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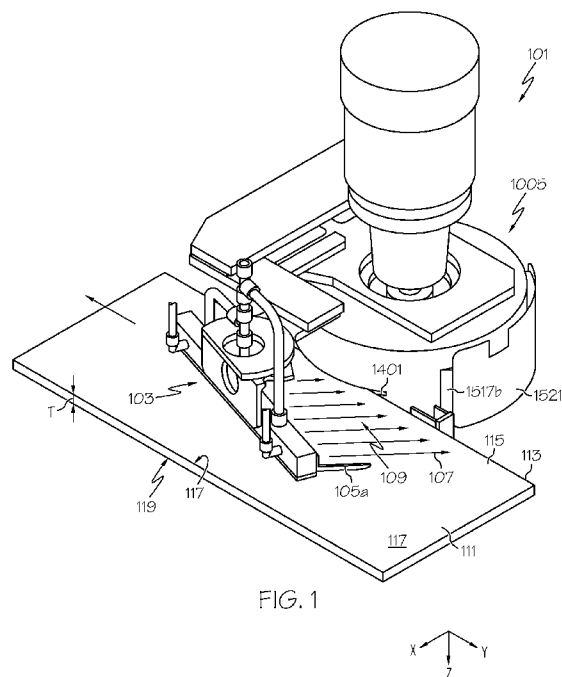


FIG. 1

(57) Abstract: A glass treatment apparatus, in one example, can include a fluid dispensing device configured to dispense a substantially laminar flow of a fluid film. In another example, a shroud substantially circumscribes an outer peripheral surface of a working wheel. The shroud includes a slot configured to receive an edge portion of a glass sheet. Methods of treating glass, in one example, include the step of dispensing a substantially laminar flow of a fluid film along a fluid plane to subsequently land on a first side of a glass sheet. In further examples, a fluid is passed over an inner surface of a shroud to carry away machined particles from a glass sheet. In still further examples, an outer peripheral surface of a working wheel is impacted with a fluid stream to clean the working wheel from glass particles generated when machining an edge of the glass sheet.



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GLASS TREATMENT APPARATUS AND METHODS OF TREATING GLASS

[0001] This application claims the benefit of priority under 35 U.S.C. § 120 of U.S. Application Serial No. 13/300921 filed on November 21, 2011 the content of which is relied upon and incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The disclosure relates generally to a glass treatment apparatus and methods and, more particularly, to glass treatment apparatus and methods for machining a surface of a glass sheet while maintaining the pristine surfaces of the glass sheet.

BACKGROUND

[0003] It is known to fusion draw glass ribbon from a fusion draw machine. The ribbon is typically further processed into glass sheets that may be used to generate various liquid crystal display configurations. During processing, it is often desired to finish the edges of the glass sheet or glass ribbon to remove sharp edges and/or other defects. There is a need to carry out such finishing techniques while maintaining the pristine surfaces of the glass sheet. Sheet edge finishing is critical to improve the edge profile and strength required for handling and the customer's panel making process.

SUMMARY

[0004] The following presents a simplified summary of the disclosure in order to provide a basic understanding of some example aspects described in the detailed description.

[0005] In one example aspect of the disclosure, a glass treatment apparatus comprises a fluid dispensing device including first and second flow expanders and a dispensing surface facing a dispensing direction. The dispensing surface defines an elongated opening including an elongated central portion extending between first and second opposed end portions. The first opposed end portion is provided with the first flow expander extending from the dispensing surface in the dispensing direction and the second opposed end portion is provided with the second flow expander extending from the dispensing surface in the dispensing direction. The fluid dispensing device is configured to dispense a substantially

laminar flow of a fluid film from the elongated opening in the dispensing direction between the first and second flow expanders to form a water film with certain thickness and velocity such that glass particles generated from edge finishing will be carried away by the water film before the glass particles can penetrate through the water film and contact the sheet surface.

[0006] In another example aspect of the disclosure, a glass treatment apparatus comprises a fluid dispensing device including a dispensing surface facing a dispensing direction. The dispensing surface defines an elongated opening. The fluid dispensing device further includes a first elongated chamber in fluid communication with the elongated opening and including a first chamber axis extending substantially parallel to the elongated opening. The fluid dispensing device further includes a second chamber in fluid communication with the first elongated chamber. The fluid dispensing device is configured to dispense a substantially laminar flow of a fluid film from the elongated opening in the dispensing direction.

[0007] In yet another example aspect of the disclosure, a glass treatment apparatus further comprises a working wheel configured to rotate such that an outer peripheral surface of the working wheel machines a surface of a glass sheet. The glass treatment apparatus also includes a shroud substantially circumscribing the outer peripheral surface of the working wheel to prevent flying particles produced during edge finishing from contacting the sheet surface. The shroud includes a slot configured to receive an edge portion of the glass sheet.

[0008] In still another example aspect of the disclosure, a method of treating glass comprises the steps of dispensing a substantially laminar flow of a fluid film along a fluid plane to subsequently land on a first side of a glass sheet and machining an edge of the glass sheet, wherein machined particles of glass are entrained in the fluid film and carried away from the glass sheet.

[0009] In accordance with a further aspect of the disclosure, a method of treating glass comprises the steps of providing: a glass sheet; a working wheel with an outer peripheral surface; and a shroud substantially circumscribing the outer peripheral surface, wherein the shroud includes a slot. The method further includes the steps of rotating the working wheel about a rotation axis and moving a glass sheet and the working wheel relative to each other such that an edge portion of the glass sheet passes through the slot with an edge

of the glass sheet being machined by the rotating working wheel. The method still further includes the step of passing a fluid over an inner surface of the shroud to carry away machined particles from the glass sheet generated when machining the edge of the glass sheet.

[0010] In accordance another aspect of the disclosure, a method of treating glass comprises the steps of providing: a glass sheet; a working wheel with an outer peripheral surface; and a shroud substantially circumscribing the outer peripheral surface, wherein the shroud includes a slot. The method further includes the steps of rotating the working wheel about a rotation axis and moving a glass sheet and the working wheel relative to each other such that an edge portion of the glass sheet passes through the slot with an edge of the glass sheet being machined by the rotating working wheel. The method further includes the step of impacting the outer peripheral surface of the working wheel with a fluid stream to clean from the working wheel glass particles generated when machining the edge of the glass sheet such that glass particles will not get reintroduced into the glass edge to negatively affect the grinding process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] These and other aspects are better understood when the following detailed description is read with reference to the accompanying drawings, in which:

[0012] **FIG. 1** is a perspective view of a glass treatment apparatus in accordance with one example of the disclosure;

[0013] **FIG. 2** is a top view of an example fluid dispensing device of the glass treatment apparatus of **FIG. 1**;

[0014] **FIG. 3** is an end view of the fluid dispensing device along line 3-3 of **FIG. 2**;

[0015] **FIG. 4** is a cross sectional view of the fluid dispensing device along line 4-4 of **FIG. 2**;

[0016] **FIG. 5** is an enlarged view of portions of the fluid dispensing device of **FIG. 4**;

[0017] **FIG. 6** is a front view of the fluid dispensing device along line 6-6 of **FIG. 2**;

[0018] **FIG. 7** is a cross sectional view of the fluid dispensing device along line 7-7 of **FIG. 2**;

- [0019] FIG. 8 is a top view of the fluid dispensing apparatus of FIG. 1;
- [0020] FIG. 9 is a front view of the fluid dispensing apparatus of FIG. 1;
- [0021] FIG. 10 is a bottom view of the fluid dispensing apparatus of FIG. 1;
- [0022] FIG. 11 is a perspective view of another fluid dispensing device of the glass treatment apparatus of FIG. 1;
- [0023] FIG. 12 is a cross sectional view of the fluid dispensing device along line 12-12 of FIG. 11;
- [0024] FIG. 13 is a cross sectional view of the fluid dispensing device along line 13-13 of FIG. 11;
- [0025] FIG. 14 is a front view of an example shroud of the glass treatment device of FIG. 1;
- [0026] FIG. 15 is a lower perspective view of the shroud of FIG. 14; and
- [0027] FIG. 16 is another lower perspective view of the shroud of FIG. 14.

DETAILED DESCRIPTION

[0028] Examples will now be described more fully hereinafter with reference to the accompanying drawings in which example embodiments are shown. Whenever possible, the same reference numerals are used throughout the drawings to refer to the same or like parts. However, aspects may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

[0029] Referring now to FIG. 1, an example glass treatment apparatus 101 is provided with various example features that may be used either alone or in combination to help prevent particles from contaminating the pristine surfaces of the glass sheet. In one example, the glass sheet can comprise a sheet of glass that may be incorporated in a liquid crystal display wherein there is a desire to machine a surface of the edge portion 115 of the glass sheet 111 to improve the edge quality of the glass sheet. As shown, the surface can comprise the outer peripheral edge 113 of the glass sheet 111 between the thickness “T” of the glass sheet 111 from a first surface 117 and a second surface 119 of the glass sheet 111. In addition or alternatively, the glass treatment apparatus 101 may be designed to machine a surface of the edge portion comprising the first surface 117 and/or the second surface 119 without machining the outer peripheral edge 113 of the glass sheet 111. In further examples,

one or both of the first surface **117** and/or the second surface **119** may be machined together with the outer peripheral edge **113** of the glass sheet **111**. For example, the glass treatment apparatus **101** may be designed to provide an angled or rounded transition between the first surface **117** and/or the second surface **119** and the outer peripheral edge **113**. Machining of the surface of the edge portion **115** of the glass sheet **111** can reduce the probability of stress fractures from forming and propagating to the interior portion of the glass sheet and/or may otherwise enhance the quality of the glass sheet **111**.

[0030] Although not required, as shown in **FIG. 1**, the illustrated example the glass treatment apparatus **101** is shown machining a glass sheet **111** that is in a substantially horizontal orientation wherein the glass sheet **111** extends substantially along the illustrated X-Y plane with the force of gravity acting in the Z direction. In further example, the glass sheet may be oriented at an incline relative to the X-Y orientation and, in some examples, may be oriented along the X-Z and/or Y-Z plane. Regardless of the orientation, one of many fluid dispensing devices may be used to dispense a substantially laminar flow of a fluid film along the first surface **117** and/or the second surface **119** of the glass sheet to help prevent particles from contaminating the pristine surfaces **117**, **119** of the glass sheet **111**.

