	0.62	0.62	0.78	1.93	0.57	1.09	0.65	
L14	0.78	1.84	0.59	1.08	0.63	0.63	0.78	1.94	0.56	1.09	0.66	
L15	0.78	1.80	0.60	1.08	0.62	0.62	0.78	1.90	0.57	1.09	0.64	
L16	0.79	1.87	0.58	1.09	0.64	0.64	0.79	1.96	0.56	1.09	0.67	

**[00250]** The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,”  
5 “including,” and “containing” are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually  
10 recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification  
15 should be construed as indicating any non-claimed element as essential to the practice of the invention.

**[00251]** Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon  
20 reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the  
25 above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A multi-piece mold comprising:
  - a plurality of mold segments adapted to be removably secured together, each mold segment including an exterior surface configured to define at least a portion of an interior surface of a slurry distributor, the mold segments configured such that when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon;
  - wherein each mold segment has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path out of a respective opening of the molded slurry distributor, the maximum cross-sectional area of each mold segment being up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path;
  - wherein the exterior surfaces of the assembled mold segments are configured to define the molded slurry distributor such that the molded slurry distributor includes a feed conduit having a first feed inlet defining one of the openings of the molded slurry distributor and a distribution conduit, the distribution conduit extending generally along a longitudinal axis and including an entry portion and a distribution outlet in fluid communication with the entry portion, the entry portion in fluid communication with the first feed inlet of the feed conduit, the distribution outlet defining one of the openings of the molded slurry distributor; and
  - wherein at least two mold segments are adapted to be removed from the interior flow region of the molded slurry distributor by following a removal path through the opening of the first feed inlet and at least one

mold segment is adapted to be removed from the interior flow region of the slurry distributor by following a removal path through the opening of the distribution outlet.

2. The multi-piece mold according to claim 1, wherein at least two  
5 mold segments define a respective passage therein, the passages being configured to be aligned with each other when the respective mold segments are disposed in an assembled position wherein the mold segment is disposed to define at least a portion of the interior surface of the slurry distributor, and further comprising a connecting rod adapted to be inserted through the aligned passages to interconnect  
10 the mold segments.

3. The multi-piece mold according to claim 1, wherein at least three mold segments define a respective passage therein, the passages being configured to be aligned with each other when the respective mold segments are disposed in an assembled position wherein the mold segment is disposed to define at least a  
15 portion of the interior surface of the slurry distributor, and further comprising a connecting rod adapted to be inserted through the aligned passages to interconnect the mold segments.

4. The multi-piece mold according to claim 1, wherein the maximum cross-sectional area of each mold segment is up to about 125% of the smallest  
20 area of the interior flow region of the molded slurry distributor through which the mold piece traverses when moving along the respective removal path.

5. The multi-piece mold according to claim 1, wherein the maximum cross-sectional area of each mold segment is in a range between greater than the smallest area of the interior flow region of the molded slurry distributor through  
25 which the mold piece traverses moving along the respective removal path and about 150% thereof.

6. The multi-piece mold according to claim 1, wherein each mold segment includes at least one mating surface, the mating surface of each mold segment configured to have a complementary shape for a shape of the mating surface of at least one other mold segment.

5 7. The multi-piece mold according to claim 1, wherein the mold segments comprise a distributor conduit mold segment configured to define an interior flow geometry of the distribution conduit, a shaped duct mold segment configured to define an interior flow geometry of a shaped duct in fluid communication with the distribution conduit, and an entry mold segment configured to define an interior flow geometry of an entry segment and the first feed inlet, the  
10 first feed inlet and the entry segment in fluid communication with each other and the shaped duct.

8. The multi-piece mold according to claim 7, wherein the first feed inlet is disposed at a feed angle in a range up to about 135° with respect to the  
15 longitudinal axis.

9. The multi-piece mold according to claim 7, wherein the mold segments comprise a second shaped duct mold segment configured to define an interior flow geometry of a second shaped duct in fluid communication with the distribution conduit, and a second entry mold segment configured to define an  
20 interior flow geometry of a second entry segment and a second feed inlet, the second feed inlet and the second entry segment in fluid communication with each other and the shaped duct, the second feed inlet being another opening of the feed conduit.

10. A method of making a slurry distributor comprising:  
25 assembling a plurality of mold segments of a multi-piece mold according to any one of claims 1 to 9 to define an exterior surface of the multi-piece mold;

dipping the assembled multi-piece mold into a solution of flexible material such that at least a portion of the multi-piece mold is submersed in the solution;

5 removing the multi-piece mold from the solution such that a layer of solution adheres substantially around the exterior surface of the multi-piece mold;

10 allowing the solution to cure such that an at least partially-solidified molded slurry distributor is formed around the multi-piece mold, wherein the molded slurry distributor has an interior surface defining an interior flow region, the interior surface of the molded slurry distributor being in contacting relationship with the exterior surface of the multi-piece mold, and the molded slurry distributor defines at least two openings each in fluid communication with the interior flow region;

15 disassembling the multi-piece mold by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening;

20 wherein each mold segment has a maximum cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor, the maximum cross-sectional area of each mold segment being up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path;

25 wherein the slurry distributor includes a feed conduit having a first feed inlet defining one of the openings and a distribution conduit, the distribution conduit extending generally along a longitudinal axis and including an entry portion and a distribution outlet in fluid communication  
30 with the entry portion, the entry portion in fluid communication with the first

feed inlet of the feed conduit, the distribution outlet defining one of the openings; and

5 wherein at least two mold segments are removed from the interior flow region of the slurry distributor by following a removal path through the opening of the first feed inlet and at least one mold segment is removed from the interior flow region of the slurry distributor by following a removal path through the opening of the distribution outlet.

11. The method of making a slurry distributor according to claim 10, wherein at least two mold segments are assembled together by aligning a  
10 respective passage defined in the mold segments and inserting a connecting rod through the aligned passages to interconnect the mold segments.

12. The method of making a slurry distributor according to claim 11, wherein each passage is aligned with at least one respective opening of the molded slurry distributor to allow for the removal of the associated connecting rod from the  
15 passage.

13. The method of making a slurry distributor according to claim 10, wherein at least three mold segments are assembled together by inserting a connecting rod through aligned passages defined therein.

14. The method of making a slurry distributor according to claim 10,  
20 wherein the maximum cross-sectional area of each mold segment is up to about 125% of the smallest area of the interior flow region of the molded slurry distributor through which the mold piece traverses when moving along the respective removal path.

15. The method of making a slurry distributor according to claim 10,  
25 wherein the maximum cross-sectional area of each mold segment is in a range between greater than the smallest area of the interior flow region of the molded



slurry distributor through which the mold piece traverses moving along the respective removal path and about 150% thereof.

16. The method of making a slurry distributor according to claim 10, wherein at least a portion of the interior surface of the molded slurry distributor is  
5 substantially a negative image of at least a portion of the exterior surface of the multi-piece mold.

17. The method of making a slurry distributor according to claim 10, wherein the first feed inlet is disposed at a feed angle in a range up to about 135° with respect to the longitudinal axis.

10 18. The method of making a slurry distributor according to claim 10, wherein the feed conduit of the slurry distributor includes a second feed inlet defining one of the openings, the second feed inlet is disposed at a feed angle in a range up to about 135° with respect to the longitudinal axis.



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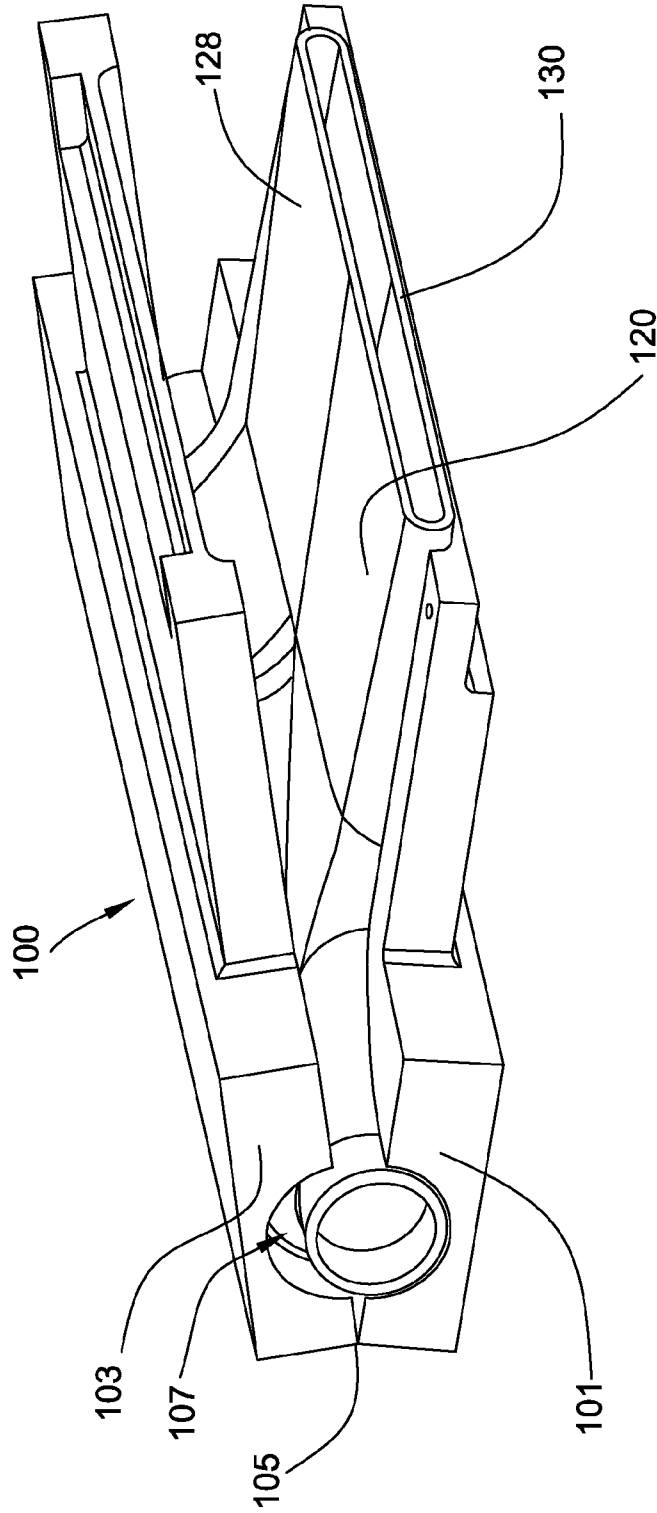


FIG. 2

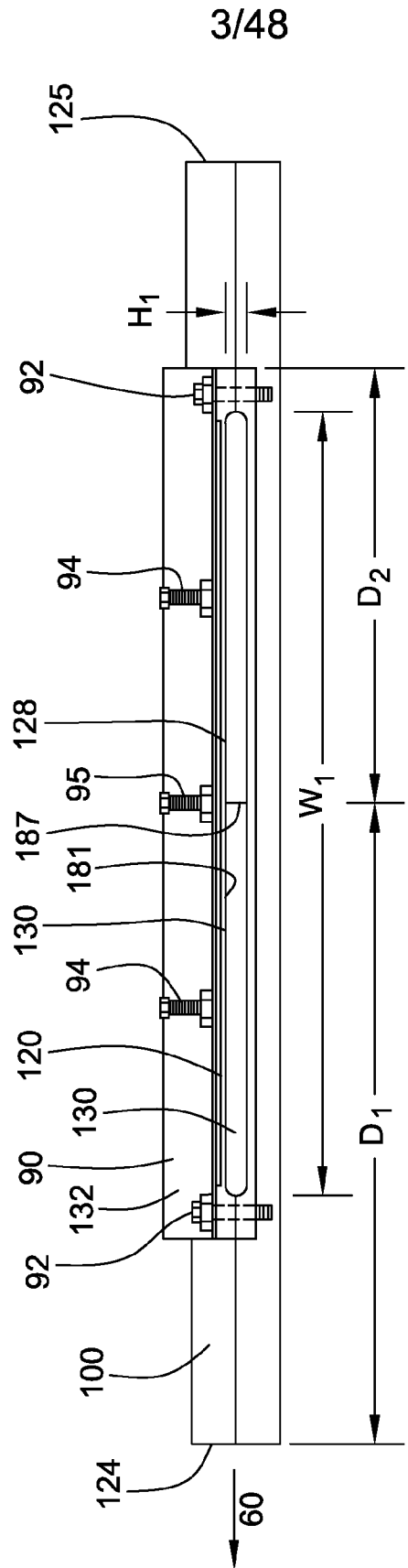
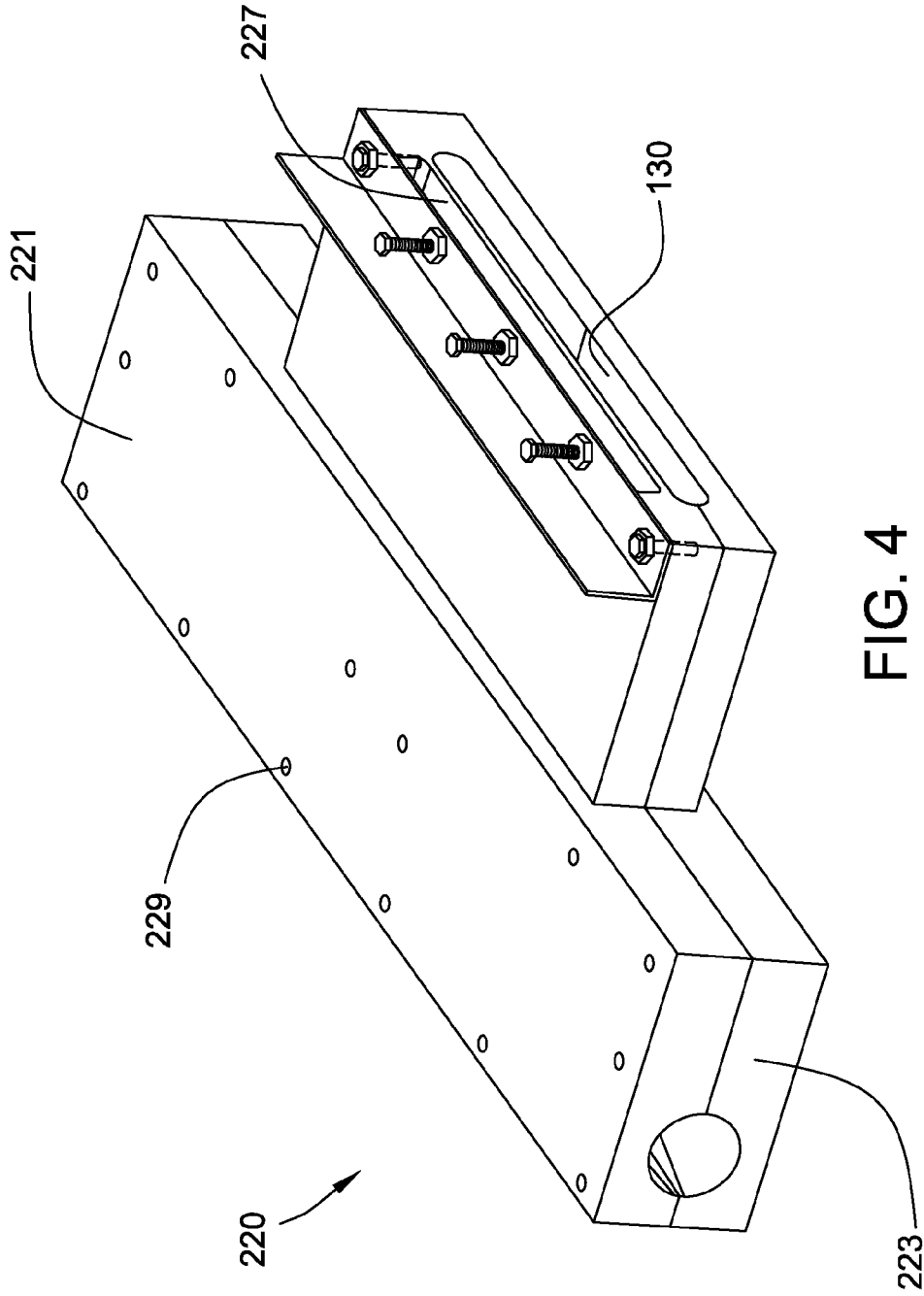


FIG. 3

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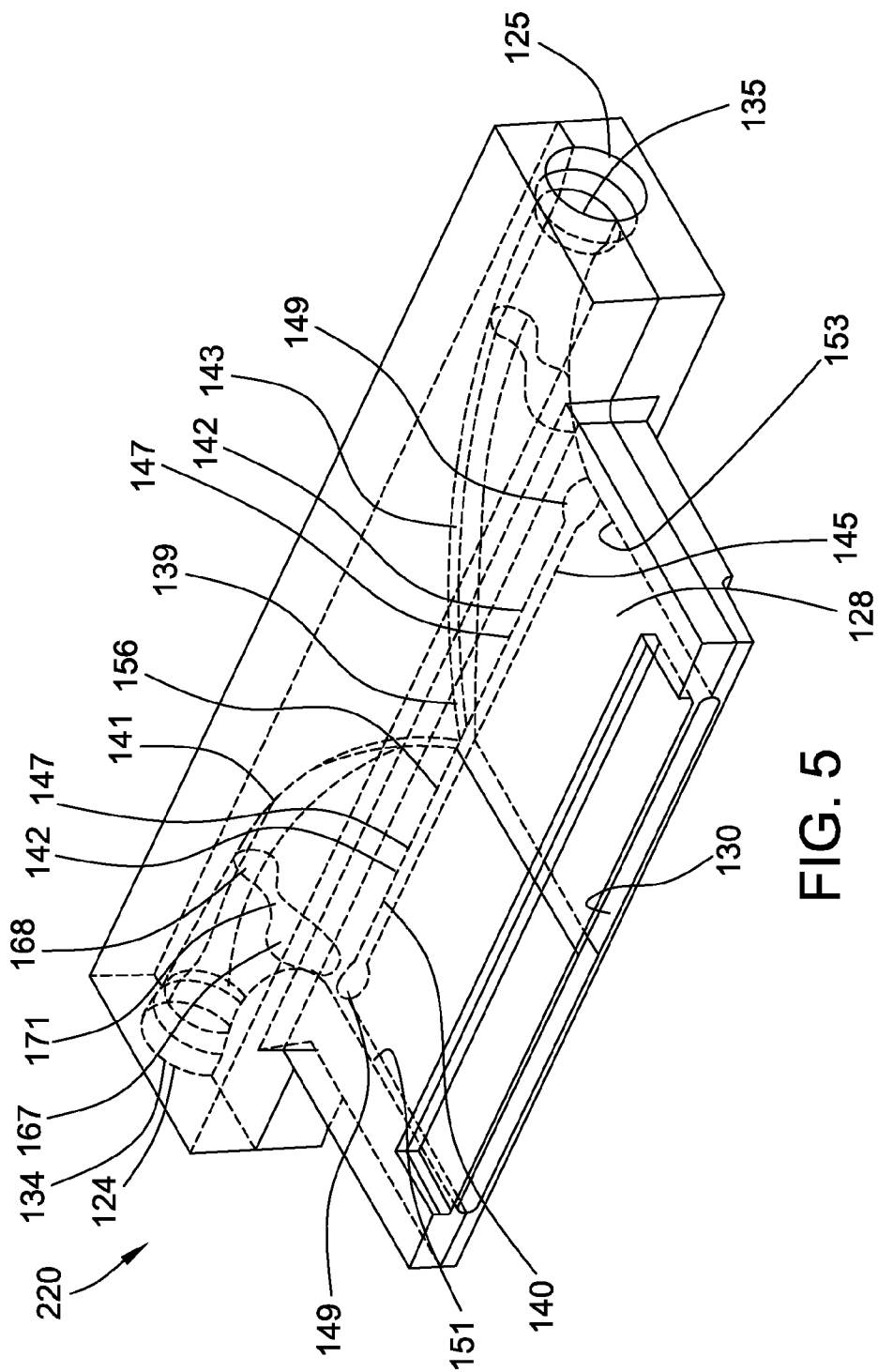