[0031] A substantially laminar flow of fluid film may include small portions that are not in laminar flow but includes a substantial portion of the flow in laminar flow. For instance, a substantially laminar flow can include one or more relatively small areas of the fluid film may include eddies or other flow disturbances while the remaining portions of the fluid film are in a substantially laminar flow. Providing a fluid film in laminar flow can be used to overcome the particle sources and particle dynamics typically observed during the machining process. Indeed, the fluid film can provide a protective fluid barrier for the first surface **117** and or the second surface **119** from particles generated during the machining process.

[0032] In a horizontal orientation, it is possible to provide one or both of the first surface **117** and/or second surface **119** with one or more fluid dispensing devices. For example, as shown in **FIG. 1**, the glass treatment apparatus **101** may include a fluid dispensing device **103** that may be used to generate a laminar flow **107** of a fluid film **109** coat the first surface **117**, that may comprise the upper surface of the glass sheet in the

orientation shown in **FIG. 1**. The fluid film may be dispensed as a planar sheet of fluid film **109** designed to coat the first surface **117** of the glass sheet **111**.

[0033] **FIGS. 2-8** illustrate example features of one fluid dispensing device **103** that may be optionally used to protect the first surface **117** of the glass sheet **111** although a similar or identical construction may be used to protect the second surface **119** of the glass sheet in further examples. **FIG. 2** illustrates a top view of the fluid dispensing device **103** with a fluid film **109** being dispensed for illustration purposes. As shown, the fluid film **109** can have a width “**W**” transverse to the laminar flow **107** that extends between a first flow expander **105a** and a second flow expander **105b**. As shown, the first and second flow expanders **105a**, **105b** can each include a corresponding expanding surface **106a**, **106b** that face one another. As shown, the expanding surfaces **106a**, **106b** can be substantially planar and may also extend substantially parallel to one another. With such a configuration, the flow expanders **105a**, **105b** can help maintain the fluid film **109** with a substantially constant width “**W**” as the fluid film is deposited to coat the first surface **117** of the glass sheet **111**. Although not shown, the expanding surfaces **106a**, **106b** may converge or diverge from one another in further examples to control the final width of the fluid film **109** being deposited on the first surface of the glass sheet **111**.

[0034] The flow expanders **105a**, **105b**, if provided, can operate to expand the width of the fluid film **109** that is being deposited to coat the first surface **117**. Indeed, without flow expanders, the surface tension of the fluid, such as water, would naturally tend to cause a converging flow of the fluid film **109** as the fluid film travels away from the elongated opening of the fluid dispensing device **103**. By contacting the outer edges of the fluid film **109** with the expanding surfaces **106a**, **106b**, the fluid film is expanded from the natural tendency of the fluid film to converge as it travels away from the elongated opening. If the fluid film were allowed to converge uncontrolled, a substantially turbulent flow may eventually be produced when introducing the fluid film to coat the surface **117** of the glass sheet. As such, the flow expanders **105a**, **105b** may be provided to help maintain the laminar flow **107** of the fluid film **109** as it is placed on the surface **117** of the glass sheet.

[0035] As shown in **FIGS. 2-4**, the first and second flow expander **105a**, **105b** may be substantially identical or similar to one another. In the illustrated example, the first flow

expander **105a** may be longer than the second flow expander **105b** although the flow expanders may have substantially identical lengths in further examples. As further shown in **FIGS. 4 and 5**, the fluid dispensing device **103** includes a dispensing surface **401** facing a dispensing direction **501**. As shown in **FIG. 6**, the first dispensing surface **401** defines an elongated opening **503** that is elongated to define the width “**W**” of the fluid film **109**. Although not necessarily to scale, as shown in **FIG. 5**, the elongated opening **503** can include a thickness “**t**” within a range of from about 50 microns to about 1 mm, for example, from about 100 microns to about 500 microns, for example, from about 200 microns to about 300 microns, for example, about 250 microns.

[0036] As further shown in **FIG. 5**, in one example, the fluid dispensing device **103** can be configured to dispense the laminar fluid film **109** such that the dispensing direction **501** at an angle “**A**” that can be substantially 90° relative to the dispensing surface **401**. Providing the dispensing direction **501** of the fluid film **109** in a substantially perpendicular orientation with respect to the dispensing surface **401** can help prevent the fluid film **109** exiting from the elongated opening **503** from wrapping backwards and thereby creating a turbulent flow. As such, dispensing the laminar fluid film **109** such that the dispensing direction at an angle “**A**” that is substantially perpendicular to the dispensing surface **401** can help maintain the laminar flow **107** of the fluid film **109**.

[0037] As shown in **FIG. 6**, the dispensing surface **401** defines the elongated opening **503** with an elongated central portion **601** extending along an elongated axis **605** between first and second opposed end portions **603a**, **603b**. The first opposed end portion **603a** can be provided with the first flow expander **105a** extending from the dispensing surface **401** in the dispensing direction **501** and the second opposed end portion **603b** can be provided with the second flow expander **105b** extending from the dispensing surface **401** in the dispensing direction **501**. As previously discussed, the width “**W**” of the fluid film **109** can thereby be defined by the elongated opening **503** with the optional flow expanders **105a**, **105b**.

[0038] Various structures may be designed to deliver fluid, such as water, through the elongated opening **503** to achieve the fluid film **109** in laminar flow **107**. For example, the fluid dispensing device **103** can include a first elongated chamber **403** having a first chamber axis **405** extending along an elongated axis **605** of the elongated opening **503**, wherein the

first elongated chamber **403** is in fluid communication with the elongated opening **503**. The first elongated chamber **403**, if provided, may be formed by a single portion or defined by a plurality of portions fastened together. For example, as shown in **FIG. 4**, the first elongated chamber **403** may be formed by fastening a second portion **411** to a first portion **413** with fasteners **415**. In further examples, the fluid dispensing device **103** can include an optional second elongated chamber **407** including a second chamber axis **409** substantially parallel to the first chamber axis **405**. In such examples, the second elongated chamber **407** can be placed in fluid communication with the first elongated chamber **403** and the first elongated chamber **403** can be positioned along a flow path between the elongated opening **503** and the second elongated chamber **407**. As such, the first elongated chamber **403** can be positioned downstream from the second elongated chamber **407** and the elongated opening **503** can be positioned downstream from the first and second elongated chambers **403**, **407**. In one example, as shown in **FIG. 6**, fluid communication between the first and second elongated chambers **403**, **407** may be provided by a plurality of apertures **701** extending through an elongated partition wall **703** extending between the elongated chambers.

[0039] As shown, the first chamber axis **405** can be oriented substantially parallel to the elongated opening **503** and the second chamber axis **409** can extend substantially parallel to the first chamber axis **405** and the elongated opening **503**. Providing the second elongated chamber **407** along the first elongated chamber **405** can further facilitate control pressure distribution and fluid flow along the length of the elongated opening **503**, thereby further helping provide an even flow that facilitates maintenance of an even and laminar flow **107** of fluid film **109** through the elongated opening **503**.

[0040] As shown in **FIG. 7**, a fluid source **705**, such as a container of water, may be placed in fluid communication with one or more first ports **707** configured to introduce fluid through an opening **709** into the second elongated chamber **407** along an axis **711** that may be perpendicular to the second chamber axis **409**. In addition or alternatively, the fluid source **705** may be placed in fluid communication with one or more second ports **713** configured to introduce fluid through an opening **715** into the second elongated chamber **407** along an axis **717** that may also be perpendicular to the second chamber axis **409** and/or each elongated axis **711** of the first fluid port **707**. Providing multiple entry points for the fluid

can help facilitate maintenance of an even and laminar flow **107** of fluid film **109** through the elongated opening **503**. In one example, a pump **719** may provide fluid to a manifold **721** that may distribute the fluid to the first and second ports **707**, **713** in a manner that best achieves uniform laminar flow in the fluid film. A computer **723** may control fluid flow through the ports by operating valves in the manifold and/or controlling operation of the pump **719**.

[0041] **FIGS. 9-13** disclose another example fluid dispensing device **901** of the glass treatment apparatus **101**. As shown in **FIGS. 9 and 10**, the fluid dispensing device can include a first dispensing device **901a** and a second dispensing device **901b** although a single dispensing device or more than two dispensing devices may be used in further examples. Moreover, as shown, the fluid dispensing devices **901a**, **901b** may be identical to one another although alternative constructions may be provided in further examples. The fluid dispensing devices **901a**, **901b** can be configured to dispense a substantially laminar flow **903a**, **903b** of a fluid film **905a**, **905b** from an elongated opening in a dispensing direction of the fluid dispensing device.

[0042] The fluid dispensing devices **901a**, **901b** can be designed to coat the second surface **119** with the substantially laminar flow **903a**, **903b** of the fluid film **905a**, **905b**. In the illustrated orientation, the second surface **119** can comprise the lower surface of the glass sheet **111**. As such, the fluid dispensing devices **901a**, **901b** may provide a relatively reduce width fluid film when compared to the fluid film **109** associated with the fluid dispensing device **103** discussed above. As such, the flow expanders may not be necessary for the fluid dispensing devices illustrated in **FIGS. 11 and 12**.

[0043] As shown in **FIGS. 11 and 12**, the fluid dispensing devices **901a**, **901b** can include a dispensing surface **1103** facing a dispensing direction **1105**, wherein the dispensing surface **1103** defines an elongated opening **1107**. As shown in **FIG. 12**, the fluid dispensing devices **901a**, **901b** each further includes a first elongated chamber **1201** in fluid communication with the elongated opening **1107**. The first elongated chamber **1201** can include a first chamber axis **1203** extending substantially parallel to the elongated opening **1107**. In another example, the fluid dispensing devices **901a**, **901b** each further includes a second chamber **1205** in fluid communication with the first elongated chamber **1201**.

Although not necessary, as shown, the second chamber **1205** may be elongated along a second chamber axis **1207** extending substantially parallel to the first chamber axis **1203** and the elongated opening **1107**. Moreover, as shown in **FIG. 13**, a plurality of apertures **1301a**, **1301b**, **1301c** may provide fluid communication between the first elongated chamber **1201** and the second chamber **1205**. Providing separate chambers with the apertures can help facilitate maintenance of a substantially laminar flow fluid film through the elongated opening **1107**.

[0044] Further referring to back to **FIG. 10**, the glass treatment apparatus **101** can include a working wheel **1001** configured to rotate in a direction **1104** about a rotation axis **1102** such that an outer peripheral surface **1003** of the working wheel **1001** machines a surface, such as an outer peripheral edge **113**, of a glass sheet **111**. The glass treatment apparatus can also include a shroud **1005** substantially circumscribing the outer peripheral surface **1003** of the working wheel **1001**. In the illustrated example, the shroud **1005** can be open in the **Z** direction illustrated in **FIG. 1** such that gravity may draw fluid, particles and/or other contaminants downward in the **Z** direction. The shroud **1005** can be designed to shield the pristine surfaces **117**, **119** of the glass sheet **111** from particles and/or other contaminants associated with the machining process.

[0045] As shown in **FIG 14**, if provided, the shroud **1005** can be provided with a slot **1401** configured to receive the edge portion **115** of the glass sheet **111**. The slot includes a first segment **1403** having a thickness **T1** sufficient to accommodate the edge portion of the glass sheet. The slot **1401** can further include an optional second portion **1405** that may have an enlarged thickness **T2** designed to accommodate a fluid nozzle **1007** (see **FIGS. 9 and 10**) designed to introduce cooling and/or working fluid to the working interface **1015** of the outer peripheral surface **1003** of the working wheel **1001** and the surface of the glass sheet **111**. The shroud **1005** may include a recessed inner portion, such as the illustrated planar portion **1406** below the slot **1401** to allow clearance for the fluid film generated by the first and second fluid dispensing devices **901a**, **901b**

[0046] As shown in **FIG. 14**, the shroud **1005** can include an outer cylindrical peripheral wall **1407**. As shown in **FIG. 15**, in some examples, the outer cylindrical wall **1407** can comprise a circular cylindrical wall disposed about a central axis **1501** of the

shroud **1005**. As shown in **FIG. 10**, the shroud **1005** can be mounted relative to the working wheel **1001** such that the central axis **1501** of the shroud **1005** is coincident with the rotation axis **1102** of the working wheel **1001**. As shown in **FIG. 10**, a gap “G” can thereby be maintained between the outer peripheral surface **1003** of the working wheel **1001** and the inner surface **1009** of the shroud **1005**. A sufficient gap can be provided to allow movement of fluid along the inner surface **1009** of the outer cylindrical peripheral wall **1407** without substantial interference with the outer peripheral surface **1003** of the working wheel **1101** that may be rotating within a range of 3600-8000 rpm. In one example, the gap “G” may be within a range of from about 5 mm to about 15 mm although the gap may be smaller or larger in further examples.

[0047] Turning back to **FIG. 15**, the shroud **1005** further includes a top wall **1503** with an inner surface **1505** cooperating with the inner surface **1009** of the outer cylindrical peripheral wall **1407** to define a containment area **1507**. The containment area **1507** can include an open lower portion and an upper portion that is closed by the top wall **1503**. The shroud **1005** can further include one or more brackets **1509a**, **1509b** configured to provide a mounting location for the fluid dispensing devices **901a**, **901b**. Still further, the shroud may be provided with a gas port **1511** and or a wheel cleaning port **1513**.

[0048] As shown in **FIG. 10**, the gas port **1511** can be provided with a gas nozzle **1017** configured to remove liquid from a portion of the inner surface **1009** of the shroud **1005**. The gas port **1511** can therefore provide an air barrier to prevent the liquid from cycling around the inner surface **1009** of the shroud **1005**.

[0049] As further shown in **FIG. 10**, the glass treatment apparatus **101** can comprise a fluid source **1011** acting through the wheel cleaning port **1513** and configured to direct a fluid stream **1013** to impact the outer peripheral surface **1003** of the working wheel **1001** to clean the working wheel **1001** from glass particles generated when machining the surface of the glass sheet **111**.

[0050] As further illustrated in **FIG. 15**, the outer cylindrical peripheral wall **1407** can be provided with one or more exit ports to allow removal of liquid traveling along the inner surface **1009**. For example, as shown in **FIG. 15**, the shroud includes a first exit port **1515a** and a second exit port **1515b** formed by bending away corresponding first and second

flaps **1517a**, **1517b** to form corresponding first and second openings **1519a**, **1519b**, such as the illustrated window openings extending through the outer cylindrical peripheral wall **1407**. The first exit port **1515a** can allow a stream of fluid traveling along a first direction indicated by arrow **1521a** fall down along the first flap **1517a** and into the first opening **1519a** for subsequent removal from the containment area **1507** of the shroud **1005** as discussed more fully below. Likewise, second exit port **1515b** can allow another stream of fluid traveling in an opposite direction indicated by arrow **1521b** fall down along the second flap **1517b** and into the second opening **1519b** for subsequent removal from the containment area **1507** of the shroud **1005** as also discussed more fully below.

[0051] As shown in **FIGS. 10 and 15**, the shroud **1005** can also include an outer wall portion **1521** configured to facilitate dispensing of liquid and particles exiting the first and second openings **1519a**, **1519b** to travel down along an outside surface portion of the shroud and out a lower opening **1523** defined between the outer wall portion **1521** and the outer surface portion of the shroud **1005**. **FIG. 16** illustrates another perspective view of the shroud **1005** with the outer wall portion **1521** removed for clarity. As shown, the shroud **1005** can include a fluid flow guide **1601** that can include a first downwardly inclined guide wall **1603a** configured to deflect the fluid exiting the first opening **1519a** in a downward direction. Likewise, the fluid flow guide **1601** can include a second downwardly inclined guide wall **1603b** configured to deflect the fluid exiting the second opening **1519b** in a downward direction. Although not necessary, the guide walls may be connected together by a lower apex portion **1605** to facilitate final exiting of the fluid through the lower opening **1523** and/or to facilitate the manufacturing process.

[0052] Turning back to **FIG. 1**, methods of treating glass can include dispensing the substantially laminar flow **107** of the fluid film **109** along a fluid plane to subsequently land on a first side **117** of a glass sheet **111** as shown in **FIG. 4**. In one example, the method can include the step of expanding the fluid film **109** with a pair of flow expanders **105a**, **105b** disposed on each side of the fluid film **109**. In such examples, the flow expanders can help expand the fluid film **109** to maintain the laminar flow as the film travels to land on the first surface **117** of the glass sheet **111**. Still further, the method can include the step of controlling fluid flow characteristics of the fluid film along the width “**W**” of the fluid film

by controlling the pressure profile across the elongated opening **503** and the velocity profile of the fluid traveling through the elongated opening **503**. For example, the pressure profile and/or velocity profile can be controlled by providing at least one of the first elongated chamber **403**, the second elongated chamber **407**, the apertures **701** and/or the ports **707**, **713**.

[0053] It can also be desired to maintain the laminar flow of the fluid film as the fluid film **109** contacts and thereafter travels along the first side **117** of the glass sheet **111**. As shown in **FIG. 4**, one way of accomplishing a smooth continuous transition is to reduce the angle between the fluid plane and the glass sheet **111**. As shown, the fluid dispensing device **103** can be arranged such that an angle “**A1**” of the fluid plane relative to the planar surface **117** of the glass sheet **111** is within a range of from 0° to about 30°, such as from about 5° to about 30°, such as from about 10° to about 30°.

[0054] As shown in **FIGS. 9 and 10**, methods of treating glass can also include the step of dispensing the substantially laminar flow **903a**, **903b** of the second fluid film **905a**, **905b** along a second fluid plane to subsequently contact the second surface **119** of the glass sheet **111**. The angle of contact “**A2**” can be within a range of from 0° to about 30°, such as from about 5° to about 30°, such as from about 10° to about 30°. While other angles can be used in further examples, providing the angle “**A1**” and/or the angle “**A2**” within the above-referenced ranges can help maintain an organized fluid flow at the glass-water transition as the fluid film lands on the respective surface of the glass sheet.

[0055] Methods of treating the glass can also include machining the edge, such as the outer peripheral edge **113**, of the glass sheet **111**, wherein machined particles of the glass are entrained in the fluid film and carried away from the glass sheet. For example, as shown in **FIG. 10**, the working wheel **1001** may be rotated in the direction **1104** about the rotation axis **1102** such that the outer peripheral surface **1003** contacts the edge portion **115** of the glass sheet **111**. In one example, the glass sheet **111** can be moved relative to the working wheel **1001** along direction **1019** while the wheel rotates along the clockwise direction **1104** shown in **FIG. 10**. As such, the working area of the outer peripheral surface **1003** travels in a direction **1021** opposite to the direction **1019** that the glass moves relative to the working wheel **1001**. Relative movement between the glass sheet **111** and the glass treatment apparatus **101** can be provided by moving the glass treatment apparatus **101** relative to the

glass sheet **111** and/or the glass sheet **111** relative to the glass treatment apparatus **101**. The working wheel **1001** can comprise a grinding wheel with diamond particles or other materials sufficient to work (such as grind, polish or otherwise finish) the edge of the glass sheet.

[0056] The fluid nozzle **1007** can provide cooling fluid **1008** at the working interface **1015**. In one example, the fluid nozzle **1007** extends through an enlarged section **1405** (see **FIG. 14**) of the slot **1401**. The cooling fluid **1008** can then be directed to the working interface **1015** to reduce heat that may otherwise damage the glass sheet **111**. The coolant fluid can be directed generally in the direction **1021** of the working portion of the working wheel **1001**. Excess cooling fluid **1008** and any particles entrained therein can then be moved away, for example, by the laminar flow of the fluid films **109**, **905b** from the fluid dispensing devices **103**, **901**. The cooling fluid **1008** can eventually exit, for example, by passing down through the bottom of the shroud and/or through one of the exit ports in the outer cylindrical peripheral wall **1407**.

[0057] Particles of glass and/or particles of the grinding wheel may be released during the grinding process. Various example techniques are designed to protect the pristine surfaces **117**, **119** of the glass sheet **111** from these particles. As shown in **FIGS. 1 and 4**, the laminar flow **107** of the fluid film **109** can travel along the first surface **117** in a direction toward the grinding zone. As shown in **FIG. 4**, the fluid film **109** can freely travel through an upper area of the slot **1401** having a thickness “**T3**” sufficient to allow uninterrupted passage of the laminar fluid film into the containment area **1507**. In one example, “**T3**” can be about 350 microns although other thicknesses may be used in further examples. Furthermore, the slot clearance underneath the glass sheet may be sufficient, such as similar or identical to **T3**” for the fluid film **905b**. As shown, the overall slot thickness “**T1**” can be adjusted by an optional shutter **417** depending on the processing parameters of the particular application. In some examples, “**T1**” may be provided or adjusted to be about 1 mm to about 3 mm although other thicknesses may be used in further examples.