FIG. 5

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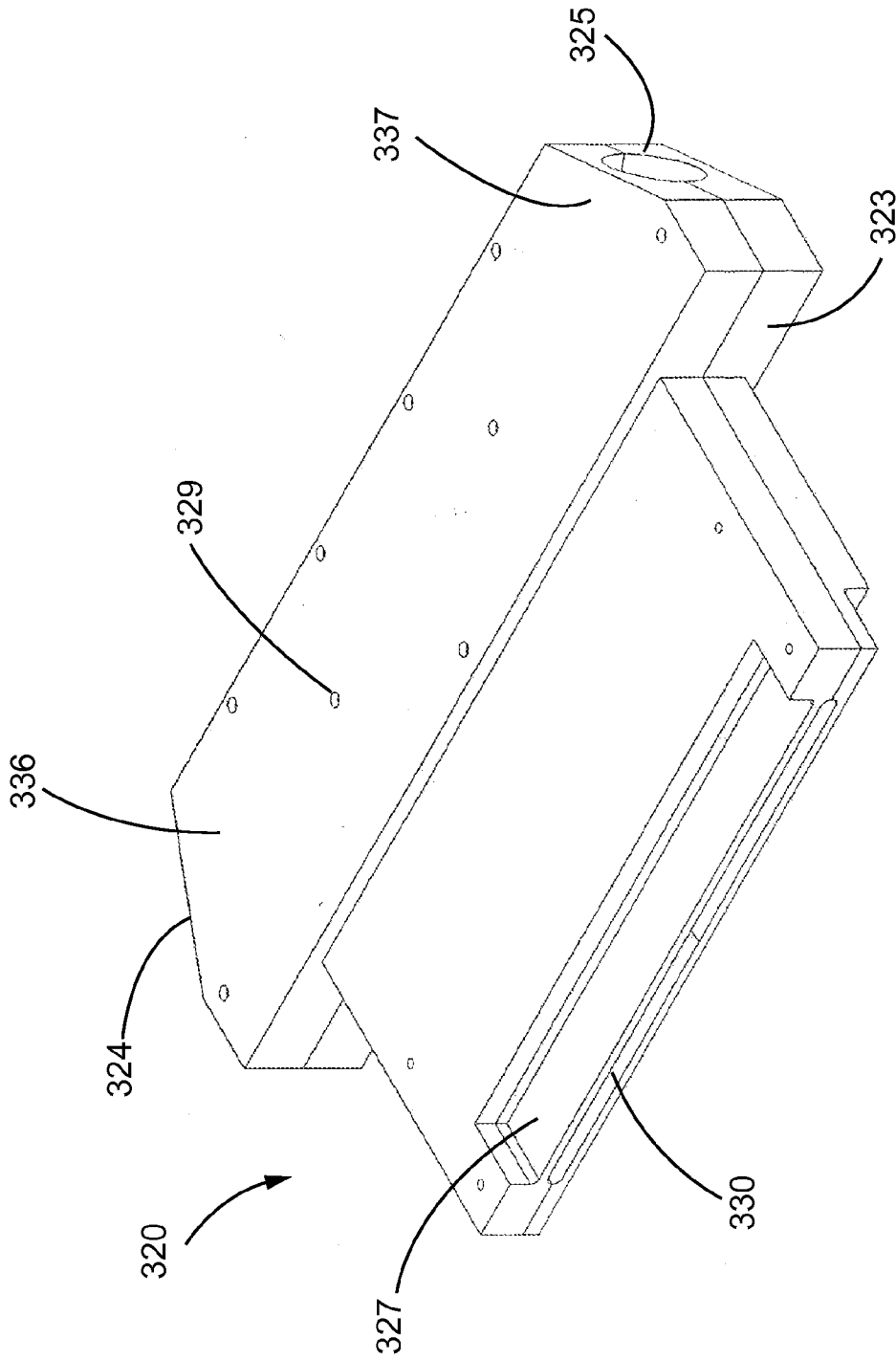


FIG. 6

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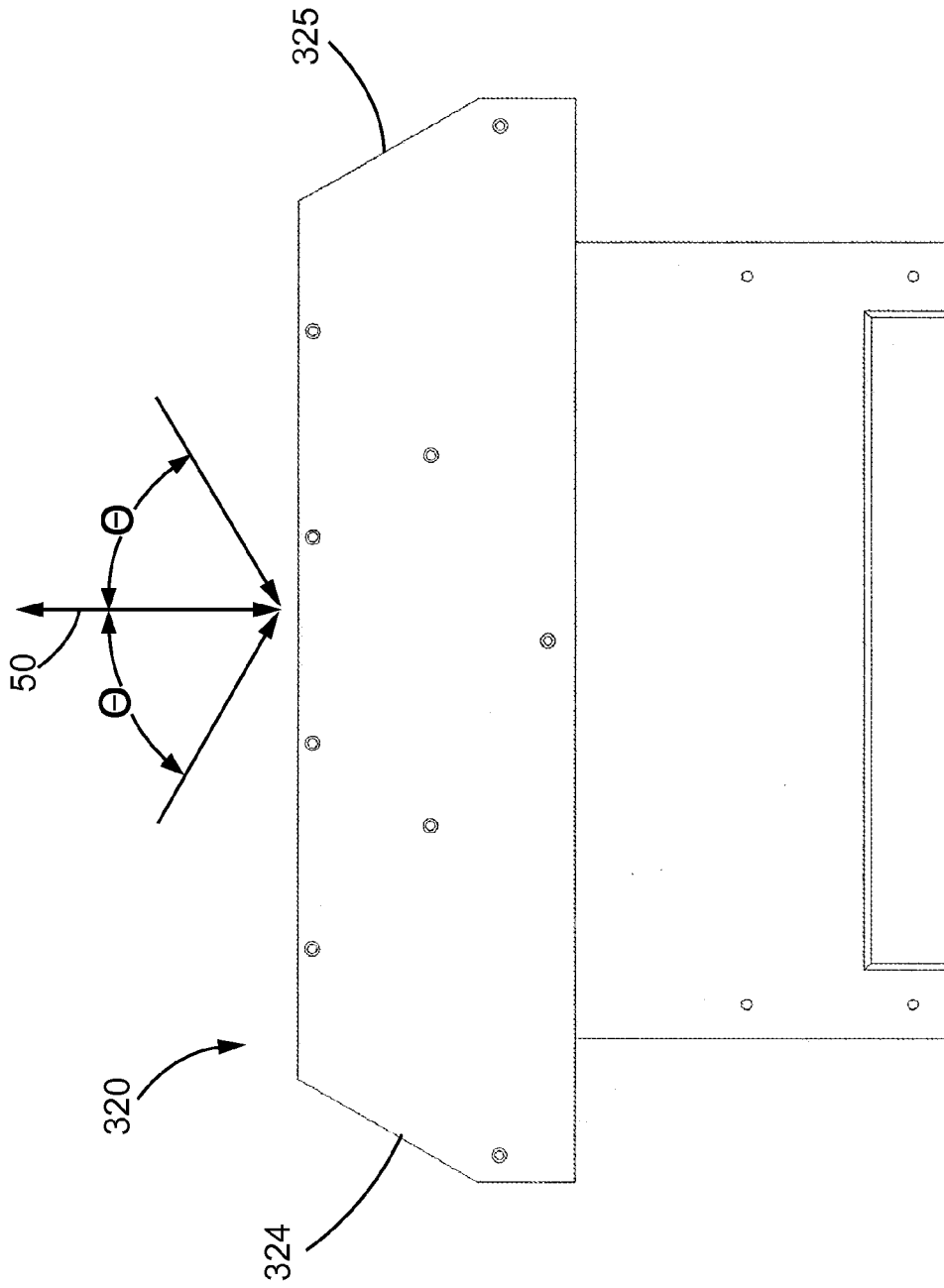


FIG. 7



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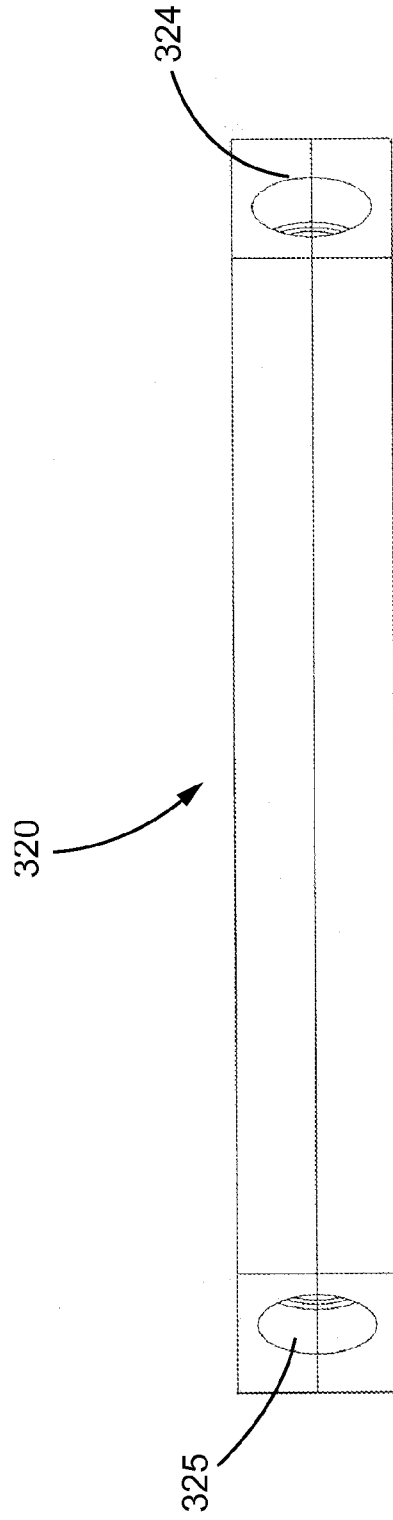


FIG. 8

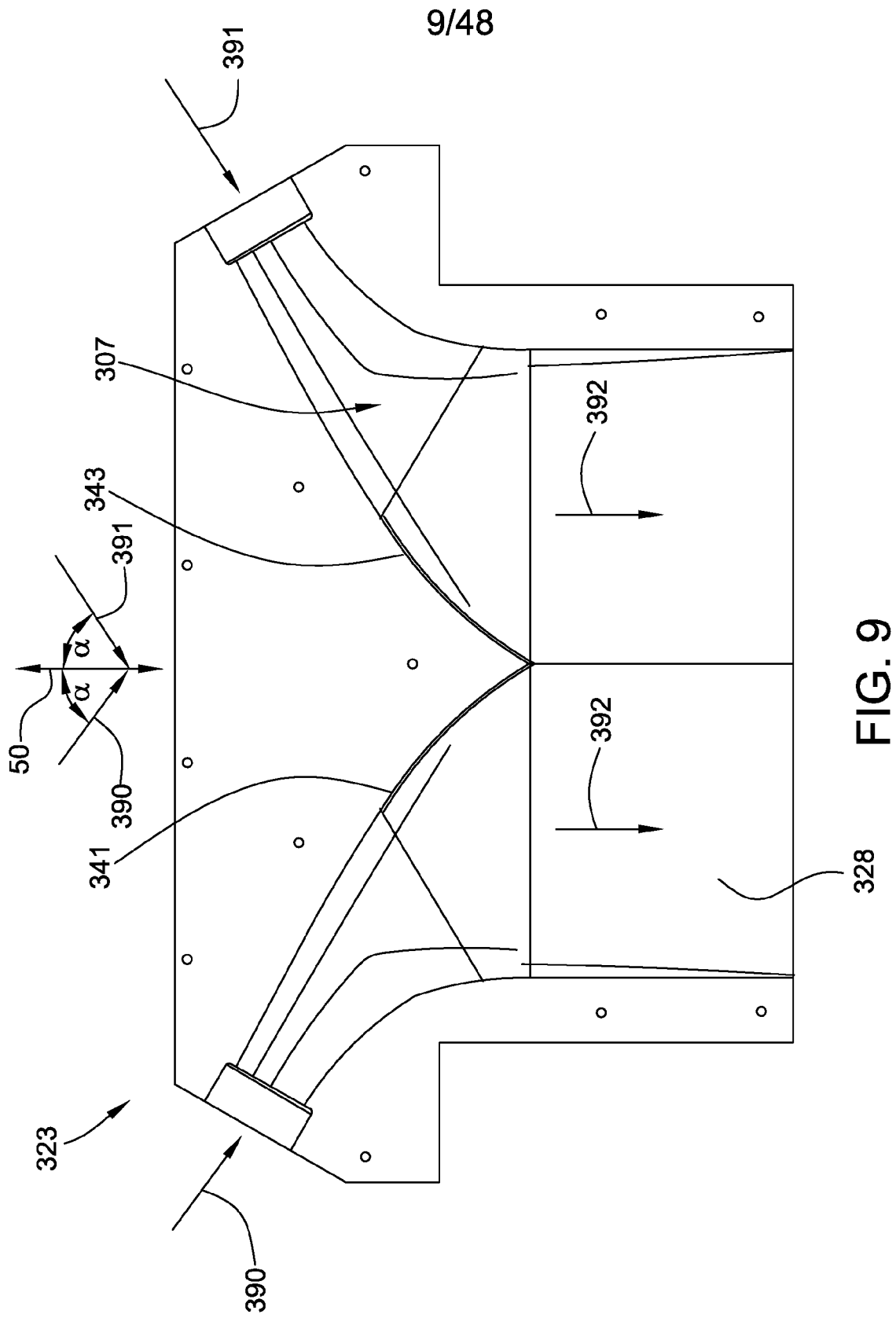


FIG. 9

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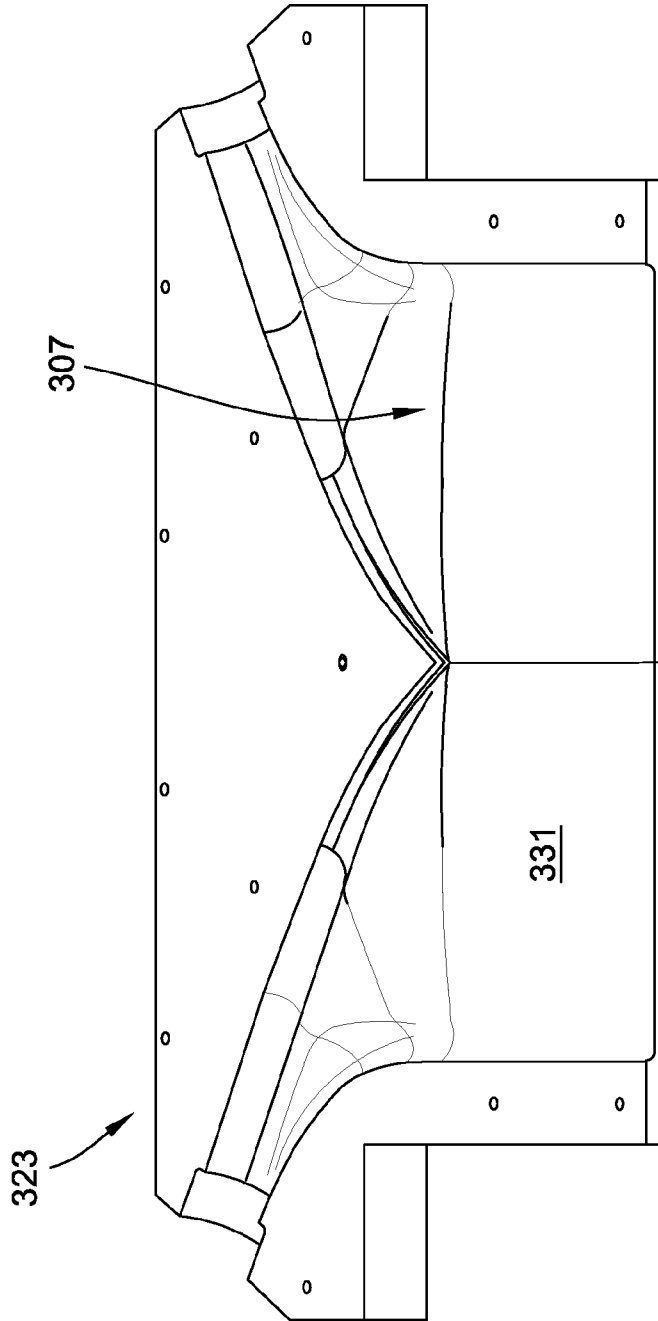


FIG. 10

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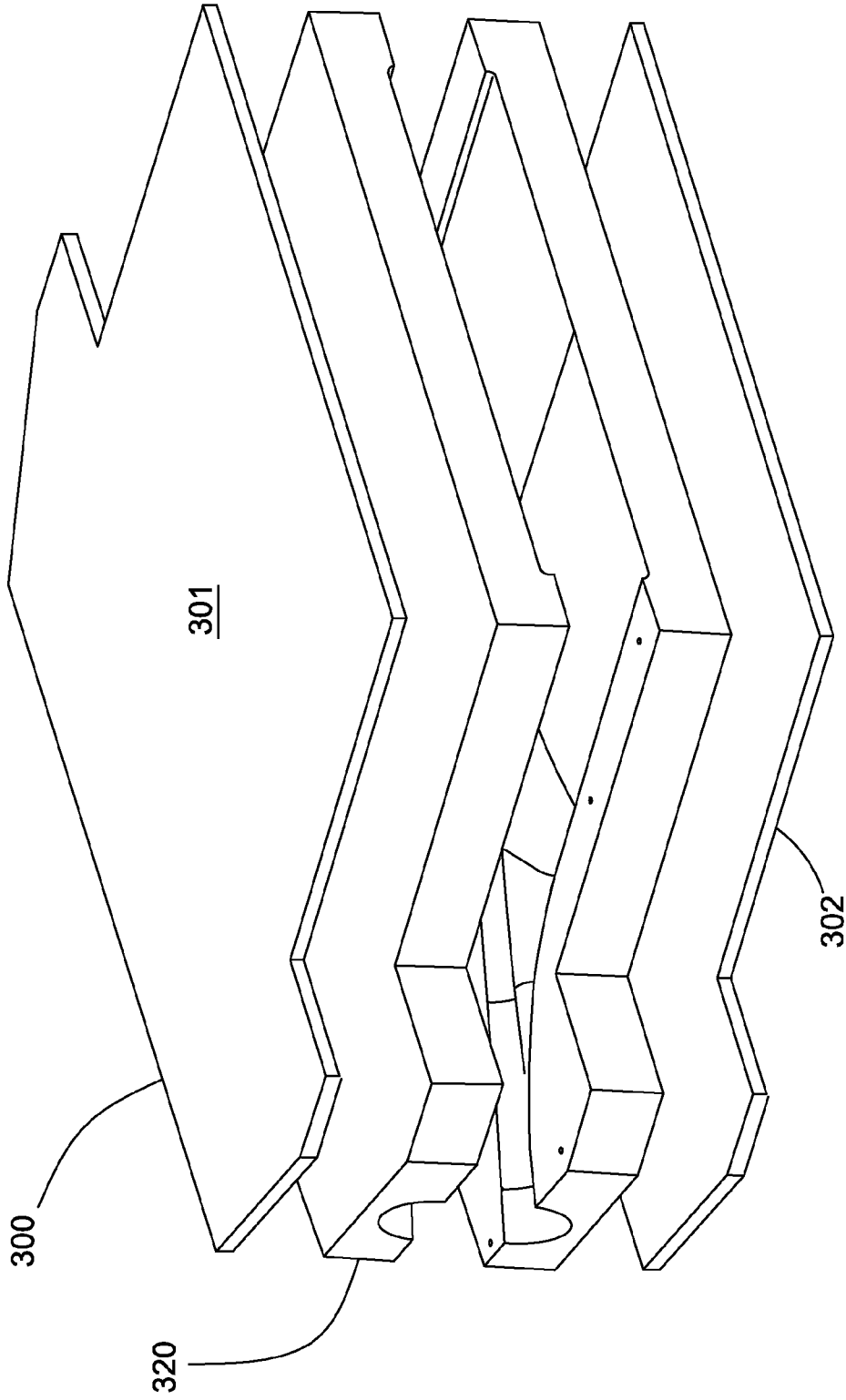