[0058] As shown in **FIG. 8**, a dashed line is shown for illustrative purposes as a line that is parallel to the elongated opening **503** and extends through the fluid plane of the laminar flow **107** of the fluid film **109**. The dashed line is also positioned to intersect the edge **113** of the glass sheet **111** at a point where the right side of the fluid film **109**, as viewed

from the top in **FIG. 8**, passes over the edge **113** of the glass sheet **111**. As such, it will be understood that the laminar flow lines **107** shown in **FIG. 8** are perpendicular to both the dashed line and the elongated opening **503** of the fluid dispensing device **103**. As represented by the dashed line in **FIG. 8**, it can be desired to orient the fluid dispensing device **103** such that an angle “**A3**” of the fluid plane relative to the intersection of the fluid plane and the outer peripheral edge **113** is within a range of about 10° to about 30°, such as about 20°. Providing such an angled orientation can help effectively protect the pristine surfaces of the glass sheet when moving the glass sheet and the glass treatment apparatus relative to one another during a machining procedure.

[0059] The laminar fluid film **109** then freely coats the first surface **117** of the glass sheet **111** and travels within and further coats the first surface **117** of the glass sheet **111** in the vicinity of the working area. Particles within the containment area **1507** are thereby prevented from contacting the first surface **117** since any particles that would otherwise land on the first surface **117** are entrained in the fluid film **109** and carried away before the particles have a chance to interact with the first surface **117** of the glass sheet **111**. Once entrained, the fluid film then leaves the surface **117** of the glass sheet **111** and can then travel down through the bottom open end of the containment area **1507**. Alternatively, the fluid passes along the inner surface **1009** of the outer cylindrical peripheral wall **1407**, out the second exit port **1515b** and down through the lower opening **1523**. As such, the liquid also prevents settling of particles on the inner surface **1009** of the shroud **1005**, thereby preventing particle accumulation that may otherwise result in eventual contamination of the pristine surfaces of the glass sheet.

[0060] In further examples, another dispensing device, such as the first and/or second fluid dispensing devices **901a**, **901b**, may be used to help protect the second surface **119** of the glass sheet **111**. For example, the fluid film **905a**, **905b** of the of the fluid dispensing devices **901a**, **901b** may coat the second surface **119** such that the laminar flow **903a**, **903b** is maintained as the fluid film travels in a direction substantially parallel to the outer peripheral edge **113** as shown in **FIG. 10**. Portions of the laminar flow of the fluid film **905b** can pass through the slot **1401** and into the containment area **1507**. As such, machined particles that may otherwise contact the second surface **119** are entrained into the fluid film **905b** and

carried away from the glass sheet without damaging the second surface **119** of the glass sheet **111**. In one example, the fluid may travel off the glass sheet and down through the bottom open end of the containment area **1507**. Alternatively, the fluid can pass along the inner surface **1009** of the outer cylindrical peripheral wall **1407**, out the second exit port **1515b** and down through the lower opening **1523**. Further, if any fluid passes back out through the slot **1401**, another laminar flow of film from the second fluid dispensing device **901a** can further facilitate removal of the fluid from the lower surface of the glass sheet.

[0061] As shown in **FIG. 10**, methods of the disclosure can include the steps of providing the working wheel **1001** with the outer peripheral surface **1003** and the shroud **1005** substantially circumscribing the outer peripheral surface **1003**. The method includes the step of rotating the working wheel **1001** in the direction **1104** about the rotation axis **1102** and moving the glass sheet **111** relative to the glass treatment apparatus **101** such that the edge portion **115** of the glass sheet **111** passes through the slot **1401** with the outer peripheral edge **113** of the glass sheet **111** being machined by the rotating working wheel **1001**. The method further includes the step of passing fluid over an inner surface **1009** of the shroud **1005** to carry away machined particles from the glass sheet **111** generated when machining the outer peripheral edge **113** of the glass sheet **111**.

[0062] In one example, fluid from one of the fluid dispensing devices **103**, **901** may eventually pass over the inner surface **1009** of the shroud **1005** and thereafter carry away machined particles. As such, fluid from the fluid dispensing devices **103**, **901** passing through the slot **1401** may eventually coat a portion of the inner surface **1009** to prevent particles from accumulating on the inner surface. Rather, any such particles would encounter the fluid passing over the inner surface and eventually pass down through the open bottom of the containment area **1507** and/or through the lower opening **1523**.

[0063] Therefore, in one example, the method can include the step of dispensing the substantially laminar flow **107** of the fluid film **109** along a fluid plane to subsequently land on the first side **117** of a glass sheet **111** at a location outside of the shroud **1005**. The method can then include the step of passing the fluid film **109** along the first side **117** of the glass sheet **111** and through the slot **1401** of the shroud **1005** as shown in **FIG. 4**. Machined particles of glass can then be entrained in the fluid film before or after a portion of the fluid

film passes over the inner surface of the shroud to carry away machined particles from the glass sheet. In one example, the method can further include the step of passing the fluid with the entrained machined particles of glass through one of the exit ports **1515a**, **1515b** in the shroud **1005**.

[0064] In another example, the method can include the step of dispensing the substantially laminar flow **903b** of the fluid film **905b** along a fluid plane to subsequently land on the second side **119** of the glass sheet **111** at a location outside of the shroud **1005**. The method can then include the step of passing the fluid film **905b** along the second side **119** of the glass sheet **111** and through the slot **1401** of the shroud **1005** as shown in **FIGS. 4 and 10**. Machined particles of glass can then be entrained in the fluid film before or after a portion of the fluid film passes over the inner surface of the shroud to carry away machined particles from the glass sheet. In one example, the method can further include the step of passing the fluid with the entrained machined particles of glass through one of the exit ports **1515a**, **1515b** in the shroud **1005**.

[0065] Further aspects of the disclosure can include cleaning the working wheel from glass particles generated when machining the edge of the glass sheet. Cleaning the working wheel can help manage glass particle accumulation to reduce the probability of large particle masses being spun off of the wheel that may otherwise contaminate the pristine surfaces of the glass sheet. As shown in **FIG. 10**, such methods can include the step of impacting the outer peripheral surface **1003** of the working wheel **1001** with a fluid stream **1013** to clean the working wheel **1001** from glass particles generated when machining the edge of the glass sheet.

[0066] As shown in **FIG. 10**, the fluid stream **1013** impacts the outer peripheral surface **1003** of the working wheel **1001** at an acute angle “**A4**” relative to a first axis **1525** that is perpendicular to a second axis **1527** that is tangent to the point of impact **1529**. As shown, the angle “**A4**” can be a positive value wherein it is tilted in the direction of the rotation of the working wheel **1001** or a negative value where it is tilted in away from the direction of the rotation of the working wheel **1001**. In one example, “**A4**” can be 30° in the positive or negative direction as shown in **FIG. 10**. Other angles may be provided in further

examples. Still further, the fluid stream **1013** may be in the direction of the first axis **1525** in still further examples.

[0067] As shown in **FIGS. 10 and 15**, orienting the stream in the positive 30° orientation can help direct fluid toward the first exit port **1515a** associated with the first flap **1517a**. As such, fluid including particles therein may be directed to exit the first exit port **1515a** and or pass down through the bottom opening of the containment area **1507**.

[0068] In still further examples, the method can include the step of providing an air barrier with the gas nozzle **1017**. As such, a portion of the inner surface **1009** may be designed to be substantially free of flowing fluid. For example, with reference to **FIG. 10**, the inner surface **1009** clockwise from the gas nozzle **1017** to the fluid nozzle **1007** can be designed to be substantially free of liquid. On the other hand, liquid can be maintained along the inner surface **1009** clockwise from the fluid nozzle **1007** and the fluid source **1011**. As such, fluid can be encouraged to be removed by one of the exit ports **1515a**, **1515b** and be prevented from cycling around the inner peripheral wall for further exposure to additional particles at the machining location.

[0069] Various aspects of the disclosure discusses above can facilitate finishing techniques that involve machining glass while maintaining the pristine surfaces of the glass sheet. Aspects of the disclosure address various particle source concerns such as: (1) glass particles generated at the edge of the glass during machining; (2) particles including the grinding and polishing coolant; (3) flying particles in the air; and (4) working wheel particles released during the machining process out such finishing techniques while maintaining the pristine surfaces of the glass sheet.

[0070] Certain aspects of the disclosure result in a fluid film, such as a water film that may be introduced by fluid dispensing devices **103**, **901** to provide sheet water management on both sides of a glass sheet. The fluid dispensing devices can help maintain the pristine surfaces of the glass sheet by creating an uninterrupted laminar film of water or other fluid to overcome particles sources and particle dynamics from various particle sources. In some examples, the particles may be designed to be removed in less than 2.2 seconds to avoid deposition of the particles on the glass surface. The laminar fluid film (e.g., water film) is

designed to provide an uninterrupted laminar fluid film and fluid flow rate to all surface areas of the glass sheet exposed to the various sources of particles.

[0071] In the orientation shown in **FIG. 1**, gravity tends to contribute to biasing particles to engage the upper side of the glass sheet while gravity tends to facilitate removal of particles away from the bottom side of the glass sheet. The fluid dispensing device **103** is designed to provide uninterrupted laminar water film and water flow rate before and after the fluid film lands on the upper surface of the glass sheet. Likewise, the fluid dispensing device **901** also provides uninterrupted laminar water film and water flow rate before and after the fluid film lands on the lower surface of the glass sheet. The uninterrupted laminar water film can help prevent particles from penetrating and/or adhering to the glass surface and can help maintain cleanliness and the pristine surfaces of the glass sheet.

[0072] Further aspects of the disclosure provide for a self-cleaning shroud that is effective to contain flying particles and prevents particle accumulation inside the shroud. For example, the shroud can help control flying particles and/or prevent accumulation of working wheel residual particles from accumulating inside the shroud. A water wall can be created within the self-cleaning shroud to flush the surface of the shroud, thereby flushing away particles that may have otherwise caused glass contamination issues. As such, the self-cleaning shroud is not only designed to contain flying particles generated during the machining process, but also timely removes the particles from the vicinity of the glass sheet to avoid accumulation inside the shroud that may otherwise present a contamination source of accumulated particles.

[0073] Still further aspects of the disclosure provide for one or more fluid (e.g., water) cleaning jets that are designed to strip particles from the working wheel so that the particles do not accumulate and thereafter redeposit on the glass surface at a later time. The water jets can facilitate stripping particles from the working wheel to prevent flying particles and accumulation of particles within the shroud. In some examples, the wheel cleaning jets can be orientated within a range of from about -30° to about $+30^{\circ}$ to facilitate maximum stripping of particles from the rotating working wheel. Other angles can be provided in further examples depending on the wheel orientation, the glass edge configuration, etc.

[0074] Further aspects of the disclosure provide for a shroud with one or more exit ports in the outer cylindrical peripheral wall designed to help reduce the residence time of the water and entrained particles within the containment area of the shroud.

[0075] It will be apparent to those skilled in the art that various modifications and variations can be made without departing from the spirit and scope of the claimed invention.

CLAIMS

What is claimed is:

1. A glass treatment apparatus comprising:
a fluid dispensing device including first and second flow expanders and a dispensing surface facing a dispensing direction, wherein the dispensing surface defines an elongated opening including an elongated central portion extending between first and second opposed end portions, wherein the first opposed end portion is provided with the first flow expander extending from the dispensing surface in the dispensing direction and the second opposed end portion is provided with the second flow expander extending from the dispensing surface in the dispensing direction,
wherein the fluid dispensing device is configured to dispense a substantially laminar flow of a fluid film from the elongated opening in the dispensing direction between the first and second flow expanders.
2. The glass treatment apparatus of claim 1, wherein the fluid dispensing device is configured to dispense the laminar fluid film in a direction substantially perpendicular to the dispensing surface.
3. The glass treatment apparatus of claim 1, wherein the fluid dispensing device includes a first elongated chamber having a first chamber axis extending along an elongated axis of the elongated opening, wherein the first elongated chamber is in fluid communication with the elongated opening.
4. The glass treatment apparatus of claim 3, wherein the fluid dispensing device includes a second elongated chamber having a second chamber axis substantially parallel to the first chamber axis, wherein the second elongated chamber is in fluid communication with the first elongated chamber and the first elongated chamber is positioned between the elongated opening and the second elongated chamber.

5. The glass treatment apparatus of claim 4, wherein a plurality of apertures provide fluid communication between the first elongated chamber and the second elongated chamber.

6. A glass treatment apparatus comprising:

a fluid dispensing device including a dispensing surface facing a dispensing direction, wherein the dispensing surface defines an elongated opening, the fluid dispensing device further including a first elongated chamber in fluid communication with the elongated opening and including a first chamber axis extending substantially parallel to the elongated opening, the fluid dispensing device further including a second chamber in fluid communication with the first elongated chamber,

wherein the fluid dispensing device is configured to dispense a substantially laminar flow of a fluid film from the elongated opening in the dispensing direction.

7. The glass treatment apparatus of claim 6, wherein the second chamber is elongated along a second chamber axis extending substantially parallel to the first chamber axis and the elongated opening.

8. The glass treatment apparatus of claim 6, wherein a plurality of apertures provides fluid communication between the first elongated chamber and the second chamber.

9. A glass treatment apparatus comprising:

a working wheel configured to rotate such that an outer peripheral surface of the working wheel machines a surface of a glass sheet; and

a shroud substantially circumscribing the outer peripheral surface of the working wheel, wherein the shroud includes a slot configured to receive an edge portion of the glass sheet.

10. The glass treatment apparatus of claim 9, wherein the shroud is provided with a gas nozzle configured to remove liquid from an inner surface of the shroud.

11. The glass treatment apparatus of claim 9, further comprising a fluid source configured to direct a fluid stream to impact the outer peripheral surface of the working wheel to clean the working wheel from glass particles generated when machining the surface of the glass sheet.

12. The glass treatment apparatus of claim 9, further including a fluid dispensing device configured to direct a laminar fluid film along a surface of the glass sheet and into the slot of the shroud.

13. The glass treatment apparatus of claim 12, further comprising another fluid dispensing device configured to direct fluid along another surface of the glass sheet and along the slot of the shroud.

14. The glass treatment apparatus of claim 12, wherein the fluid dispensing device comprises first and second flow expanders and a dispensing surface facing a dispensing direction, wherein the dispensing surface defines an elongated opening including an elongated central portion extending between first and second opposed end portions, wherein the first opposed end portion is provided with the first flow expander extending from the dispensing surface in the dispensing direction and the second opposed end portion is provided with the second flow expander extending from the dispensing surface in the dispensing direction,

wherein the fluid dispensing device is configured to dispense a substantially laminar flow of a fluid film from the elongated opening in the dispensing direction between the first and second flow expanders.

15. The glass treatment apparatus of claim 12, wherein the fluid dispensing device comprises a dispensing surface facing a dispensing direction, wherein the dispensing surface defines an elongated opening, the fluid dispensing device further including a first elongated chamber in fluid communication with the elongated opening and including a first chamber axis extending substantially parallel to the elongated opening, the fluid

dispensing device further including a second chamber in fluid communication with the first elongated chamber,

wherein the fluid dispensing device is configured to dispense a substantially laminar flow of a fluid film from the elongated opening in the dispensing direction.

16. A method of treating glass comprising the steps of:

dispensing a substantially laminar flow of a fluid film along a fluid plane to subsequently land on a first side of a glass sheet; and

machining an edge of the glass sheet, wherein machined particles of glass are entrained in the fluid film and carried away from the glass sheet.

17. The method of claim 16, wherein the fluid plane extends at an angle of from about 5° to about 30° from a planar surface of the glass sheet.

18. The method of claim 17, wherein the fluid plane intersects the edge of the glass sheet at an angle of from about 10° to about 30°.

19. The method of claim 16, further comprising the step of dispensing a substantially laminar flow of a second fluid film along a second fluid plane to subsequently land on a second side of the glass sheet, wherein the machined particles of glass are entrained in the second fluid film and carried away from the glass sheet.

20. The method of claim 16, further comprising the step of expanding the fluid film with a pair of flow expanders disposed on each side of the fluid film.

21. A method of treating glass comprising the steps of:

providing a glass sheet;

providing a working wheel with an outer peripheral surface and a shroud substantially circumscribing the outer peripheral surface, wherein the shroud includes a slot;

rotating the working wheel about a rotation axis;

moving the glass sheet and working wheel relative to each other such that an edge portion of the glass sheet passes through the slot with an edge of the glass sheet being machined by the rotating working wheel; and

passing a fluid over an inner surface of the shroud to carry away machined particles from the glass sheet generated when machining the edge of the glass sheet.

22. The method of claim 21, further including the step of passing the fluid with the machined particles of glass through an exit port in the shroud.

23. The method of claim 21, further comprising the steps of:

dispensing a substantially laminar flow of a fluid film along a fluid plane to subsequently land on a first side of a glass sheet at a location outside of the shroud;

passing the fluid film along the first side of the glass sheet and through the slot of the shroud; and then

entraining machined particles of glass in the fluid film inside of the shroud.

24. The method of claim 23, further including the step of passing the fluid with the entrained machined particles of glass through an exit port in the shroud.

25. The method of claim 24, further comprising the step of dispensing a substantially laminar flow of a second fluid film along a second fluid plane to subsequently land on a second side of the glass sheet, wherein the machined particles of glass are entrained in the second fluid film and carried away from the glass sheet.

26. The method of claim 21, further comprising the step of impacting the outer peripheral surface of the working wheel with a fluid stream to clean the working wheel from glass particles generated when machining the edge of the glass sheet.

27. The method of claim 26, further comprising the step of passing the fluid with the glass particles from the working wheel through an exit port in the shroud.

28. A method of treating glass comprising the steps of:
- providing a glass sheet;
 - providing a working wheel with an outer peripheral surface and a shroud substantially circumscribing the outer peripheral surface, wherein the shroud includes a slot;
 - rotating the working wheel about a rotation axis;
 - moving the glass sheet and the working wheel relative to each other such that an edge portion of the glass sheet passes through the slot with an edge of the glass sheet being machined by the rotating working wheel; and
 - impacting the outer peripheral surface of the working wheel with a fluid stream to clean the working wheel from glass particles generated when machining the edge of the glass sheet.
29. The method of claim 28, wherein the fluid stream impacts the outer peripheral surface of the working wheel at an acute angle relative to a first axis that is perpendicular to a second axis that is tangent to the point of impact.
30. The method of claim 29, wherein the angle is about 30°.
31. The method of claim 28, further including the step of passing the fluid with the glass particles from the working wheel through an exit port in the shroud.