FIG. 11

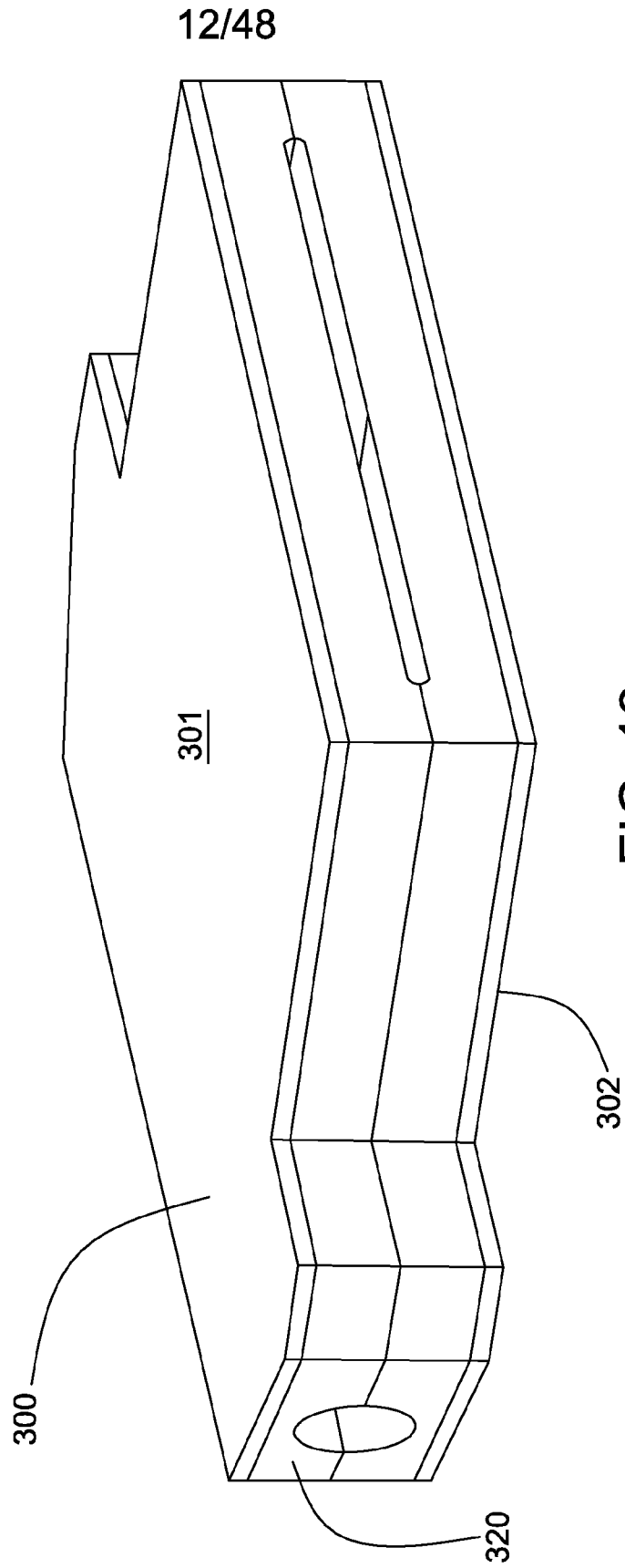


FIG. 12

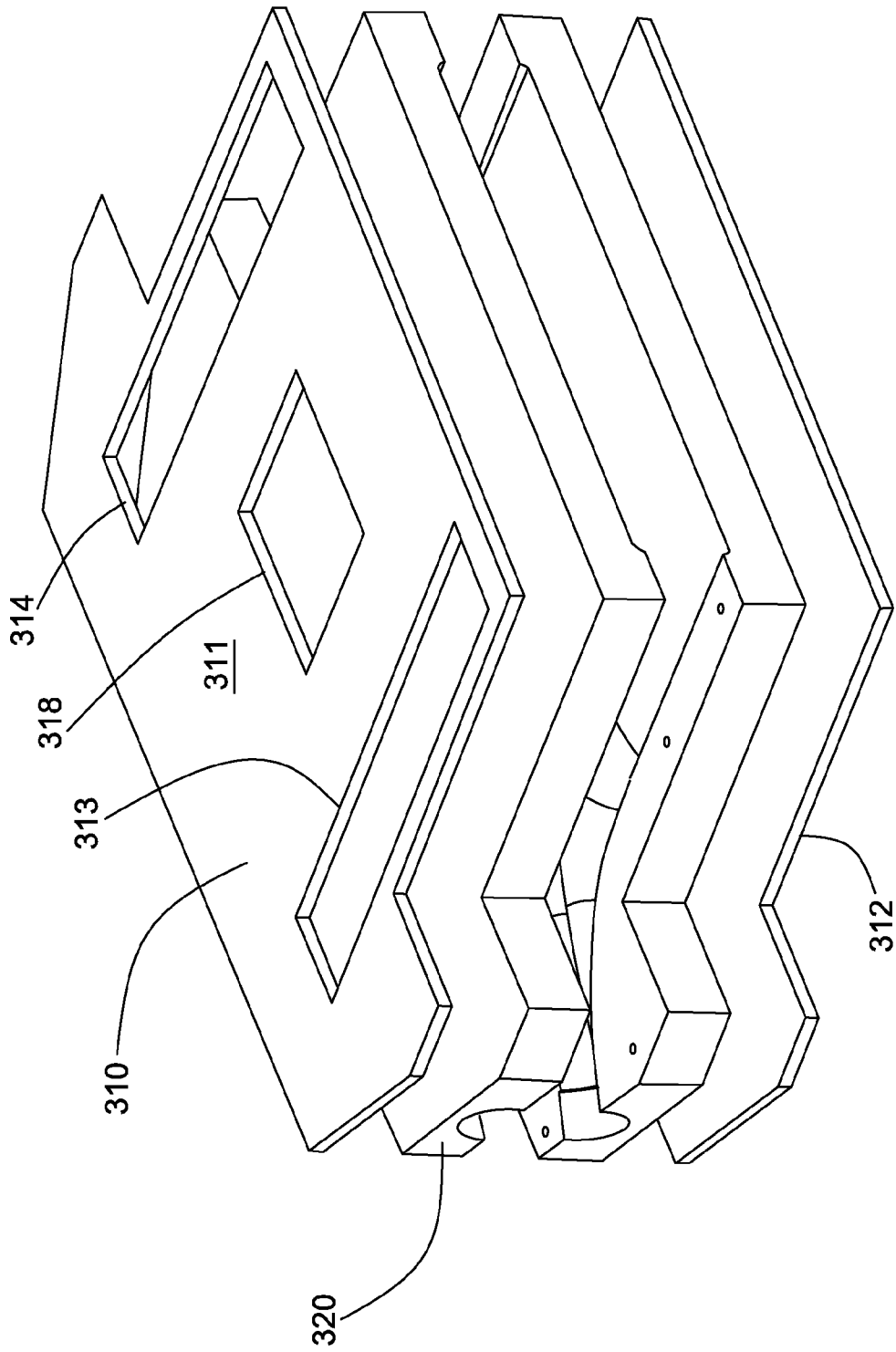


FIG. 13

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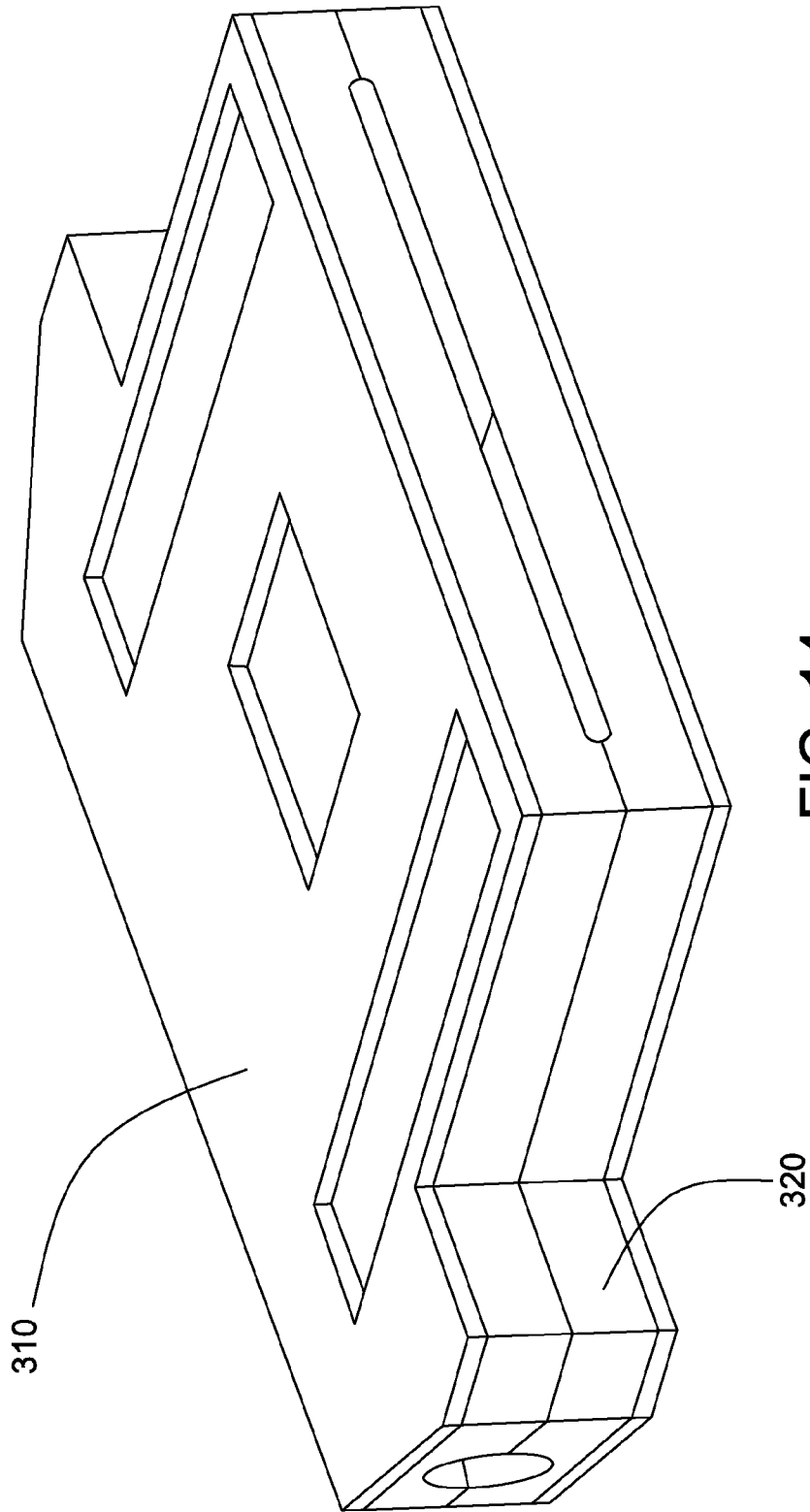


FIG. 14

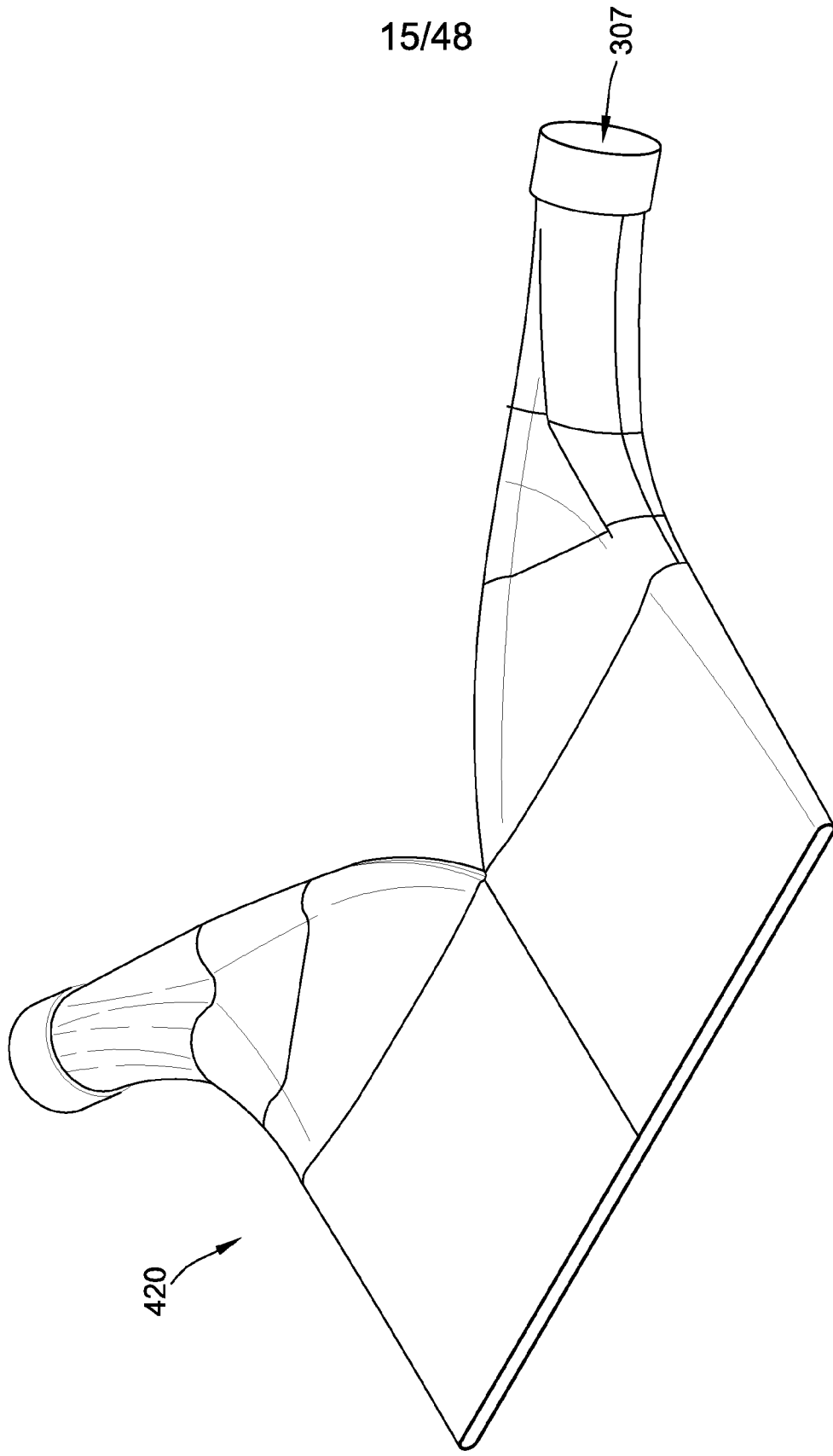


FIG. 15



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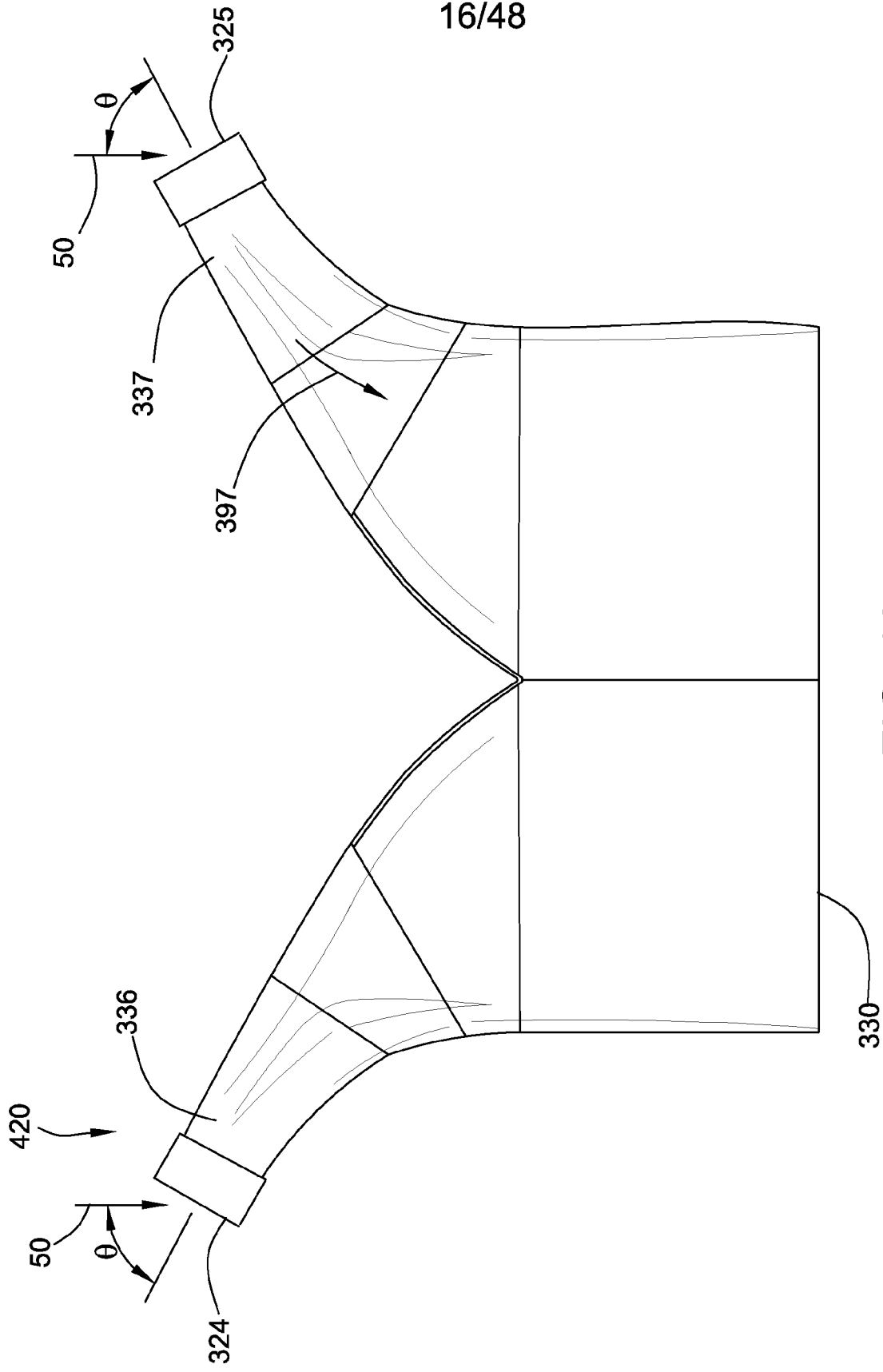


FIG. 16

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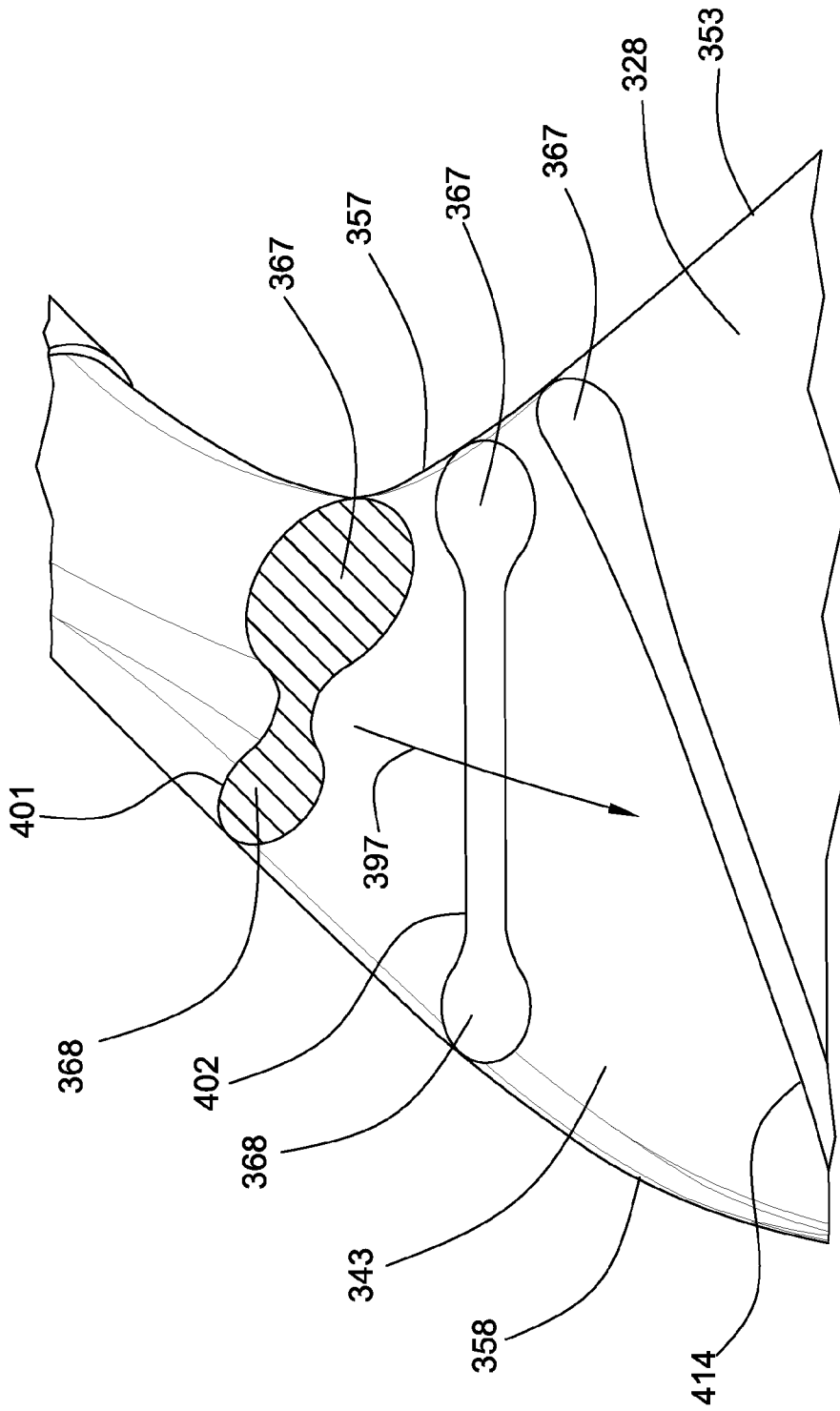


FIG. 17

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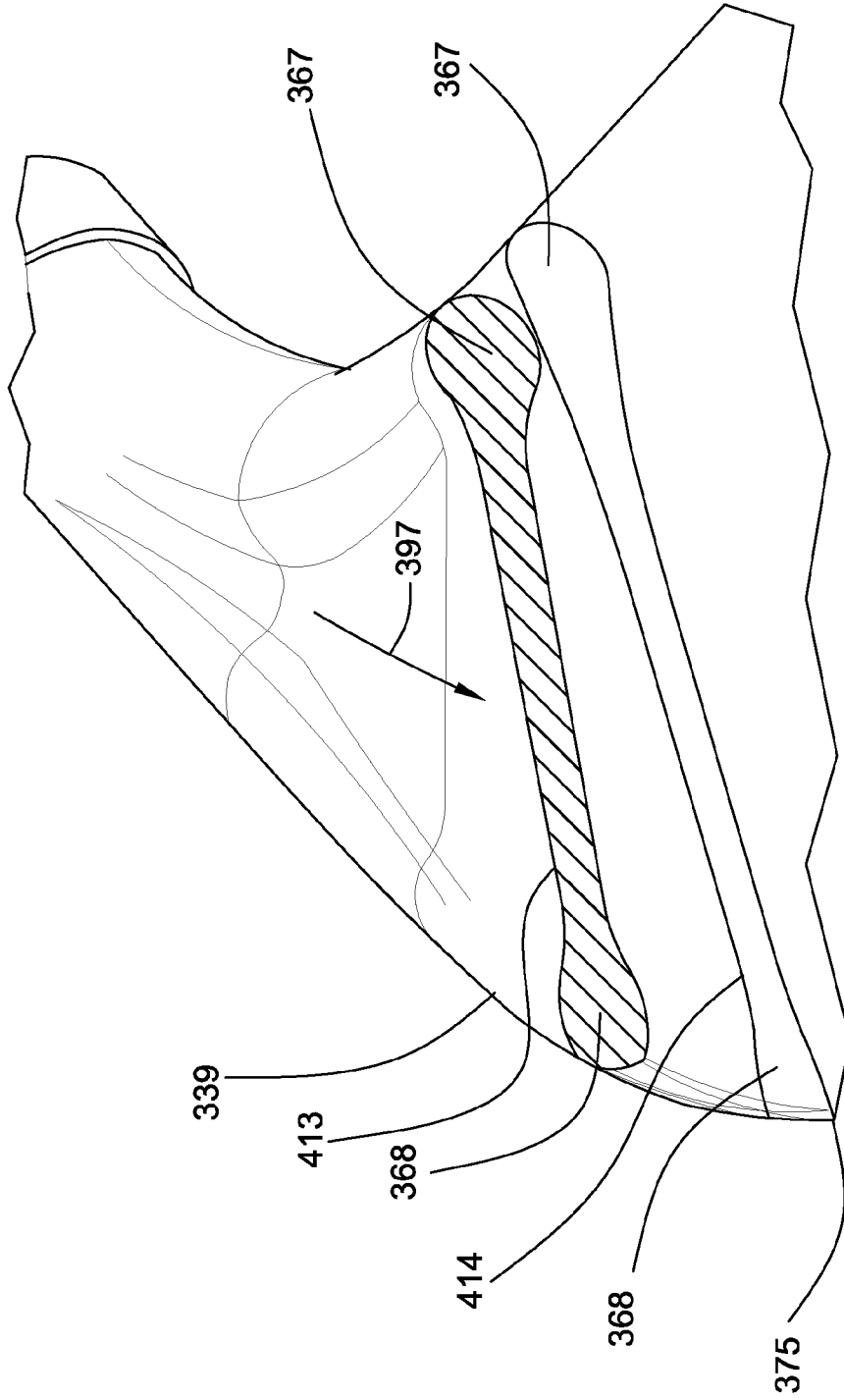


FIG. 18

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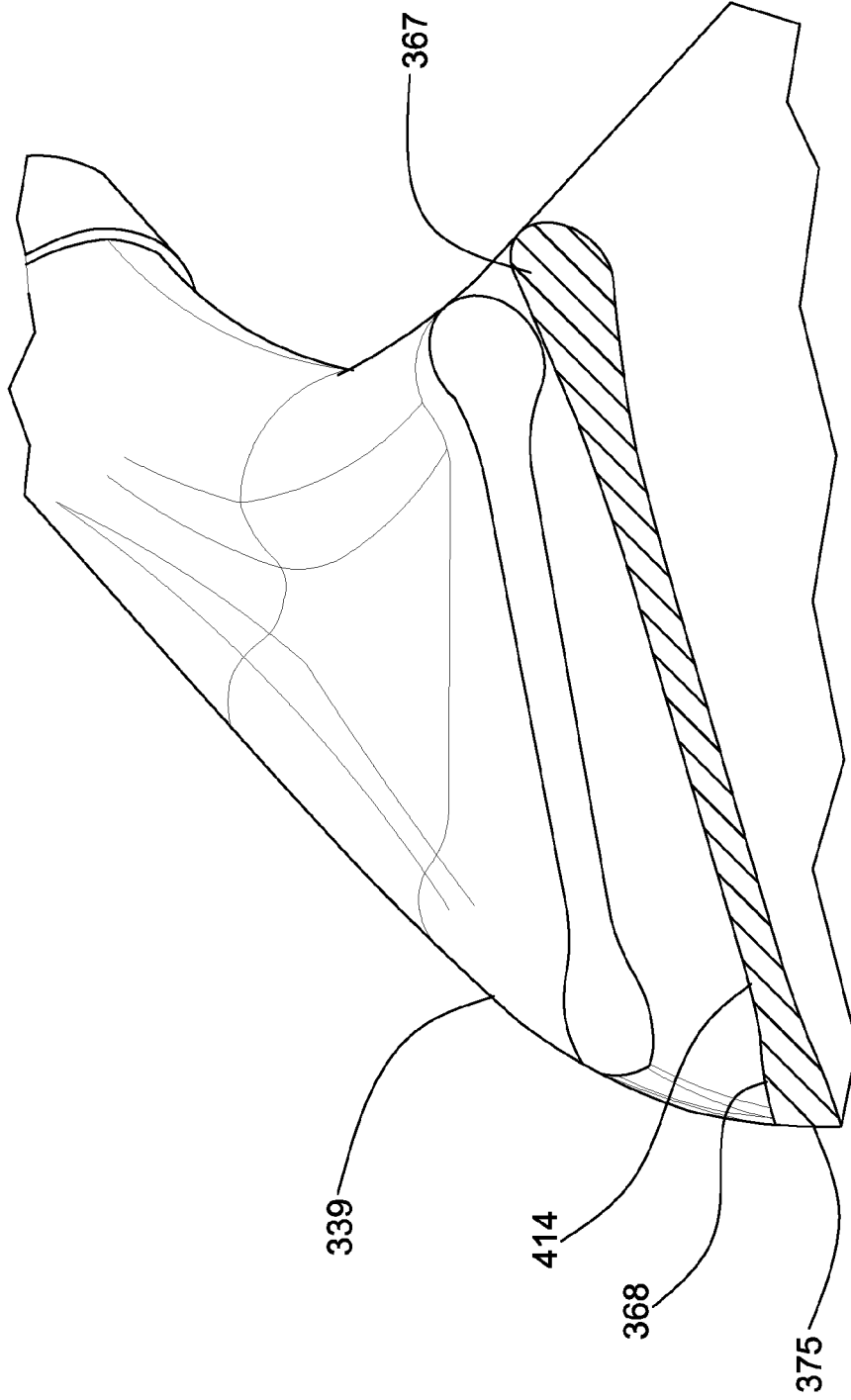


FIG. 19

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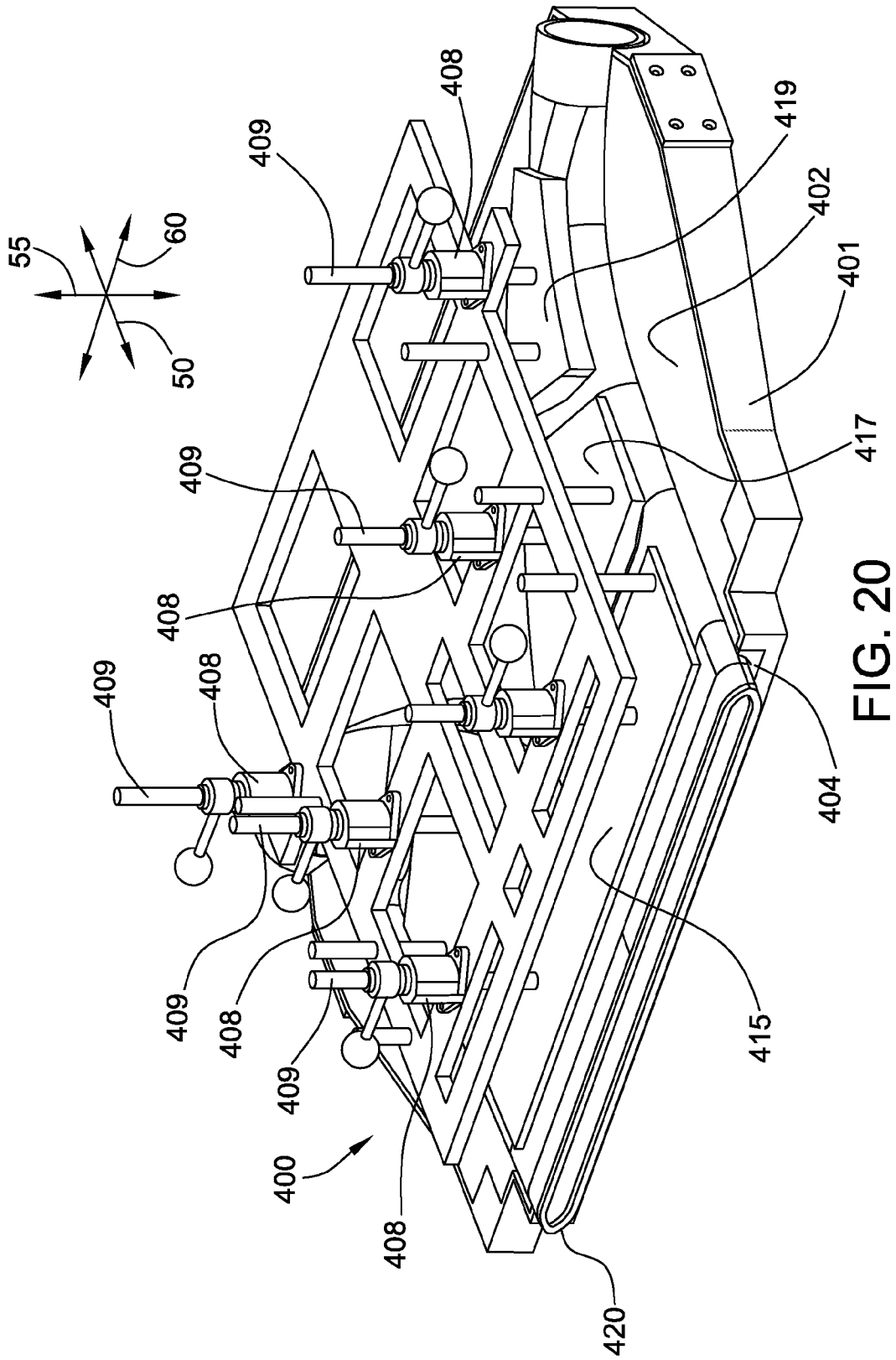


FIG. 20

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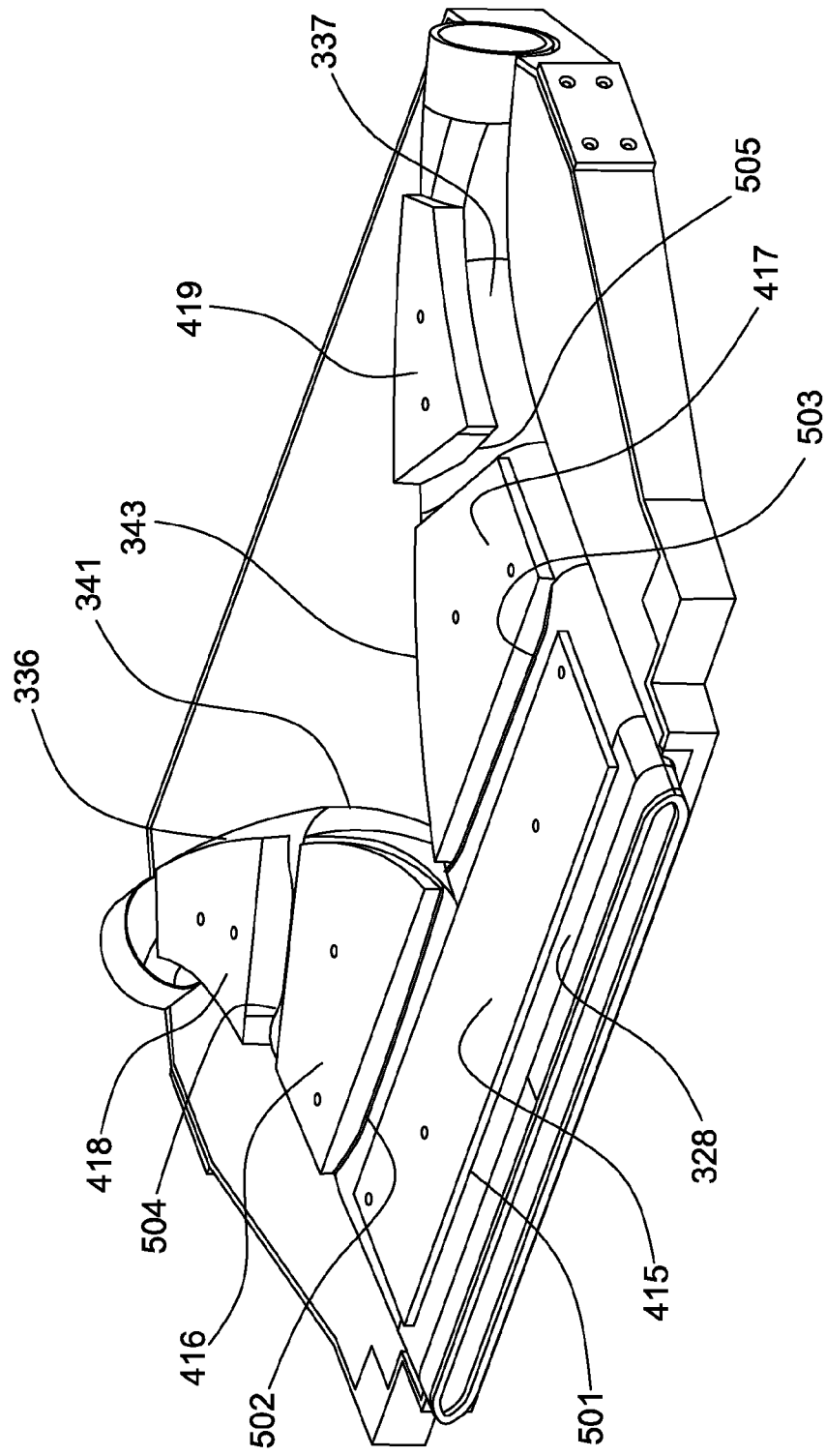


FIG. 21

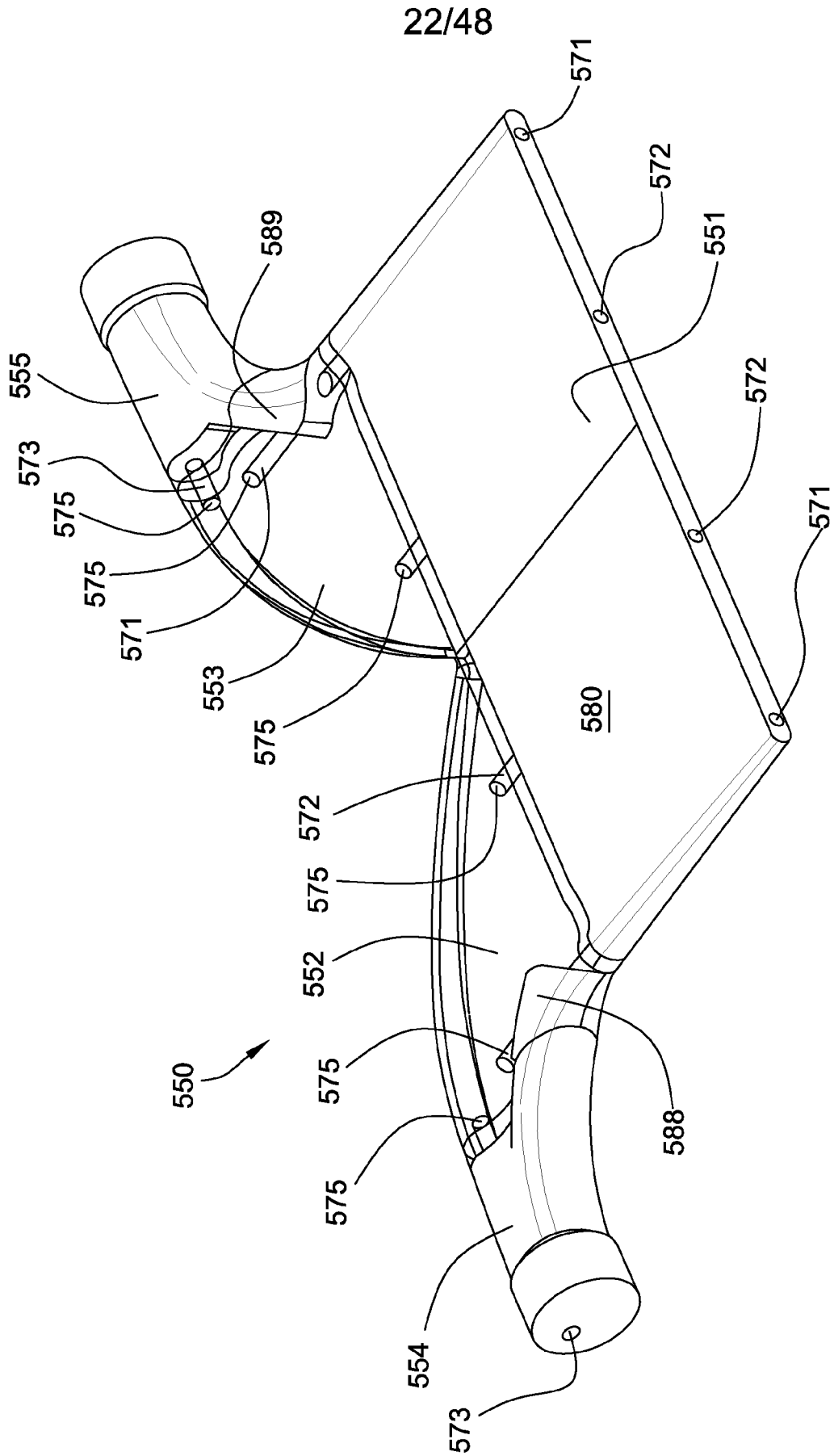


FIG. 22

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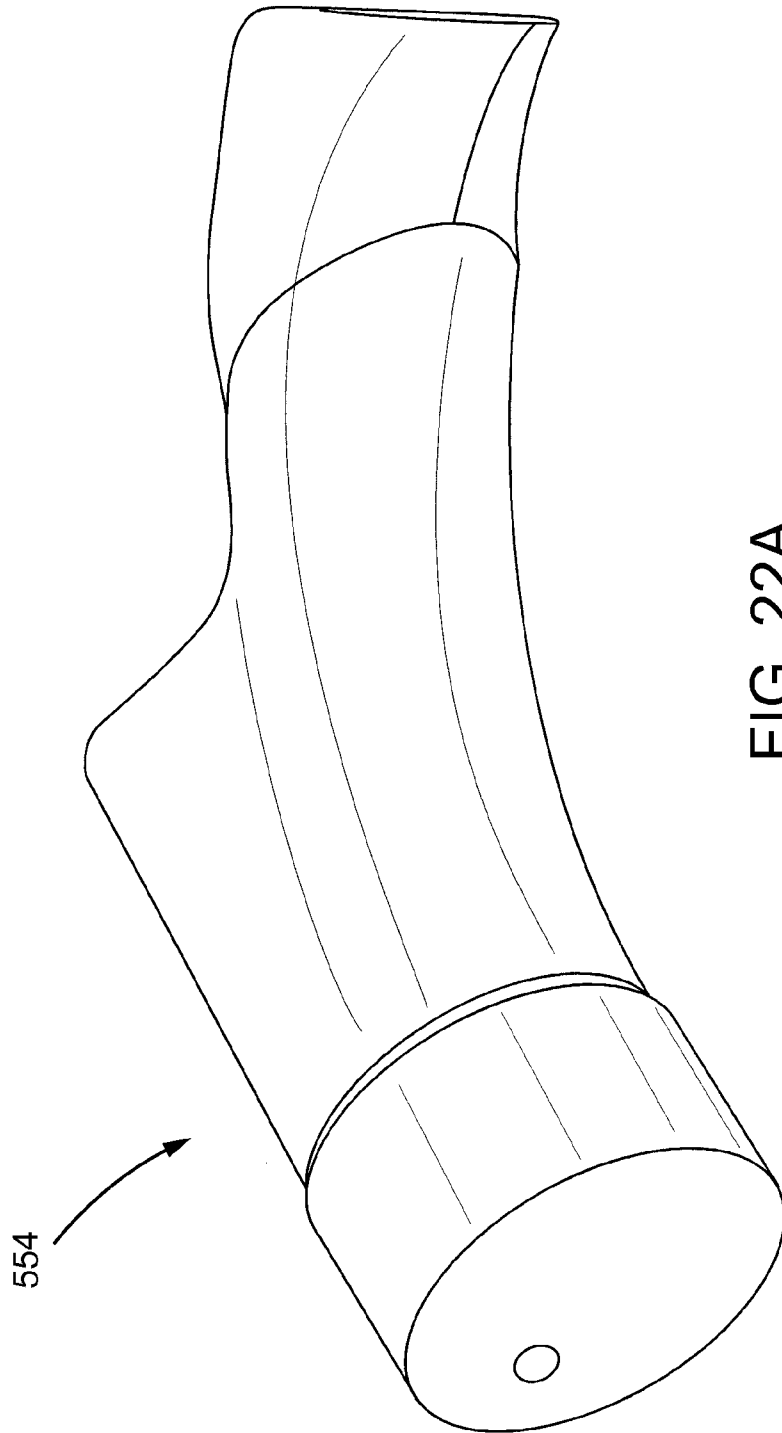
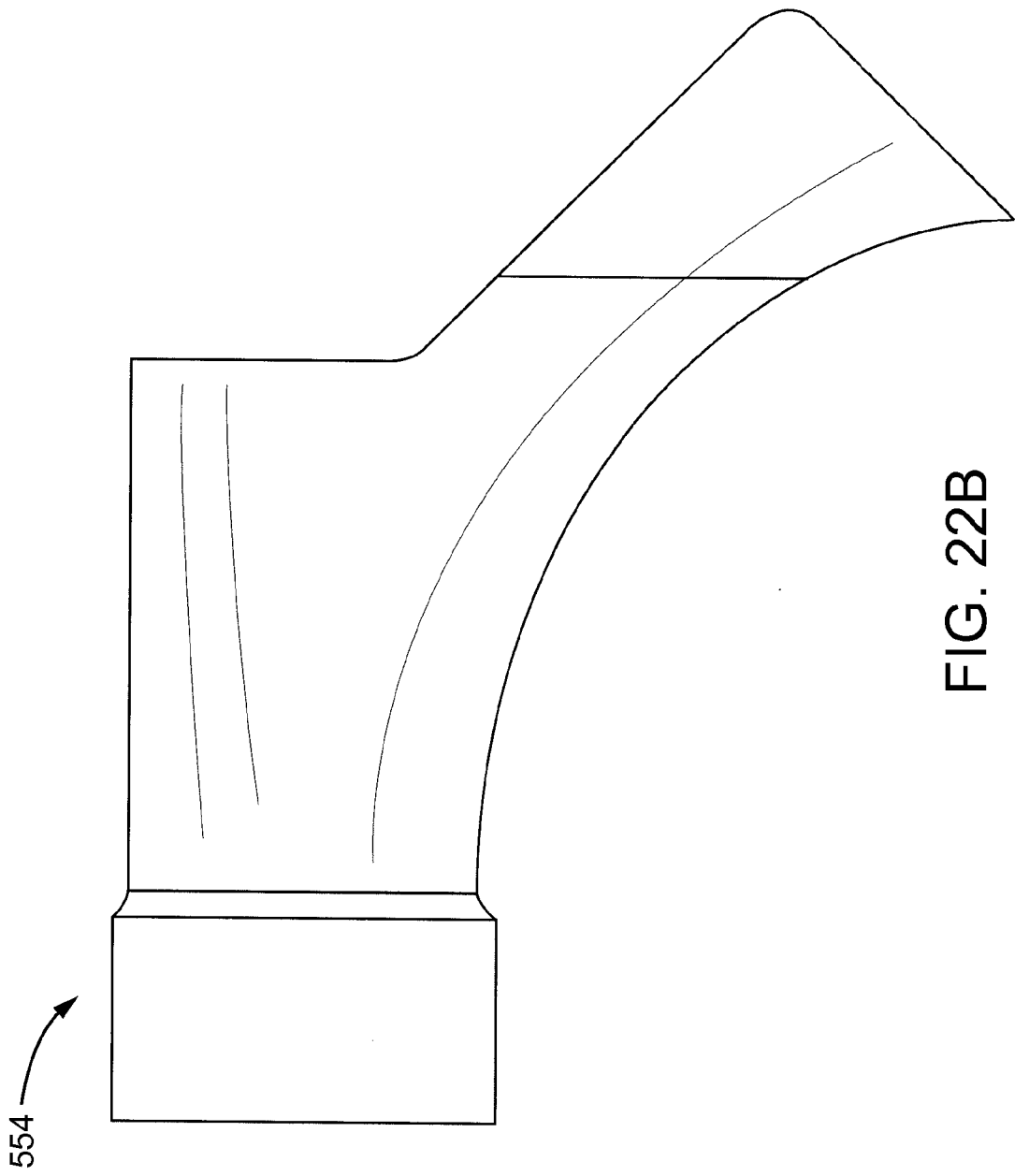