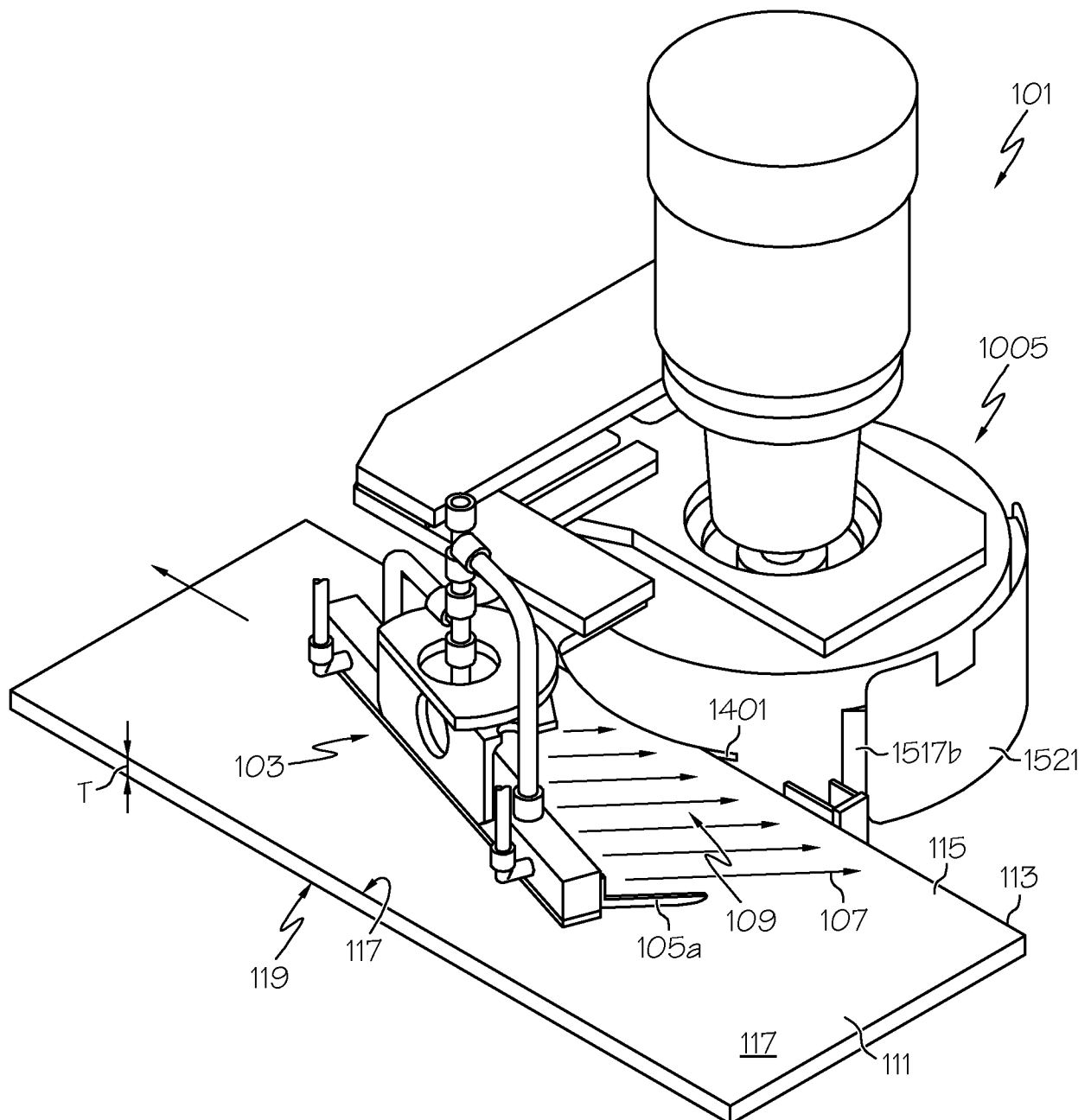
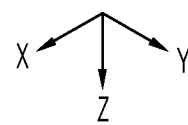


FIG. 1



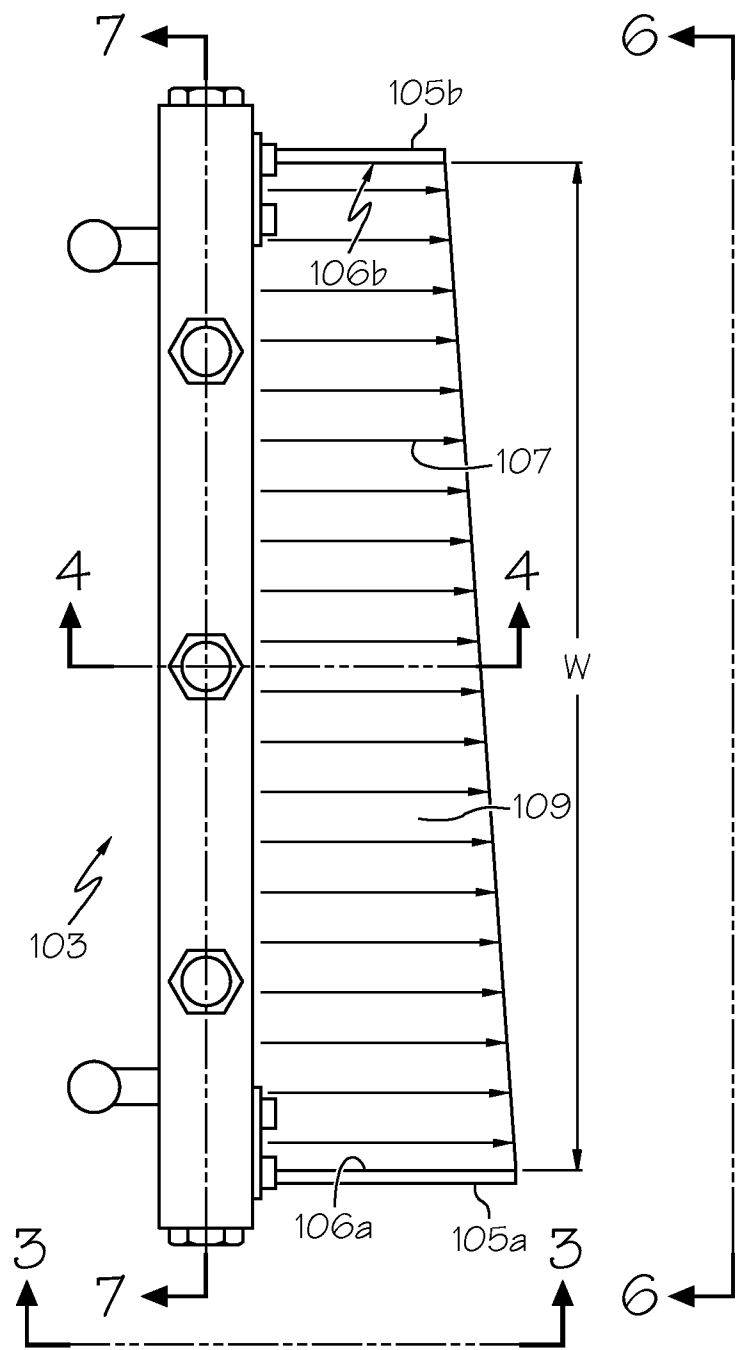


FIG. 2

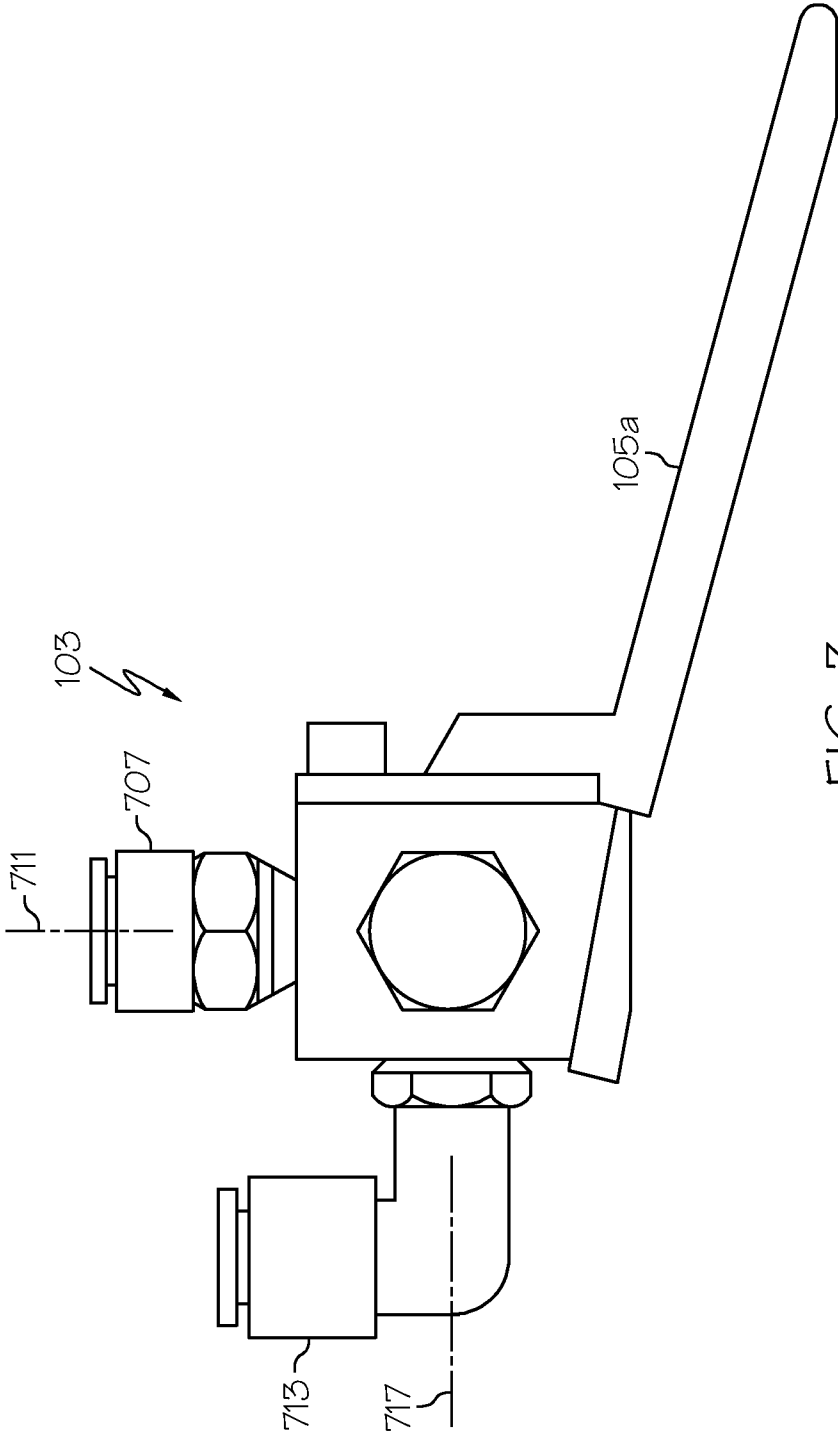
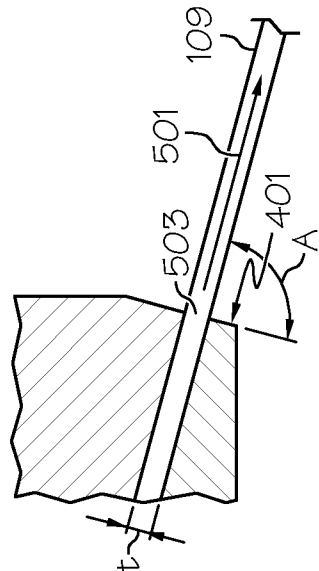
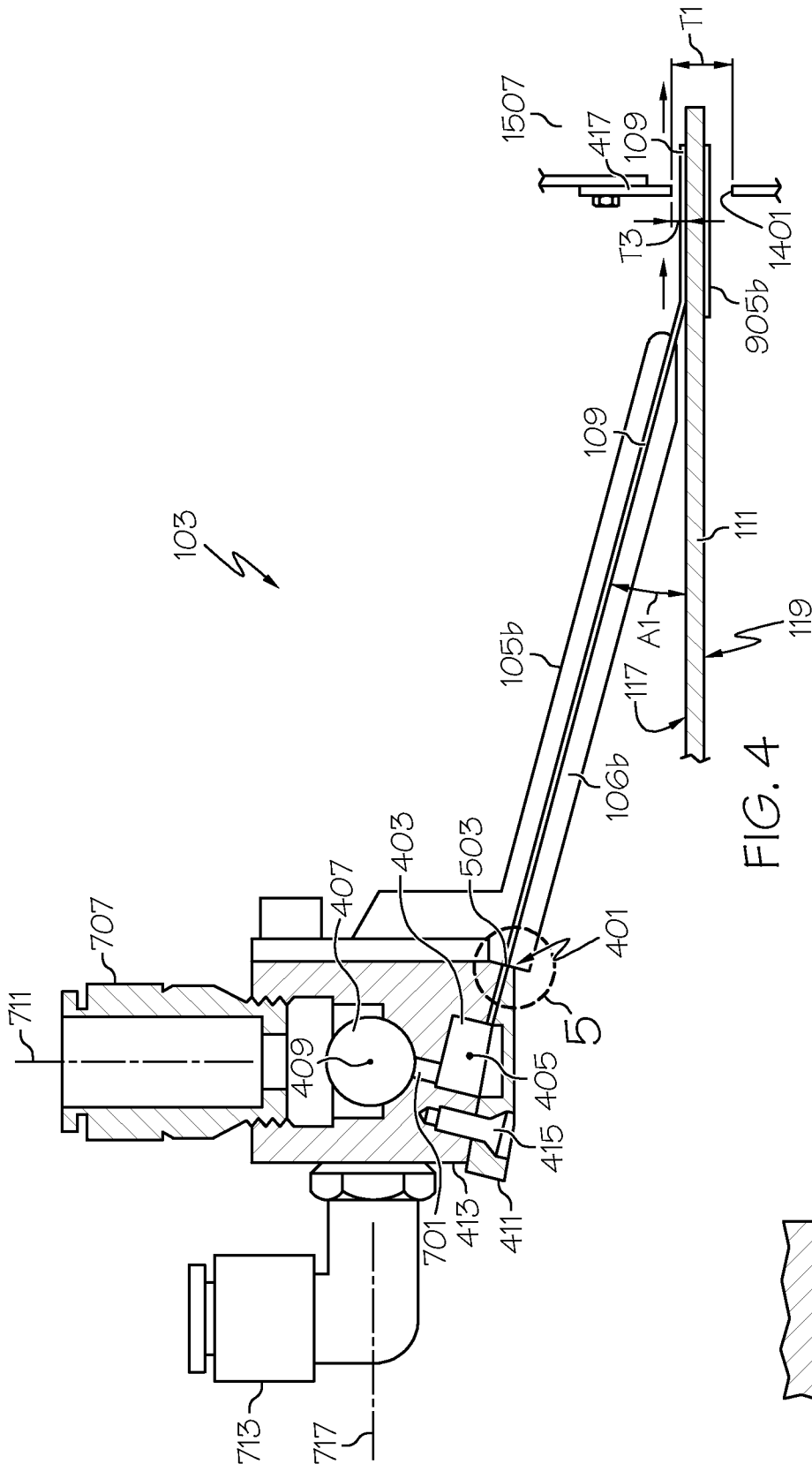