FIG. 22A



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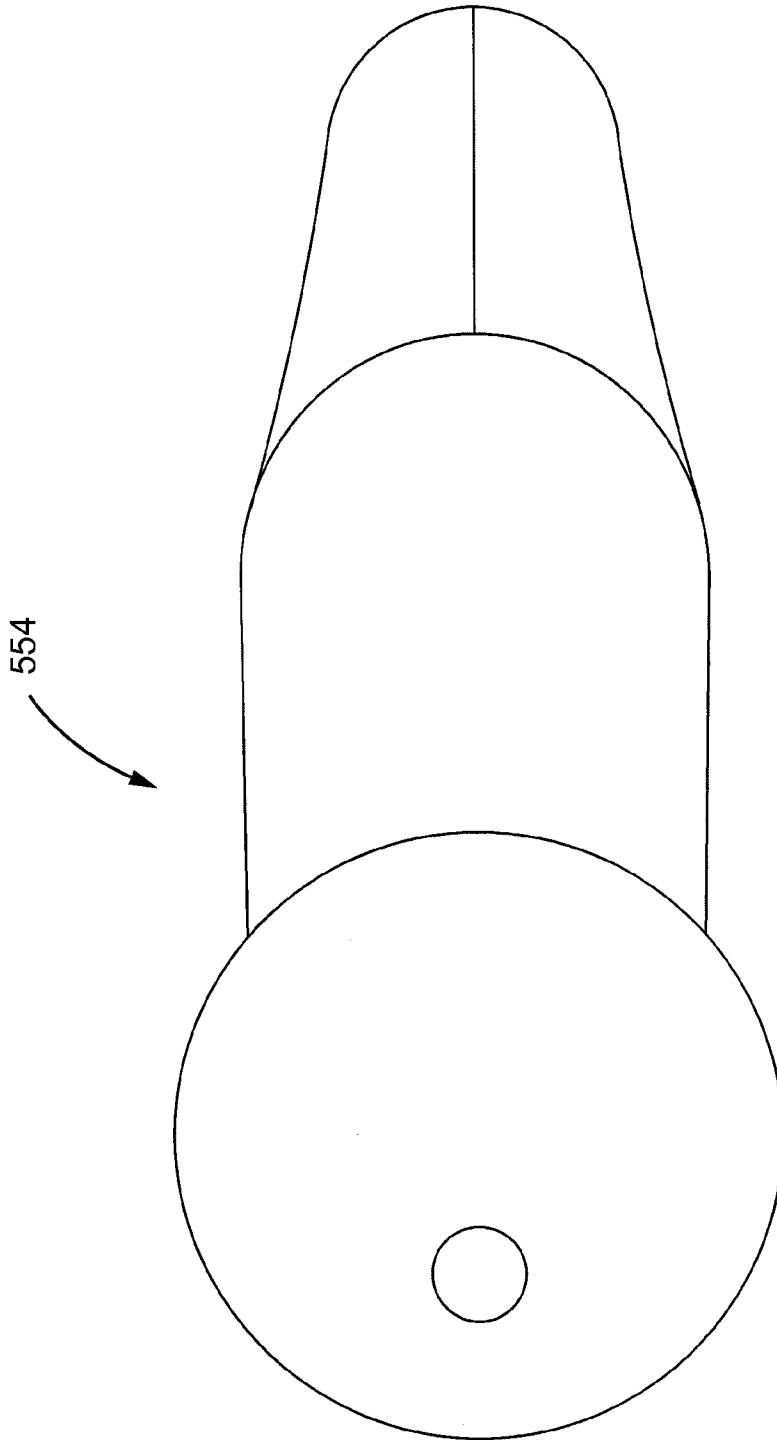


FIG. 22C

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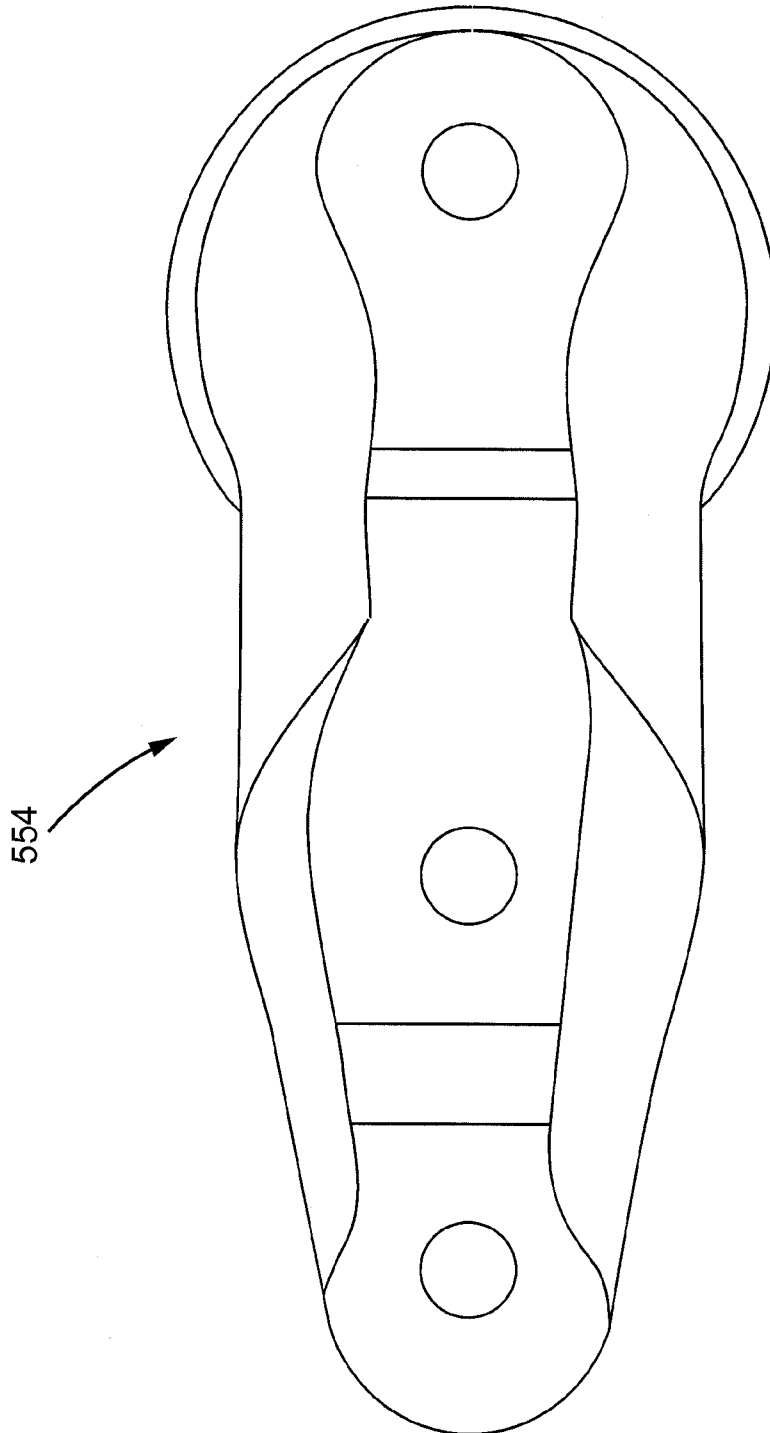


FIG. 22D

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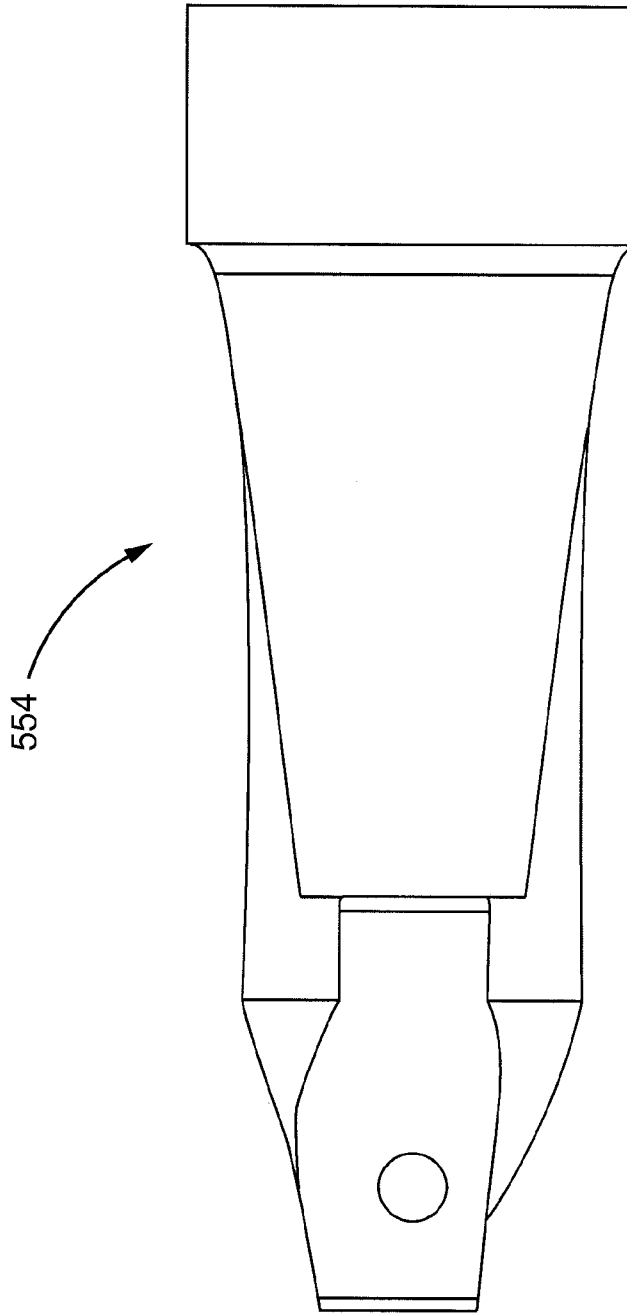


FIG. 22E

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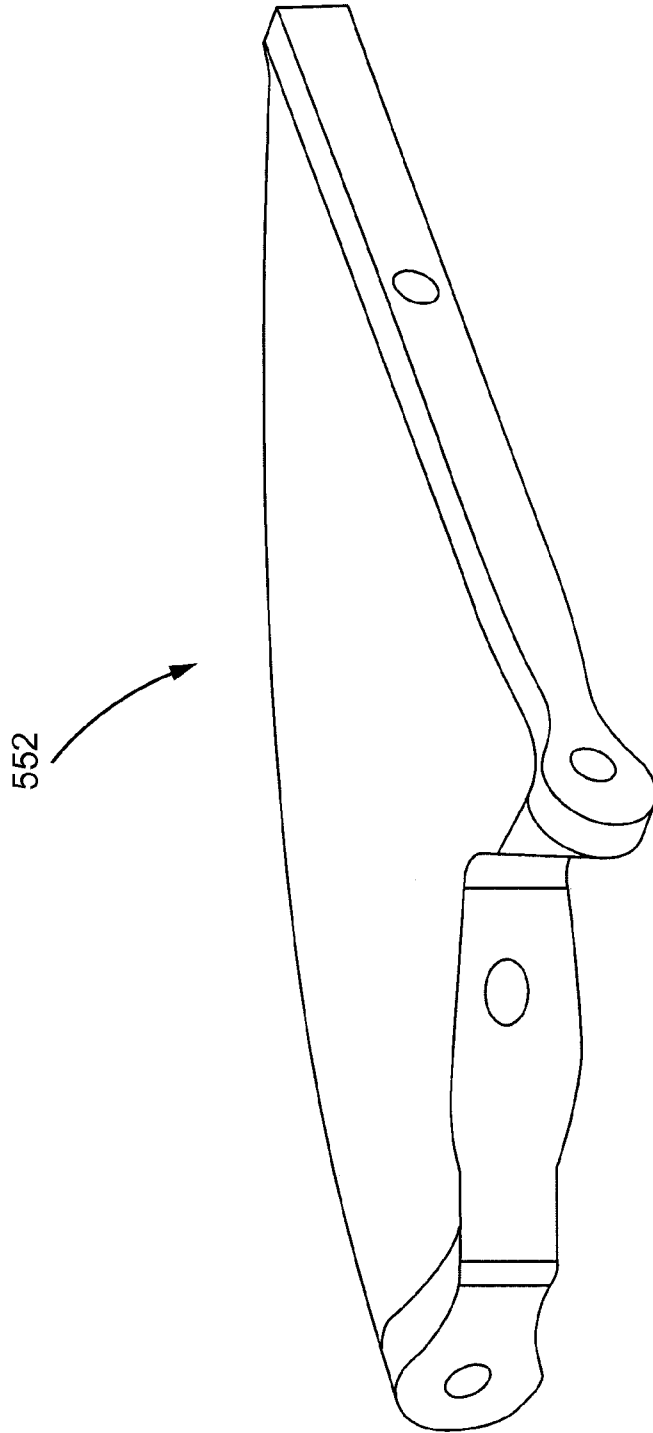


FIG. 22F

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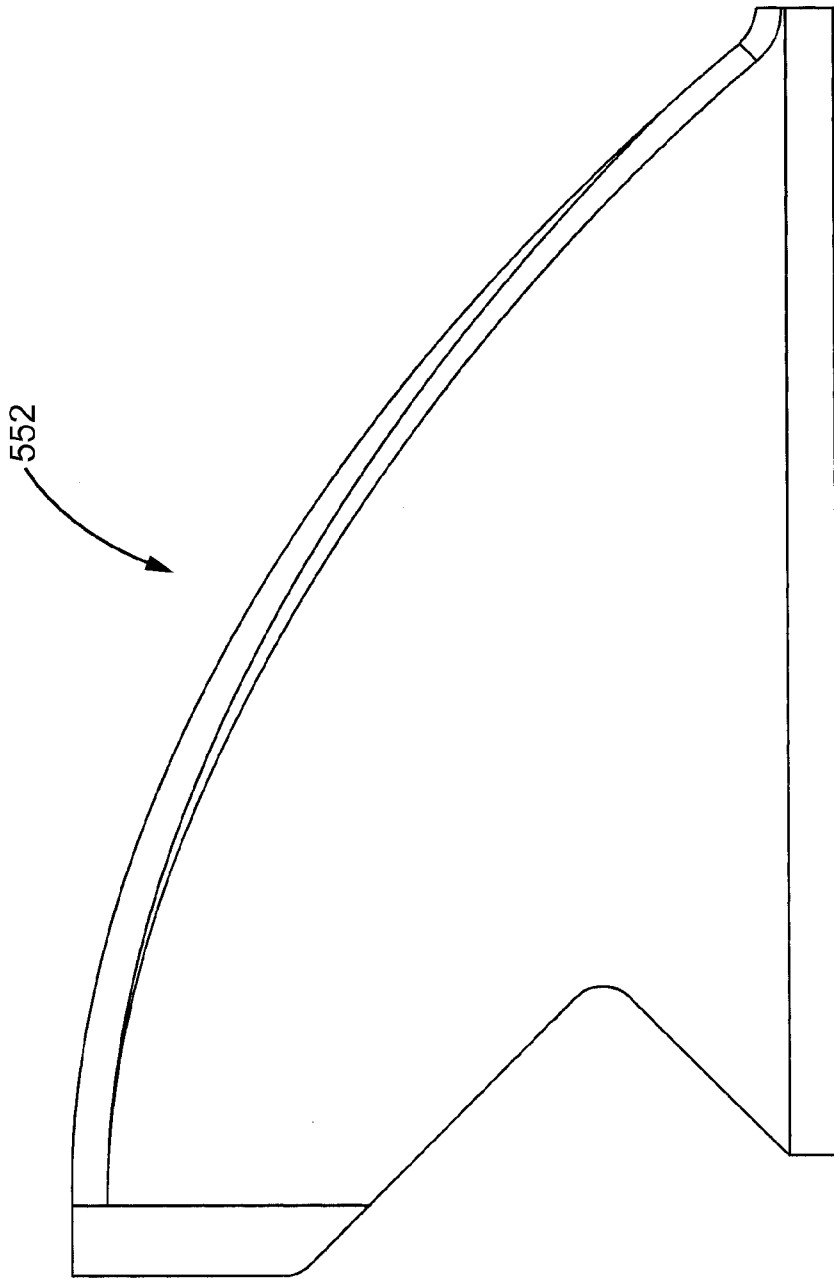


FIG. 22G

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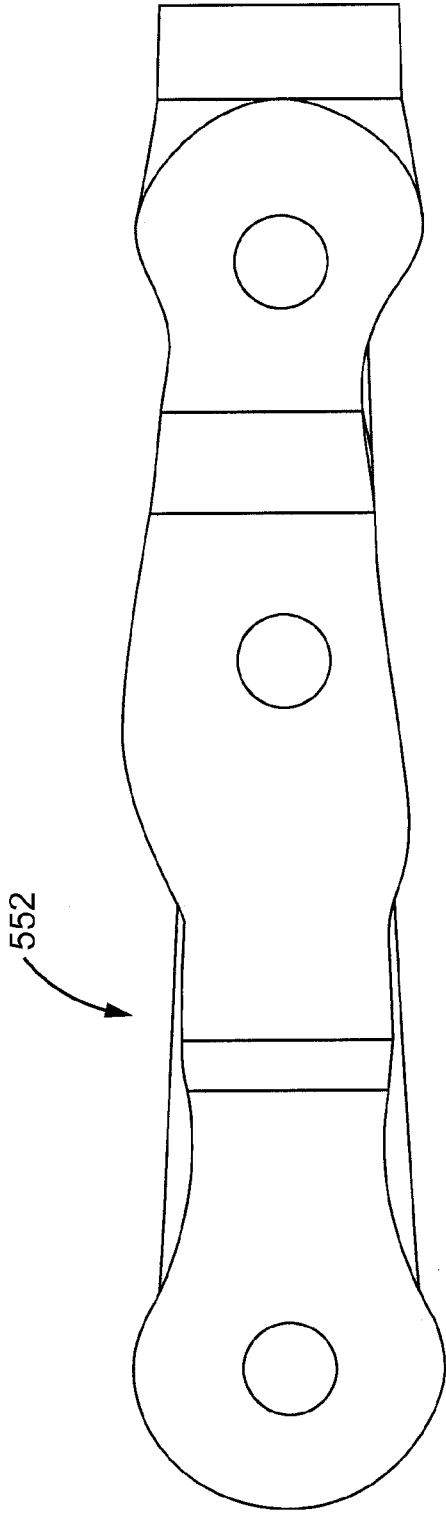


FIG. 22H

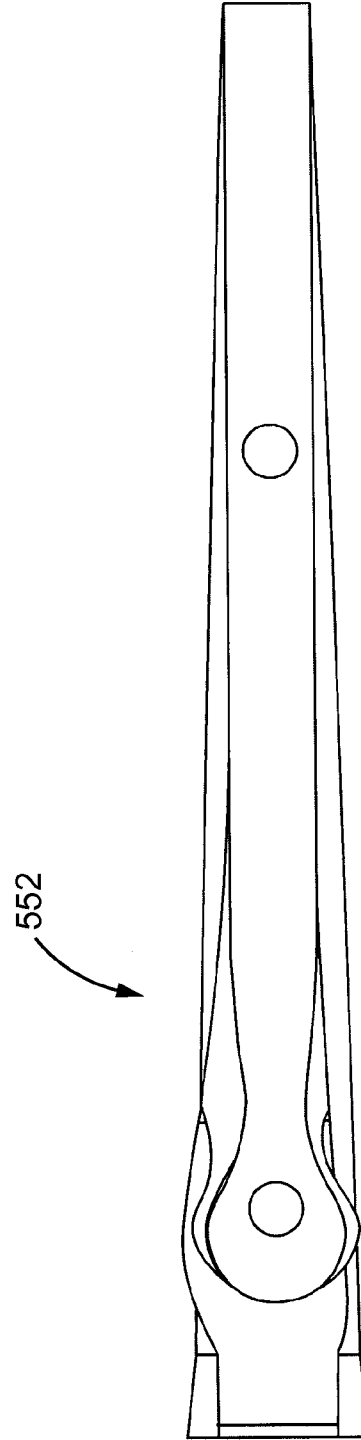
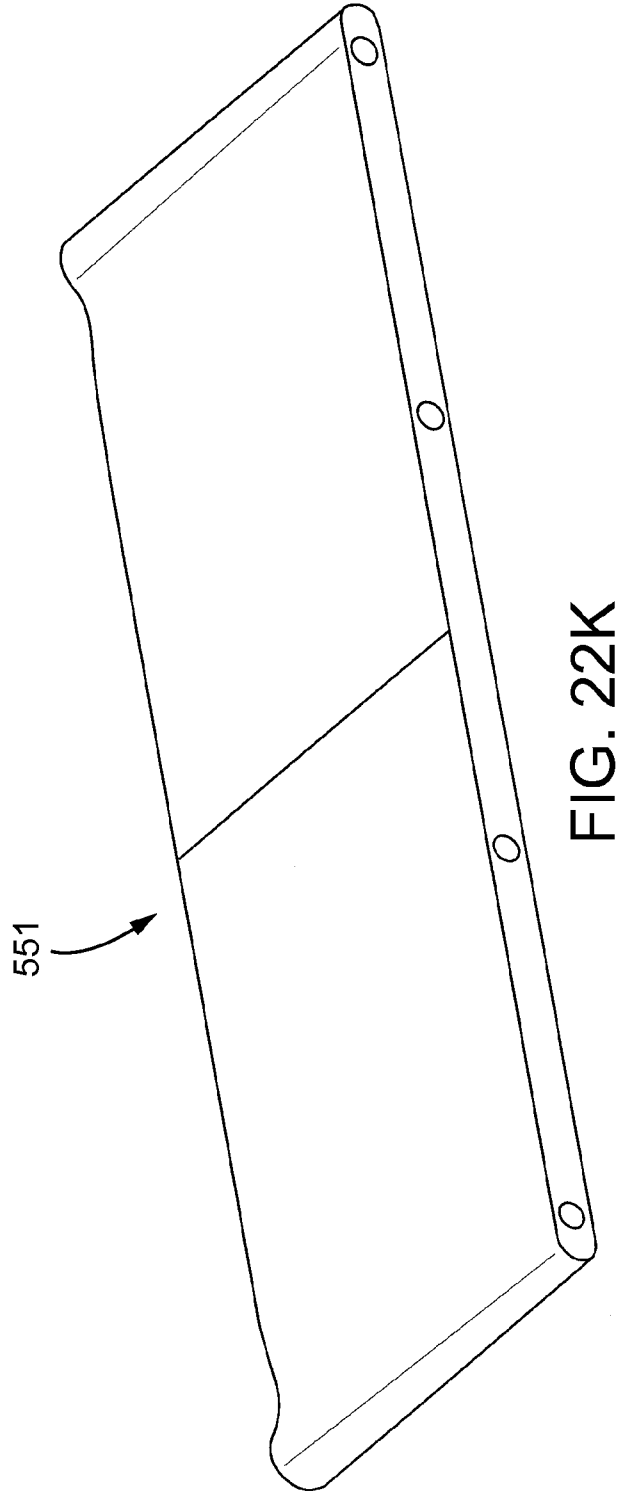
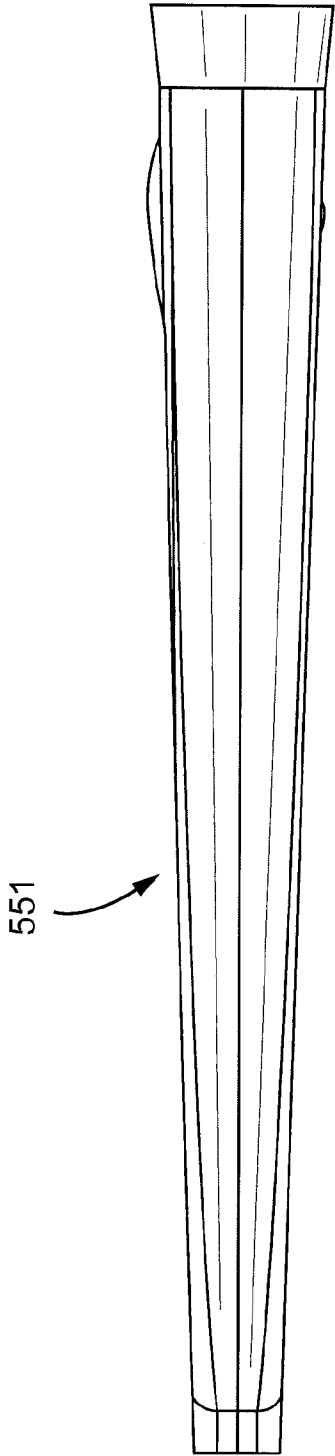


FIG. 22I

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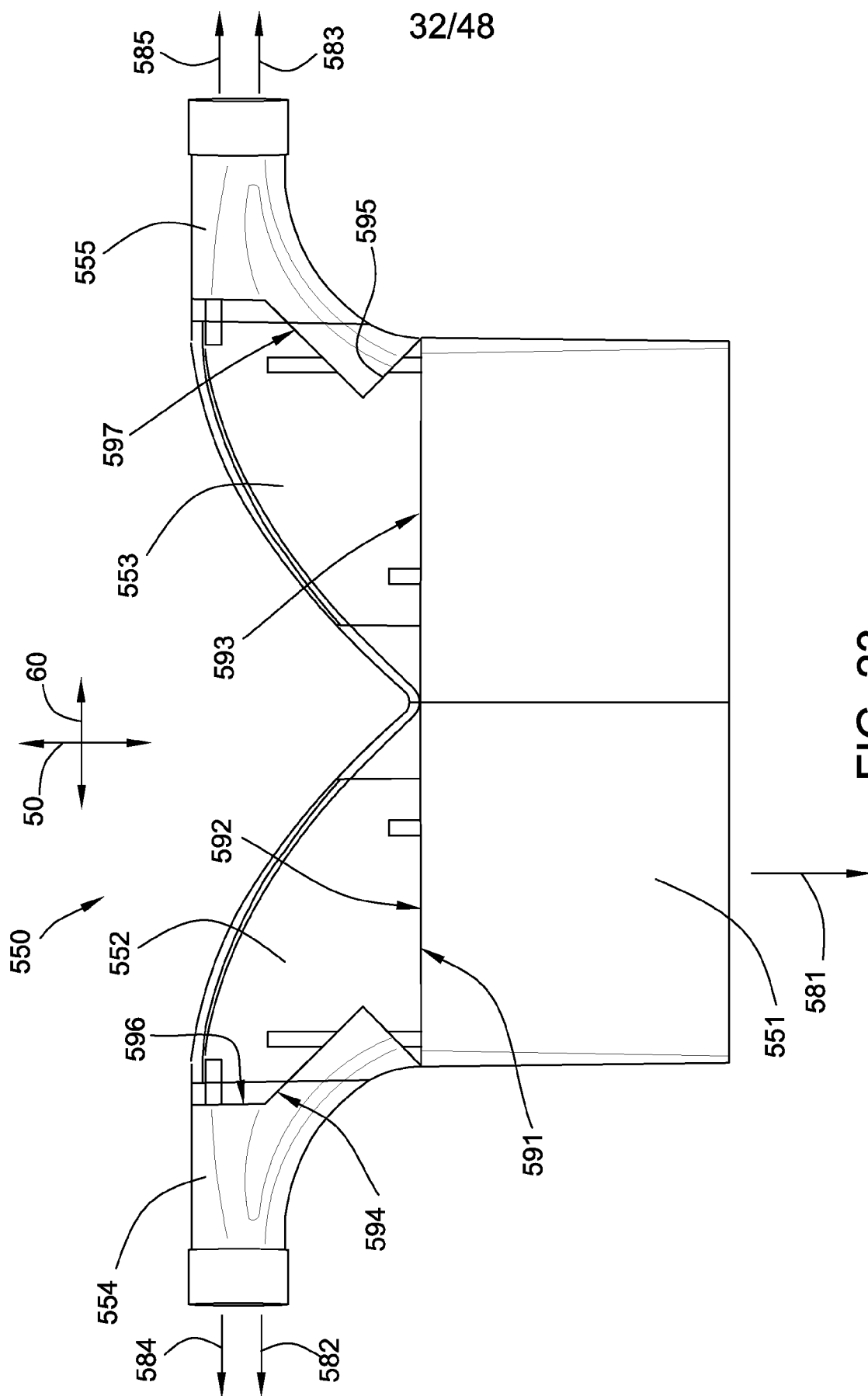


FIG. 23

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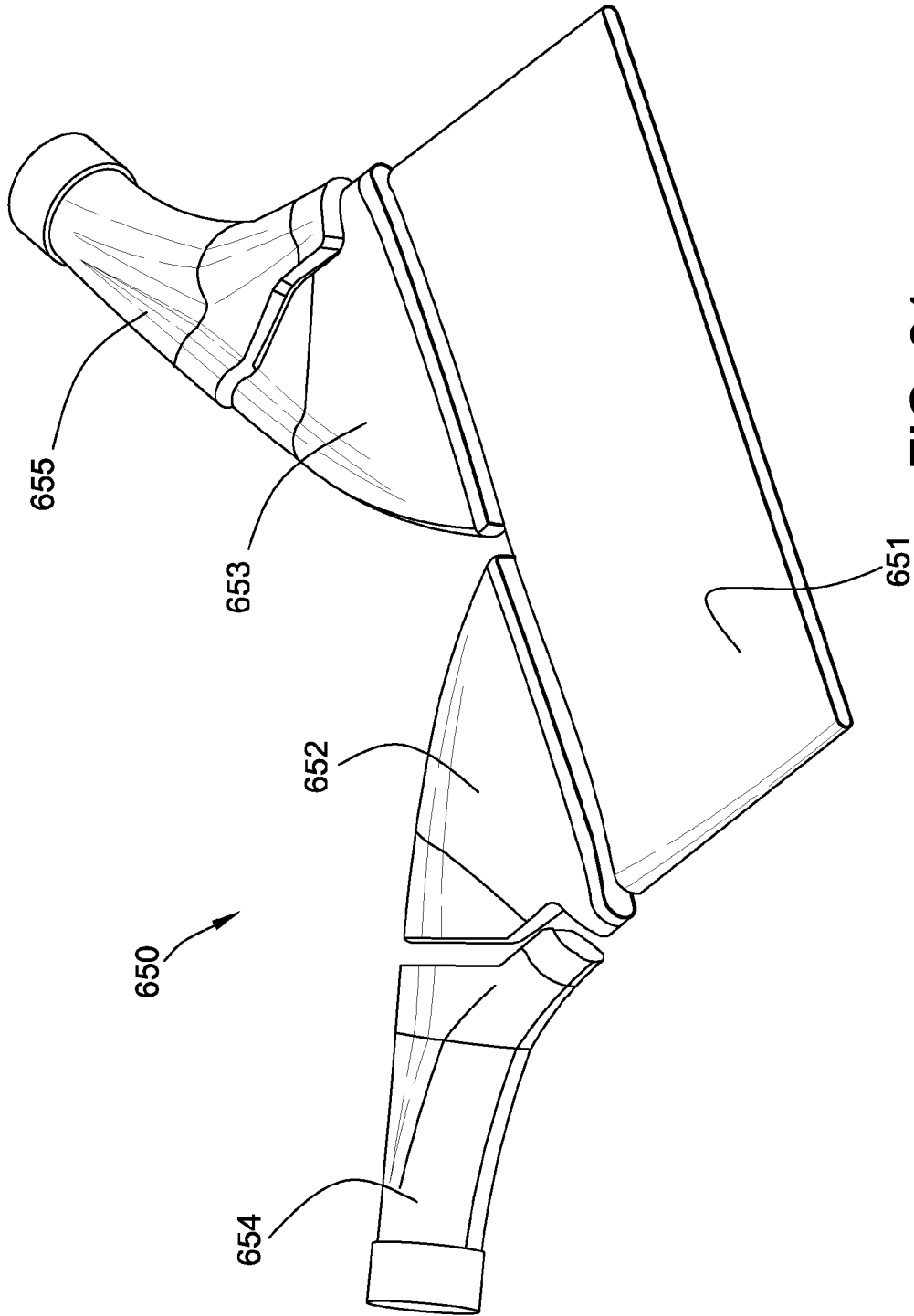


FIG. 24

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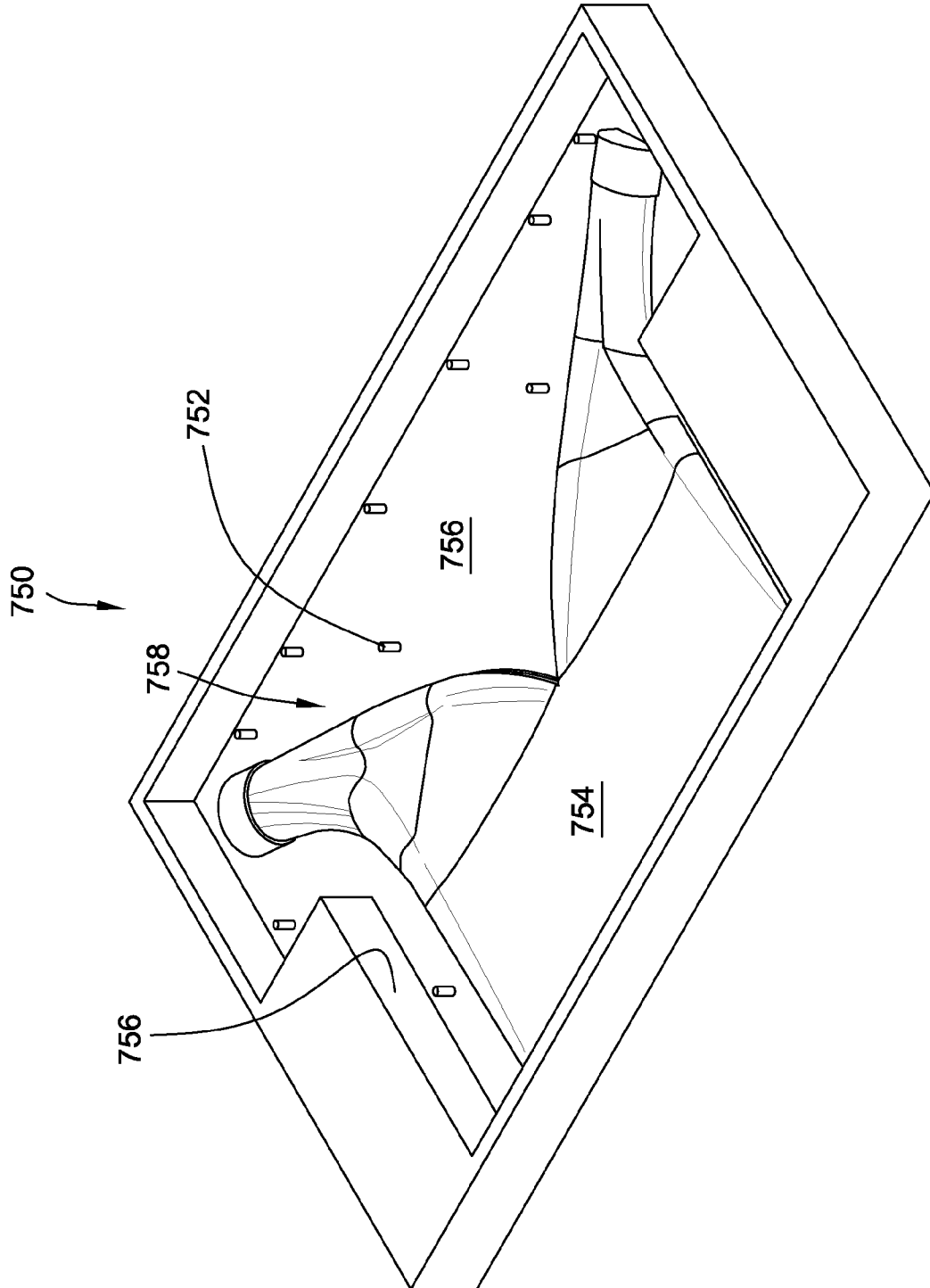


FIG. 25

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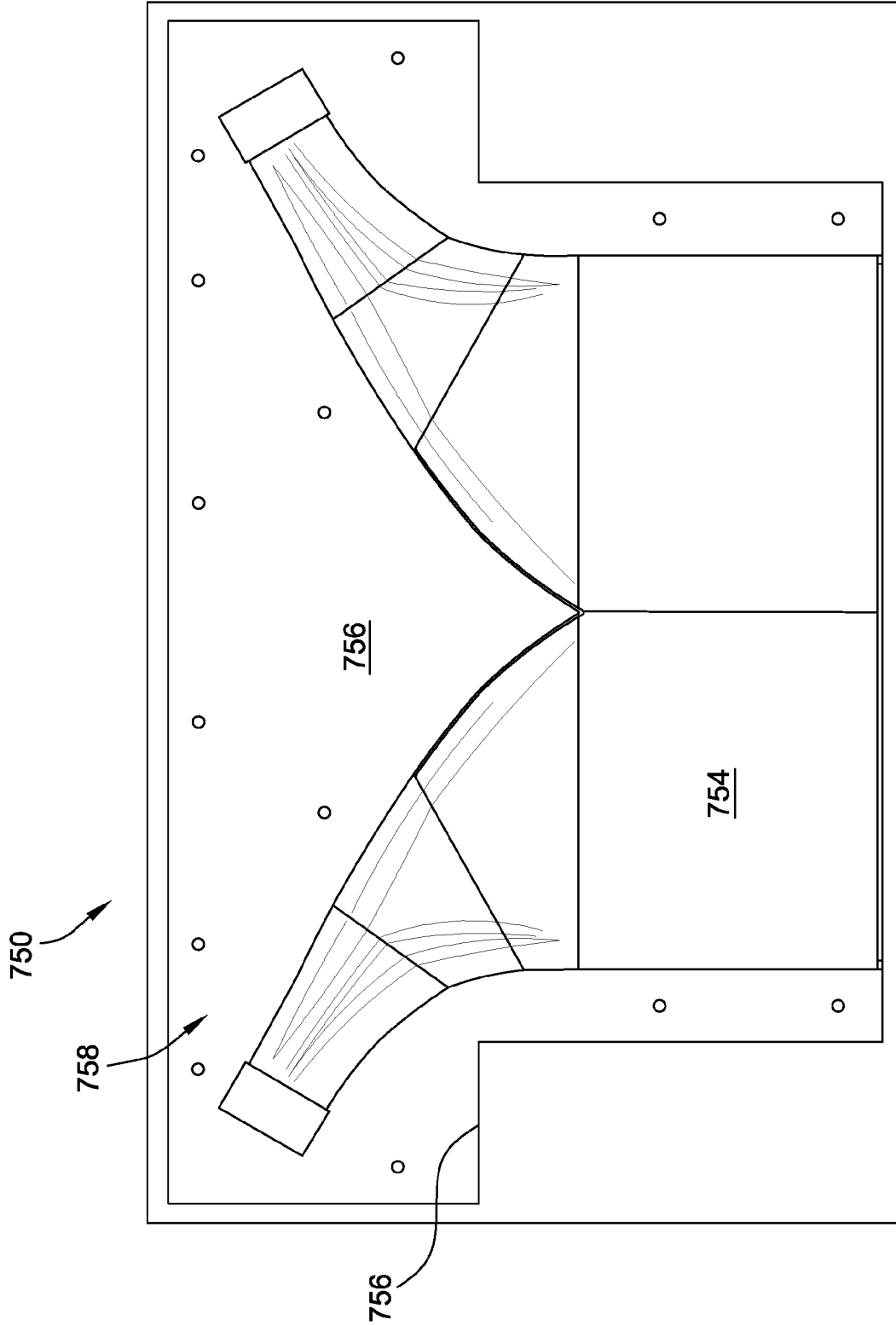