FIG. 3



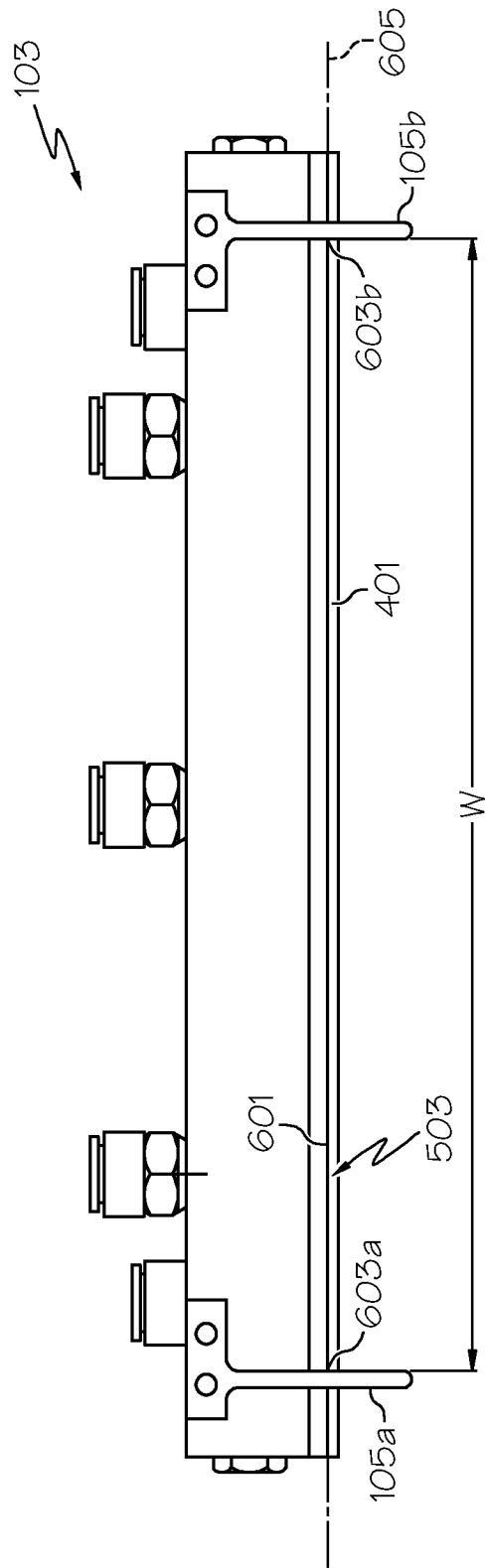


FIG. 6

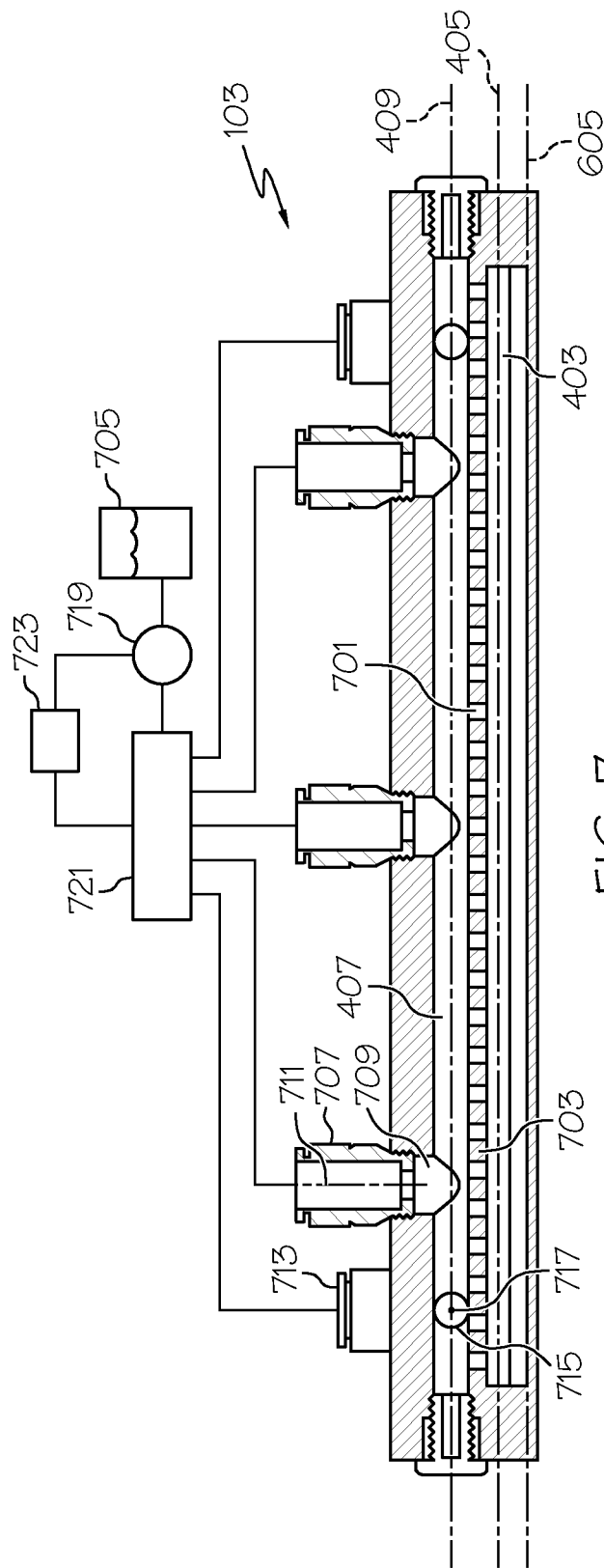


FIG. 7

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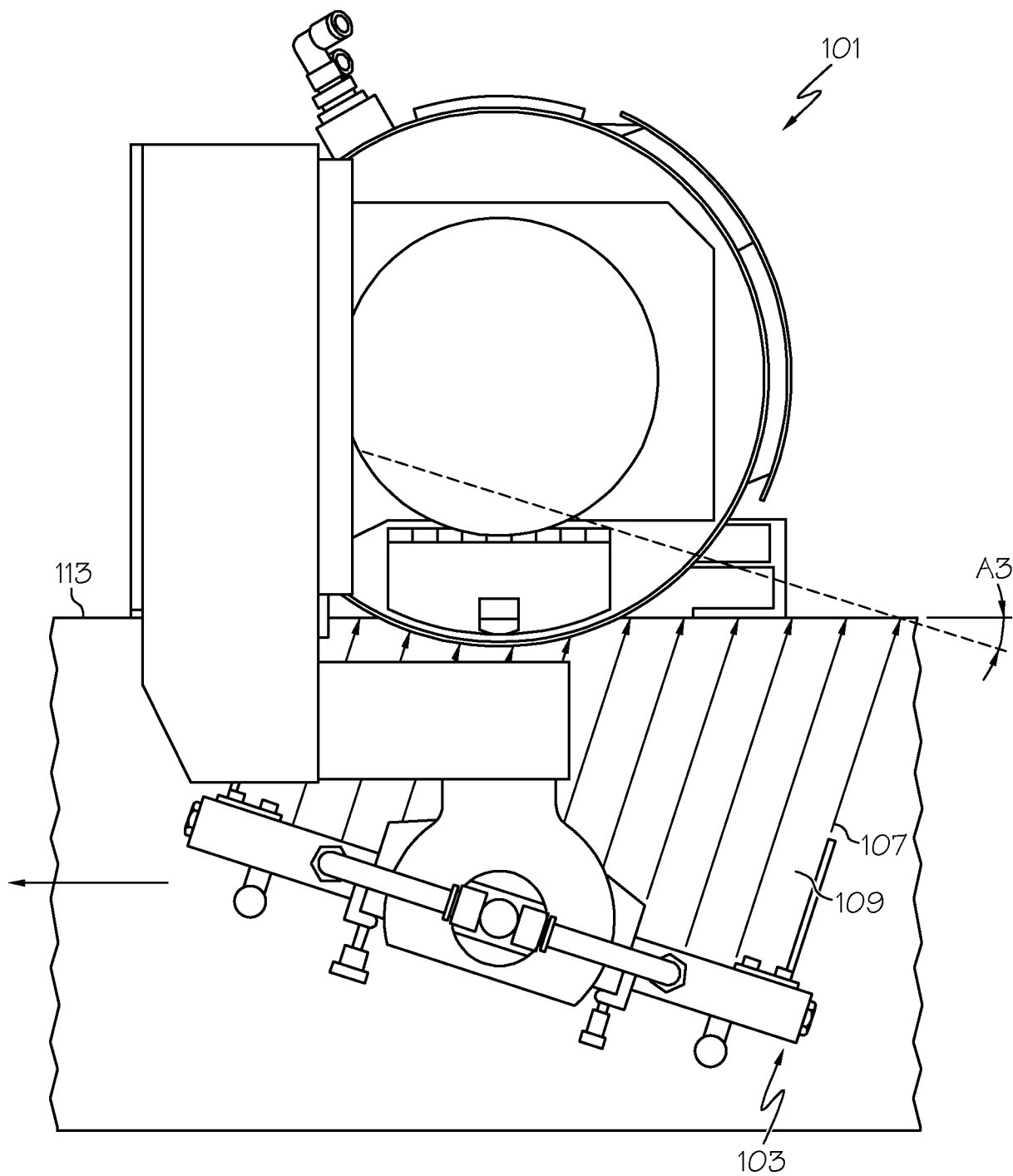


FIG. 8