FIG. 26

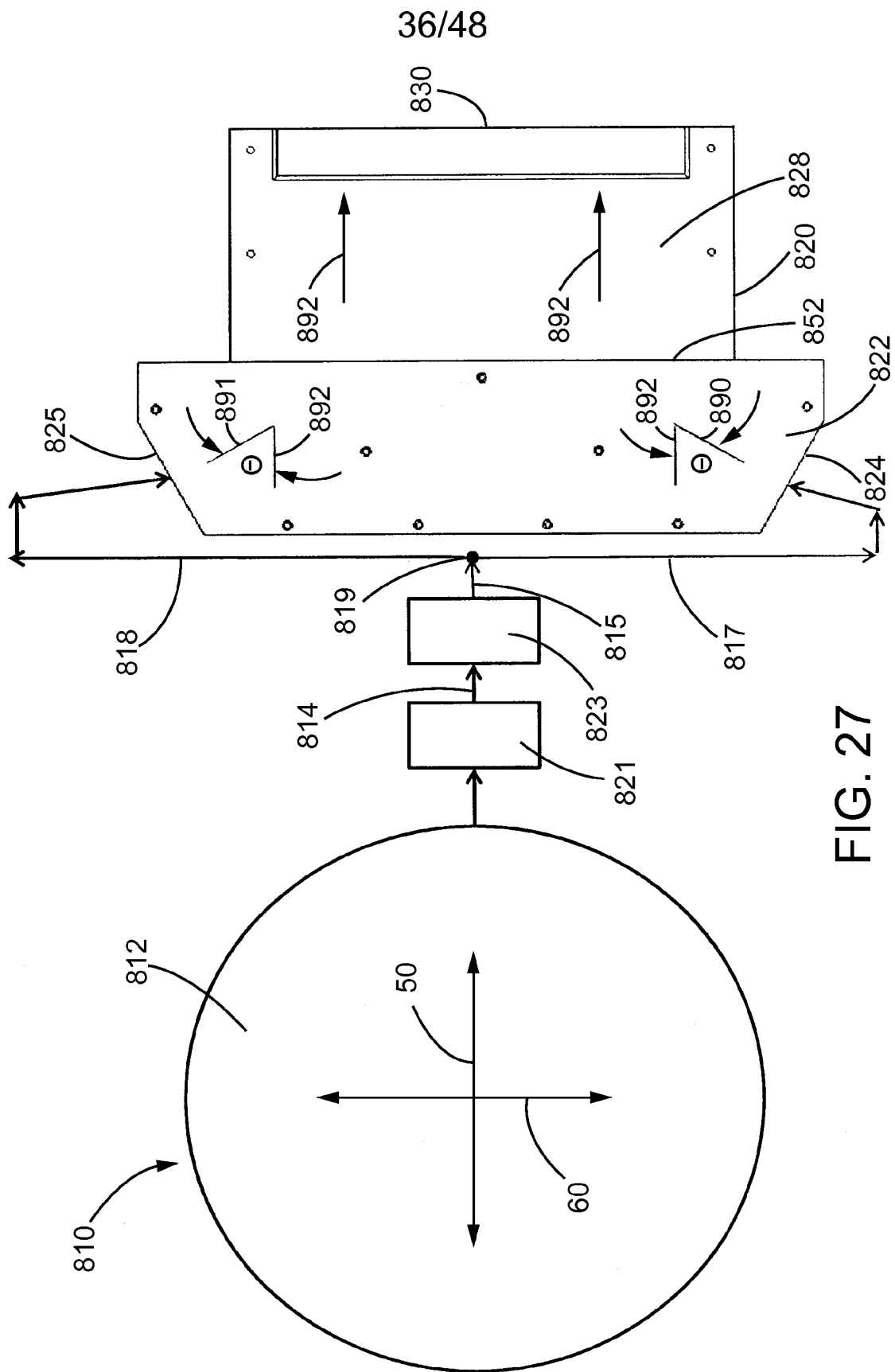


FIG. 27

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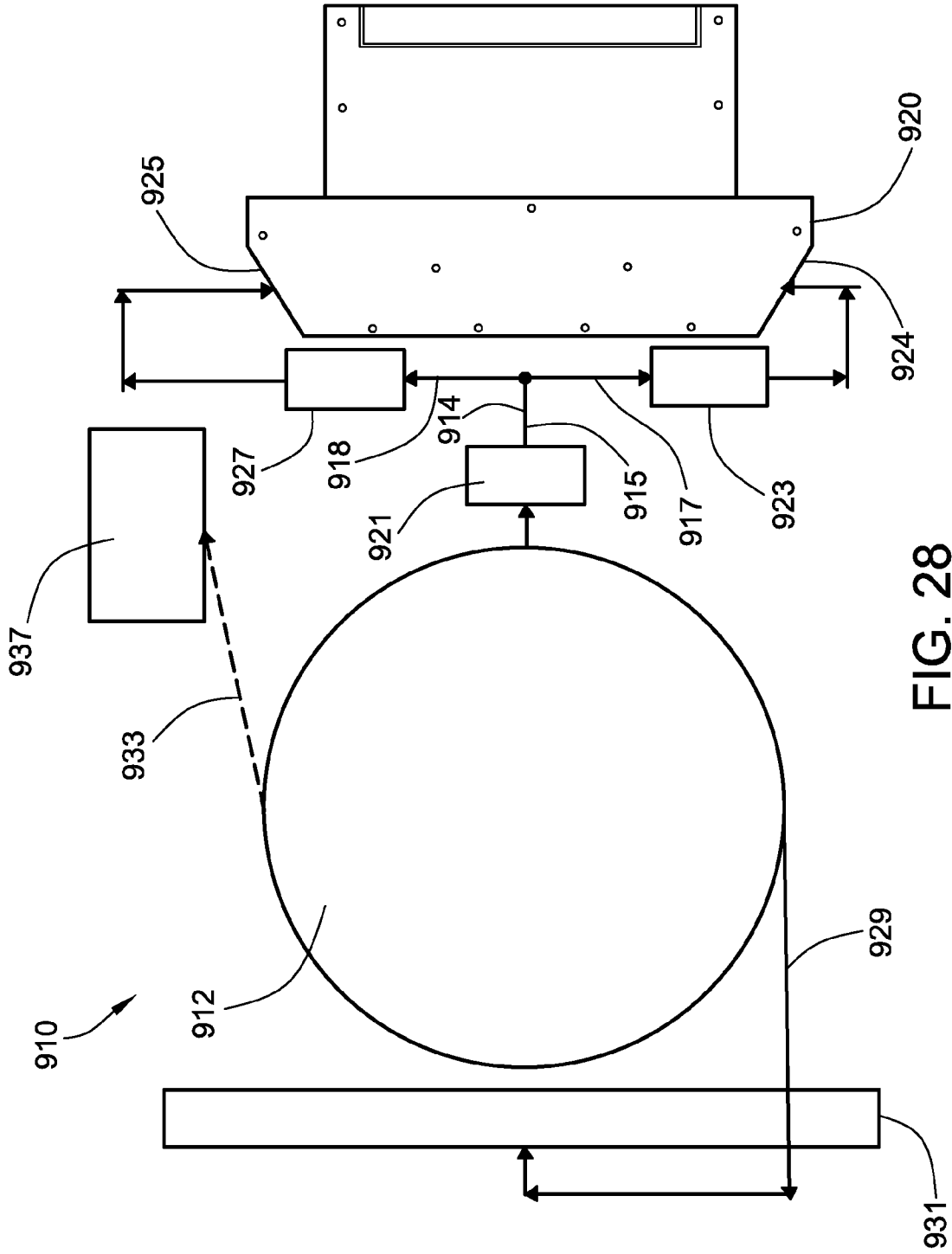


FIG. 28

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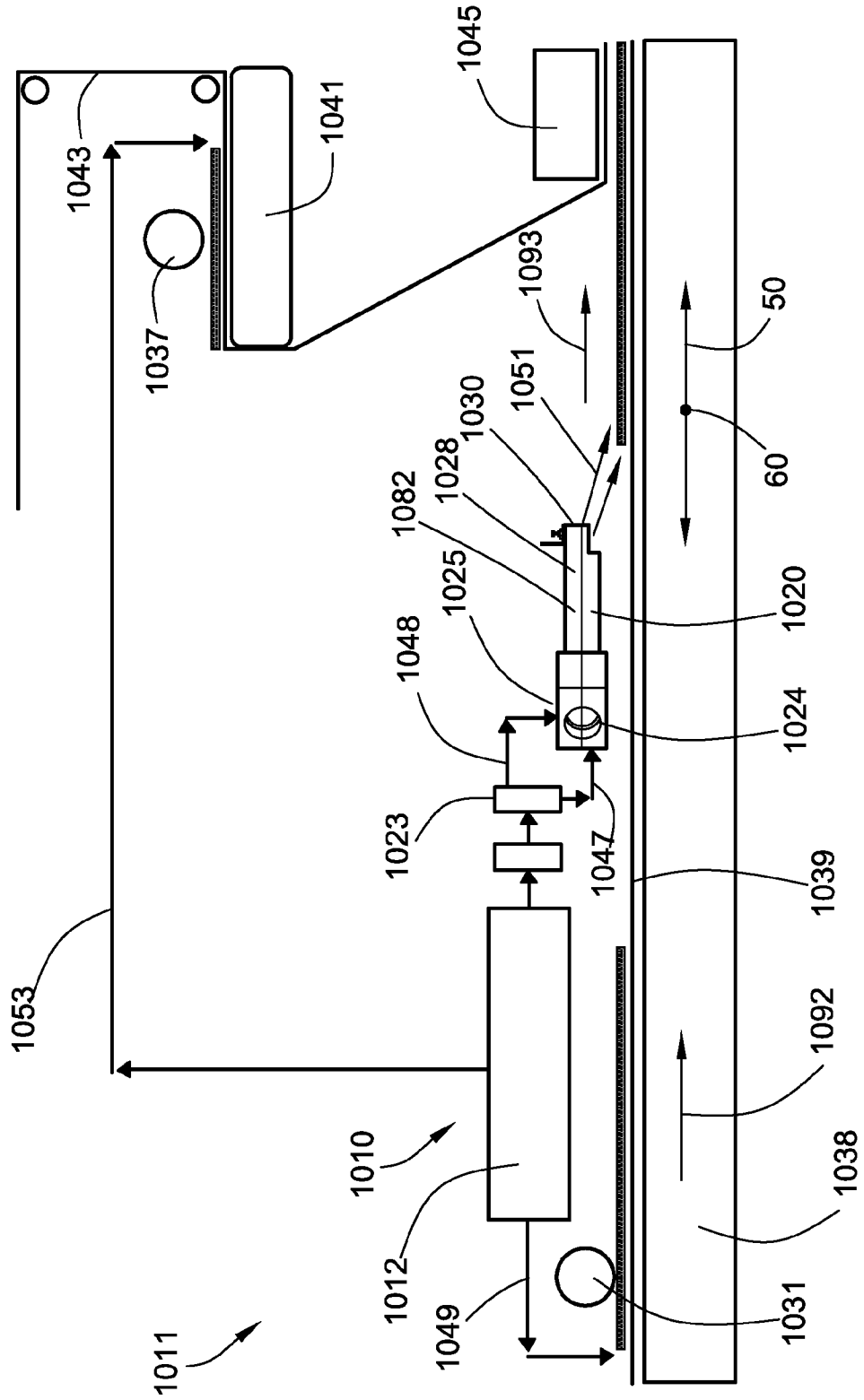


FIG. 29

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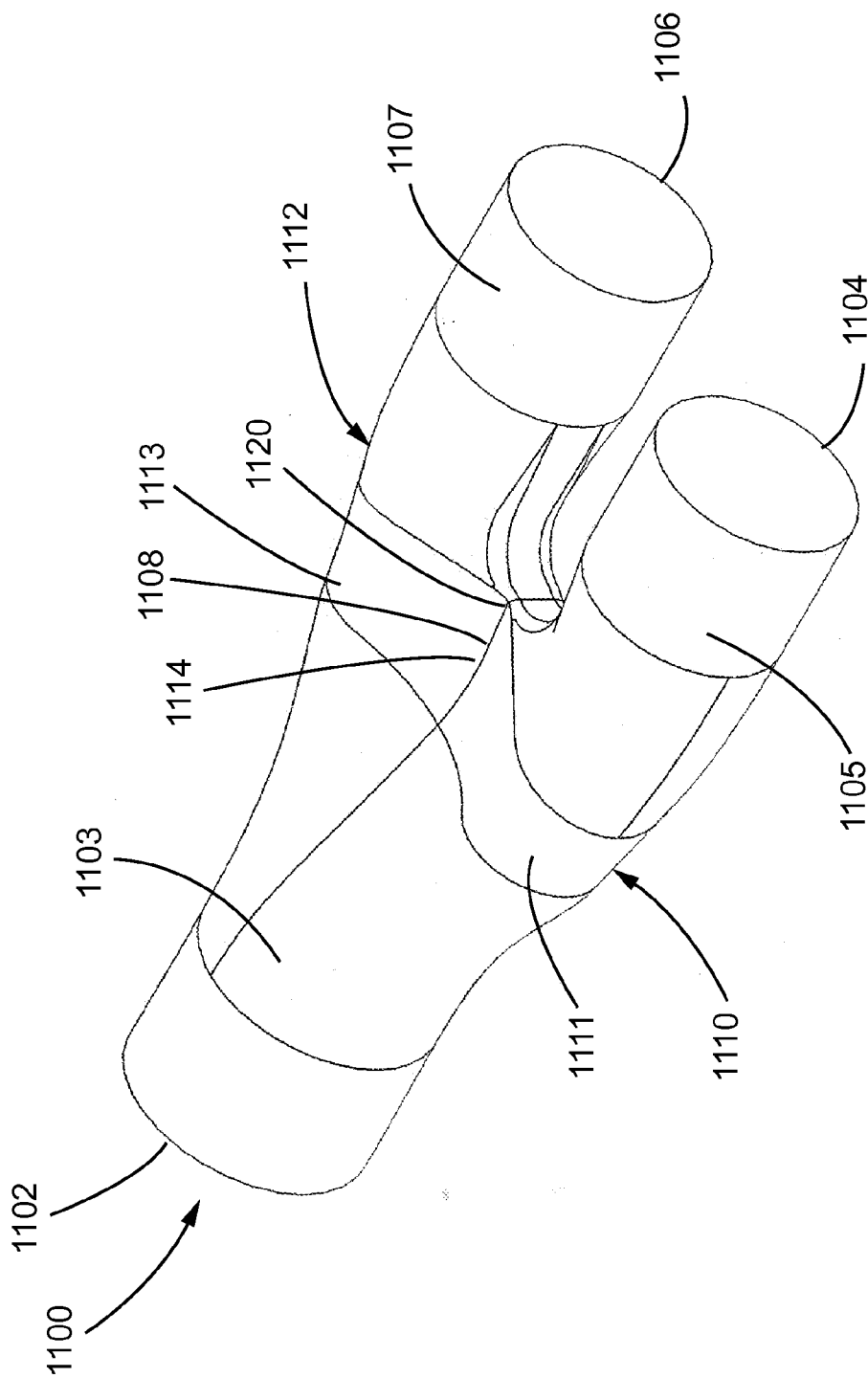


FIG. 30



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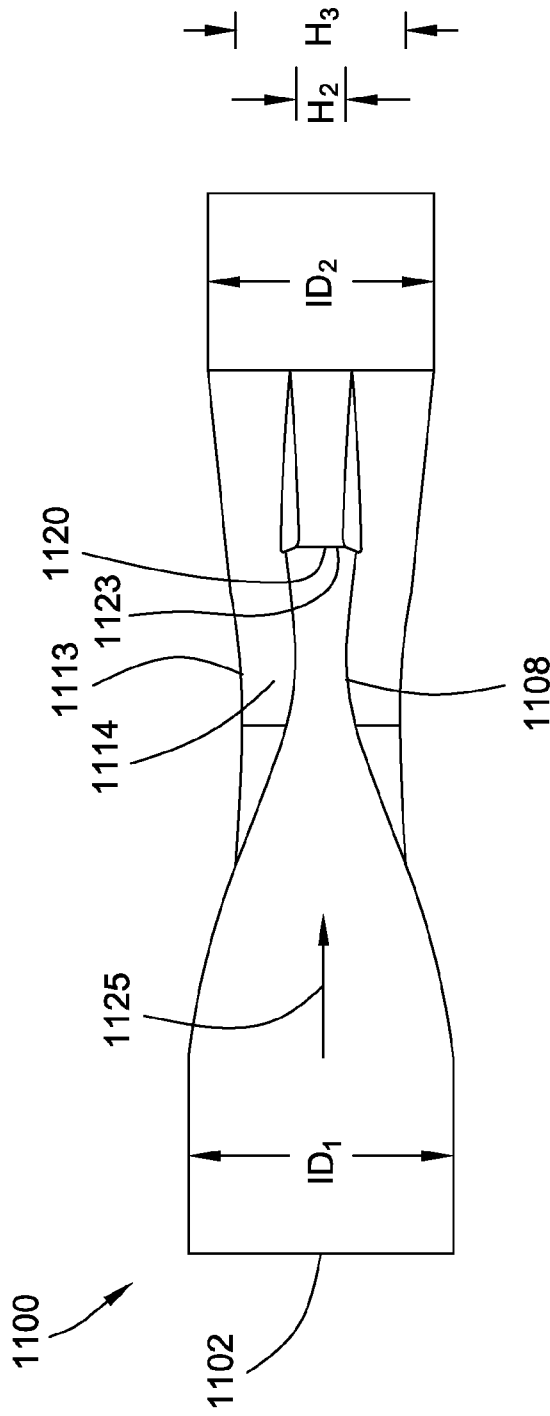


FIG. 31

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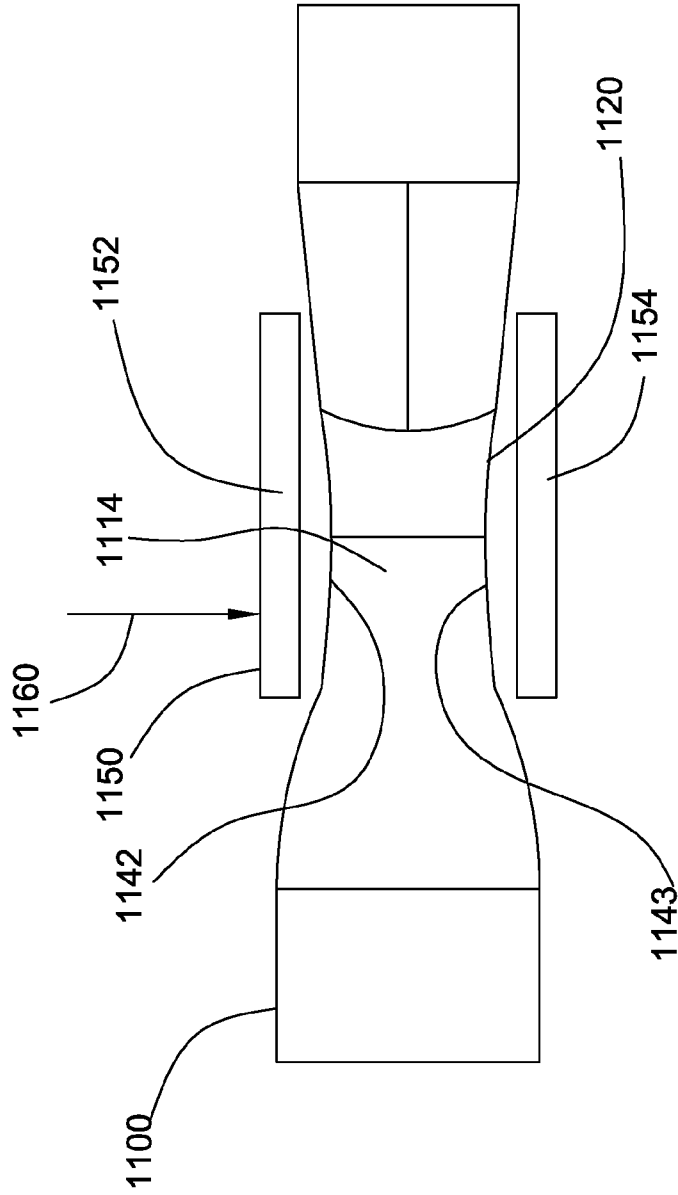
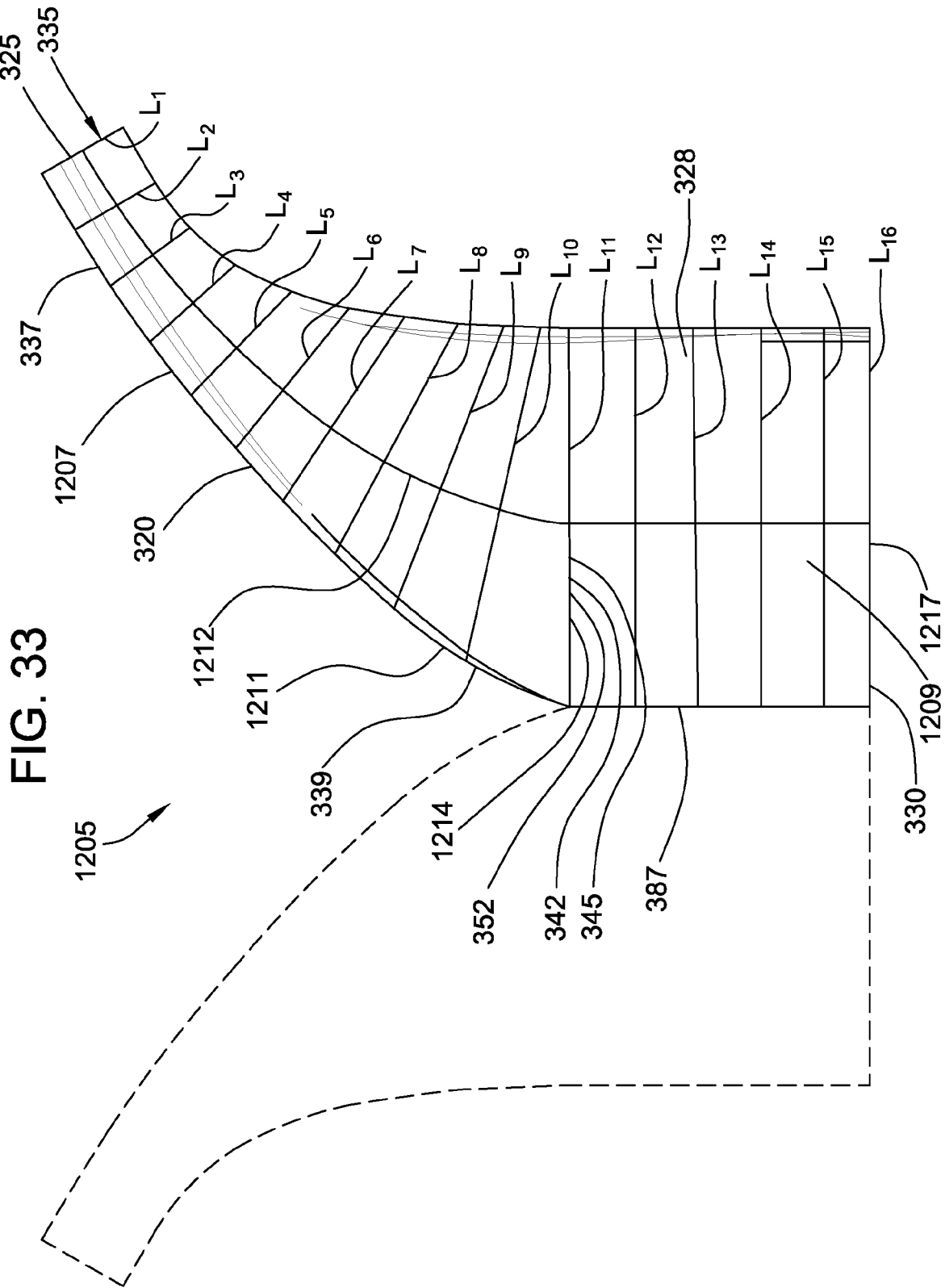


FIG. 32



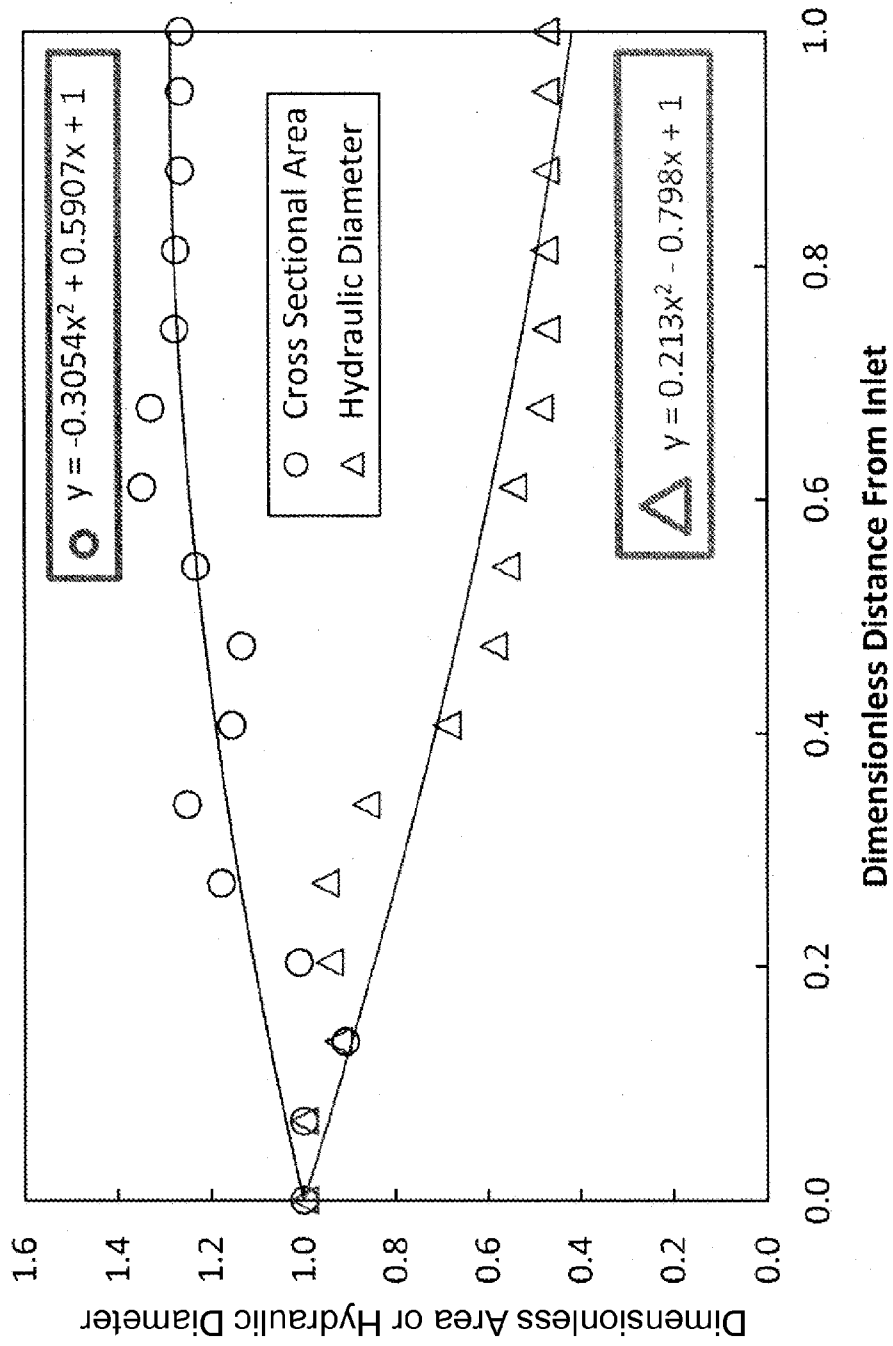


FIG. 34

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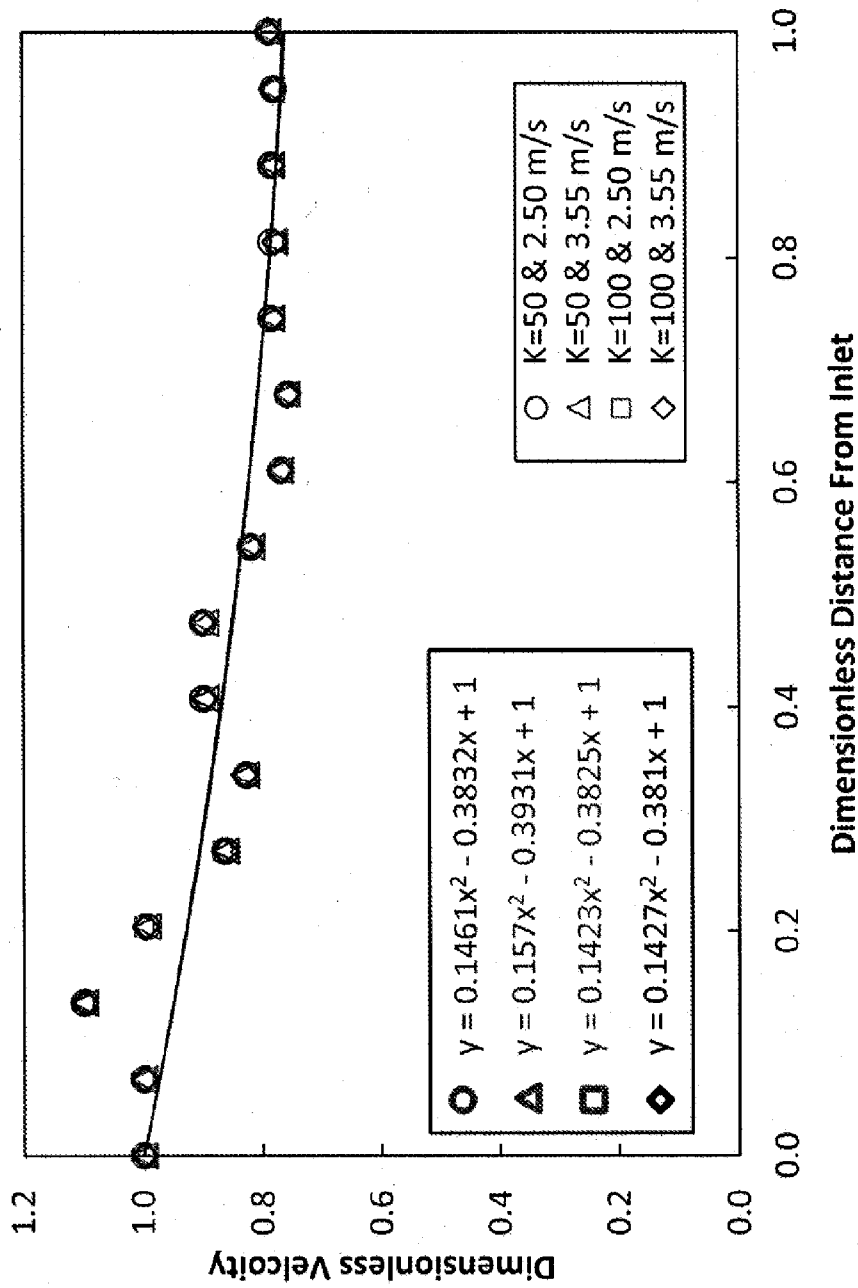


FIG. 35

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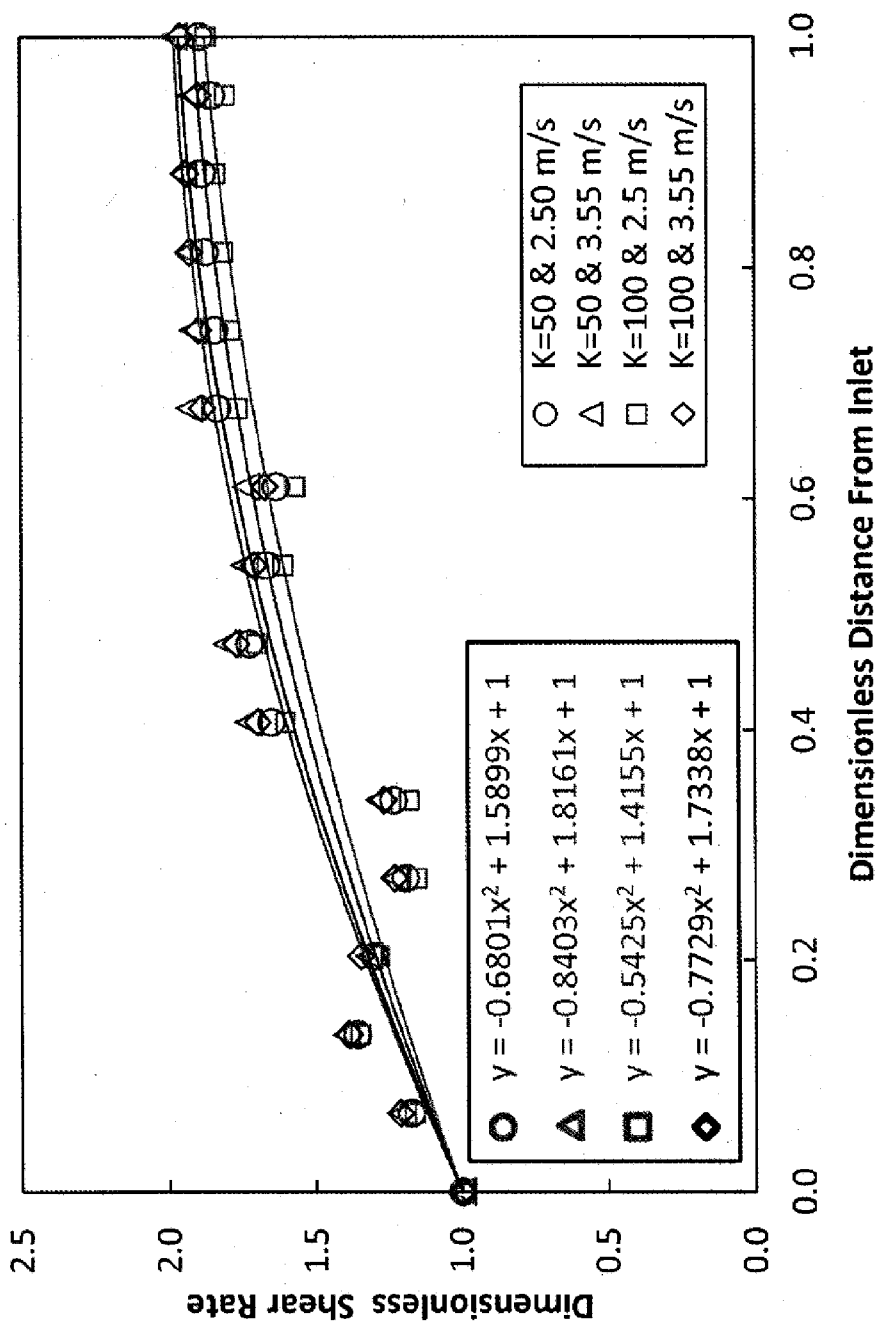


FIG. 36

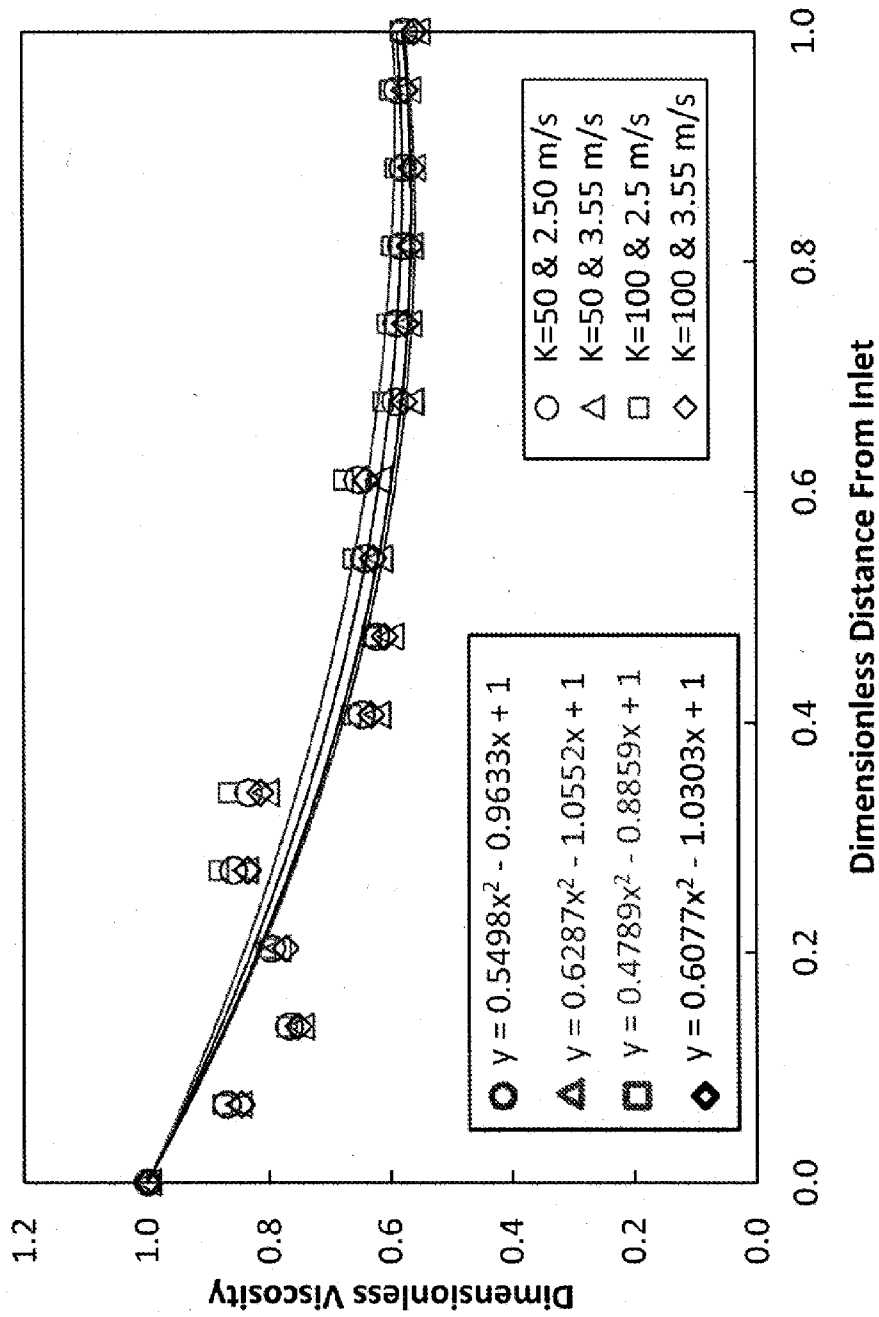


FIG. 37

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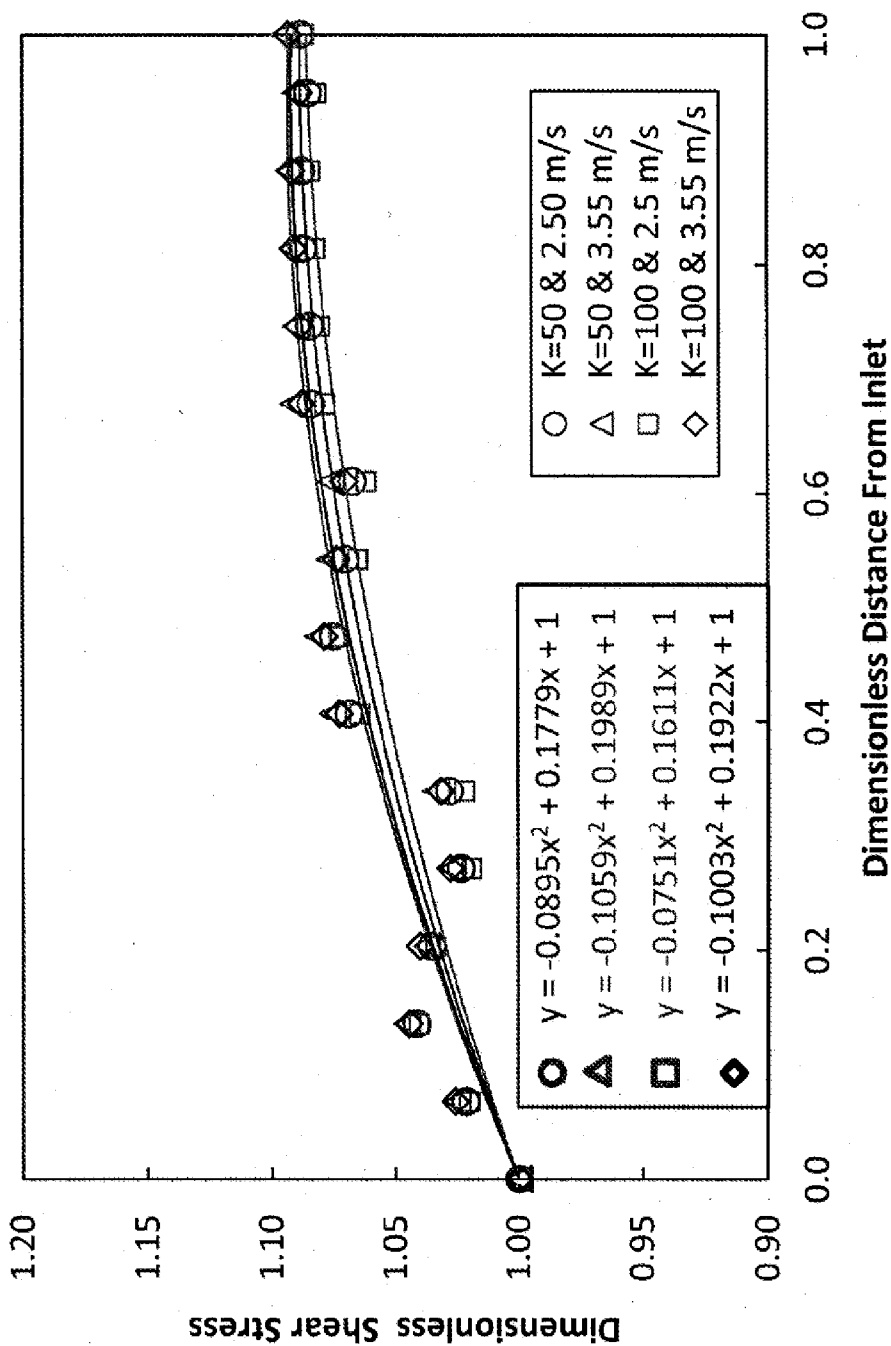


FIG. 38



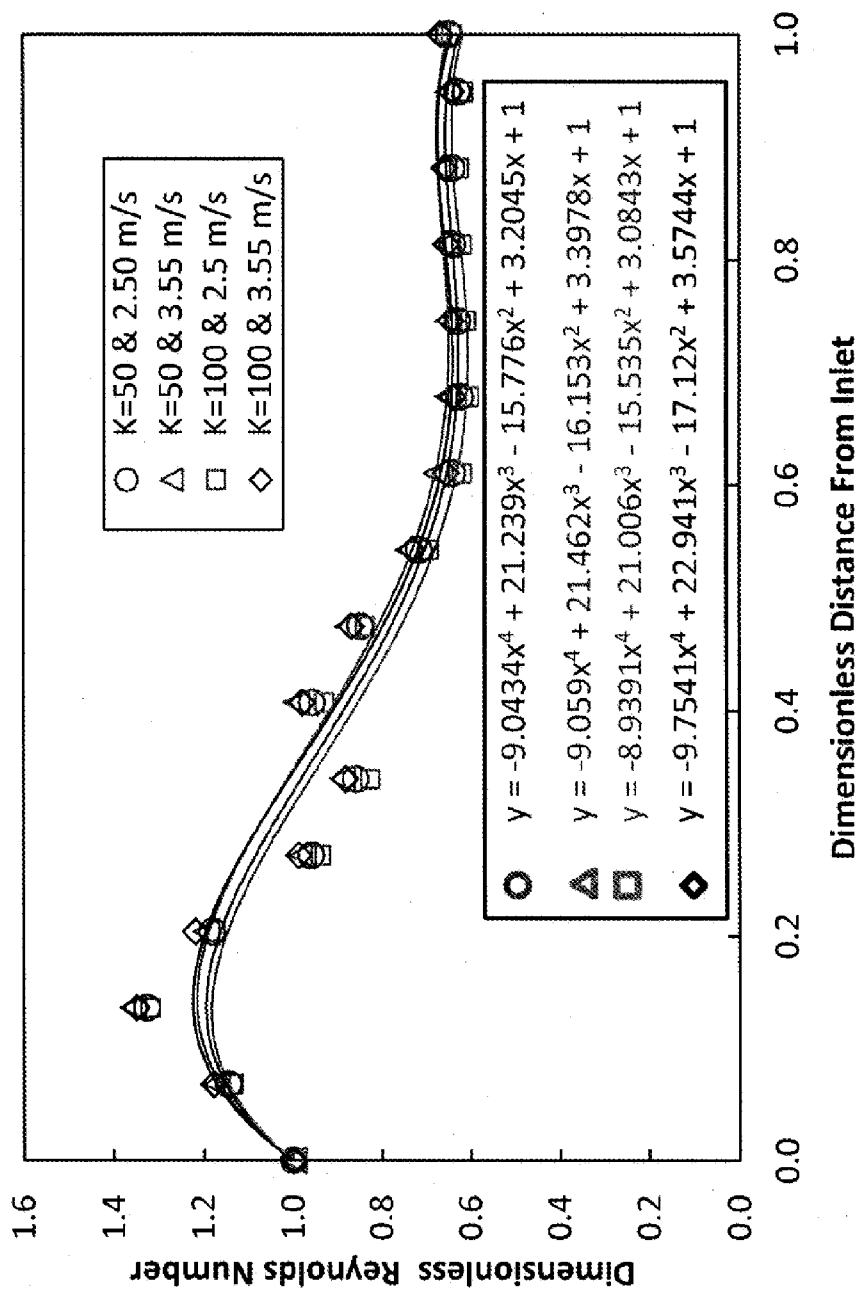


FIG. 39