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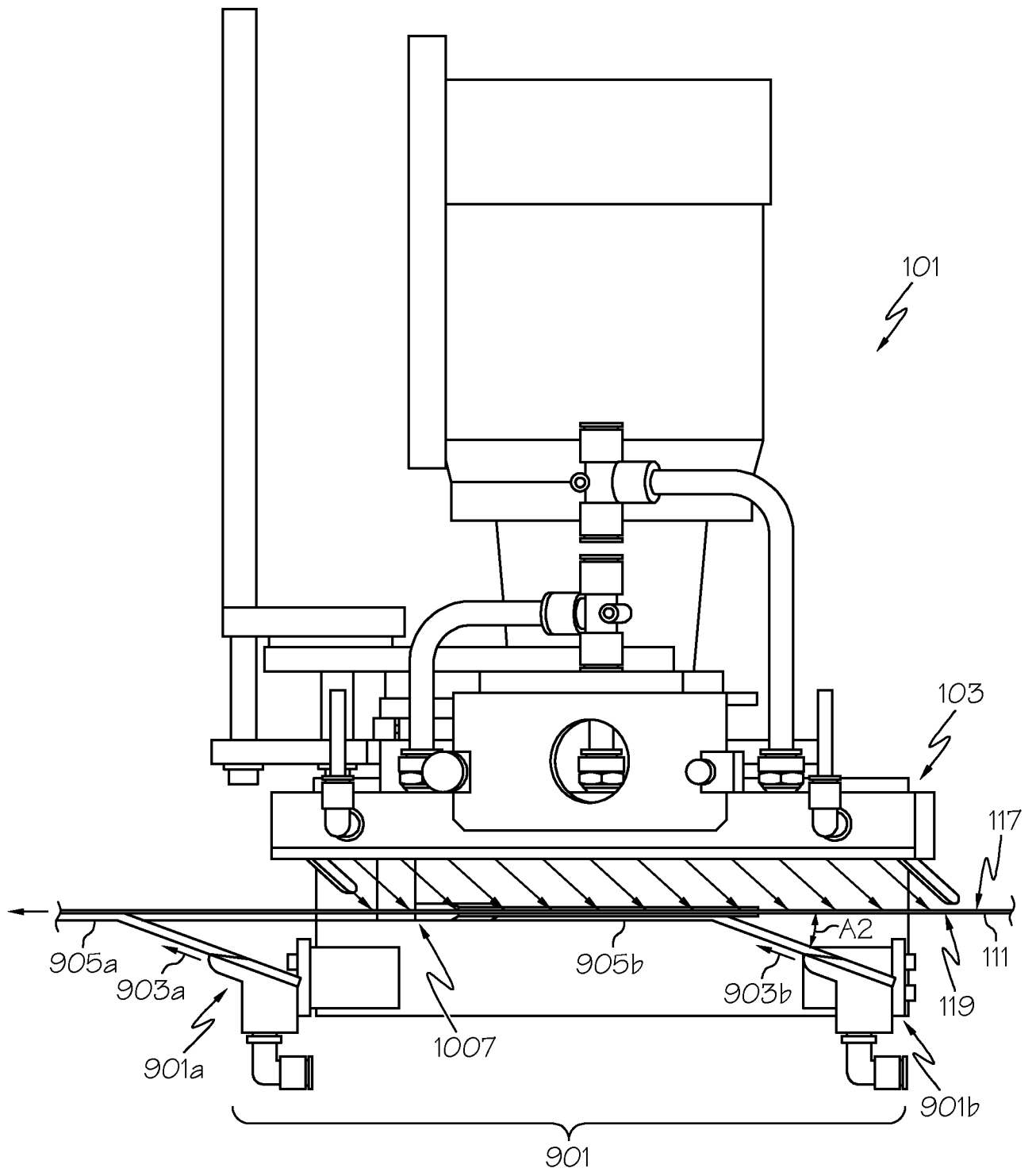


FIG. 9

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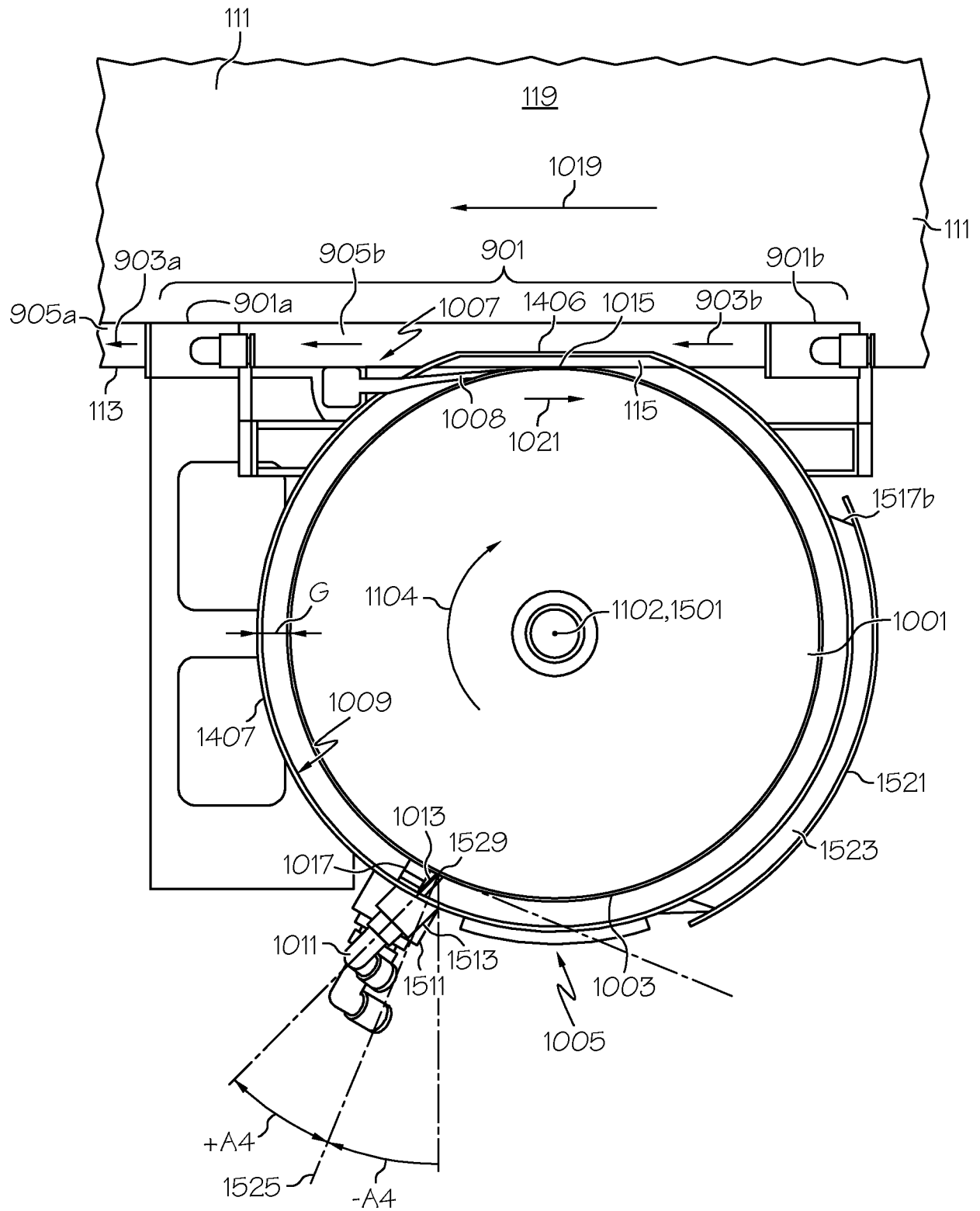


FIG. 10

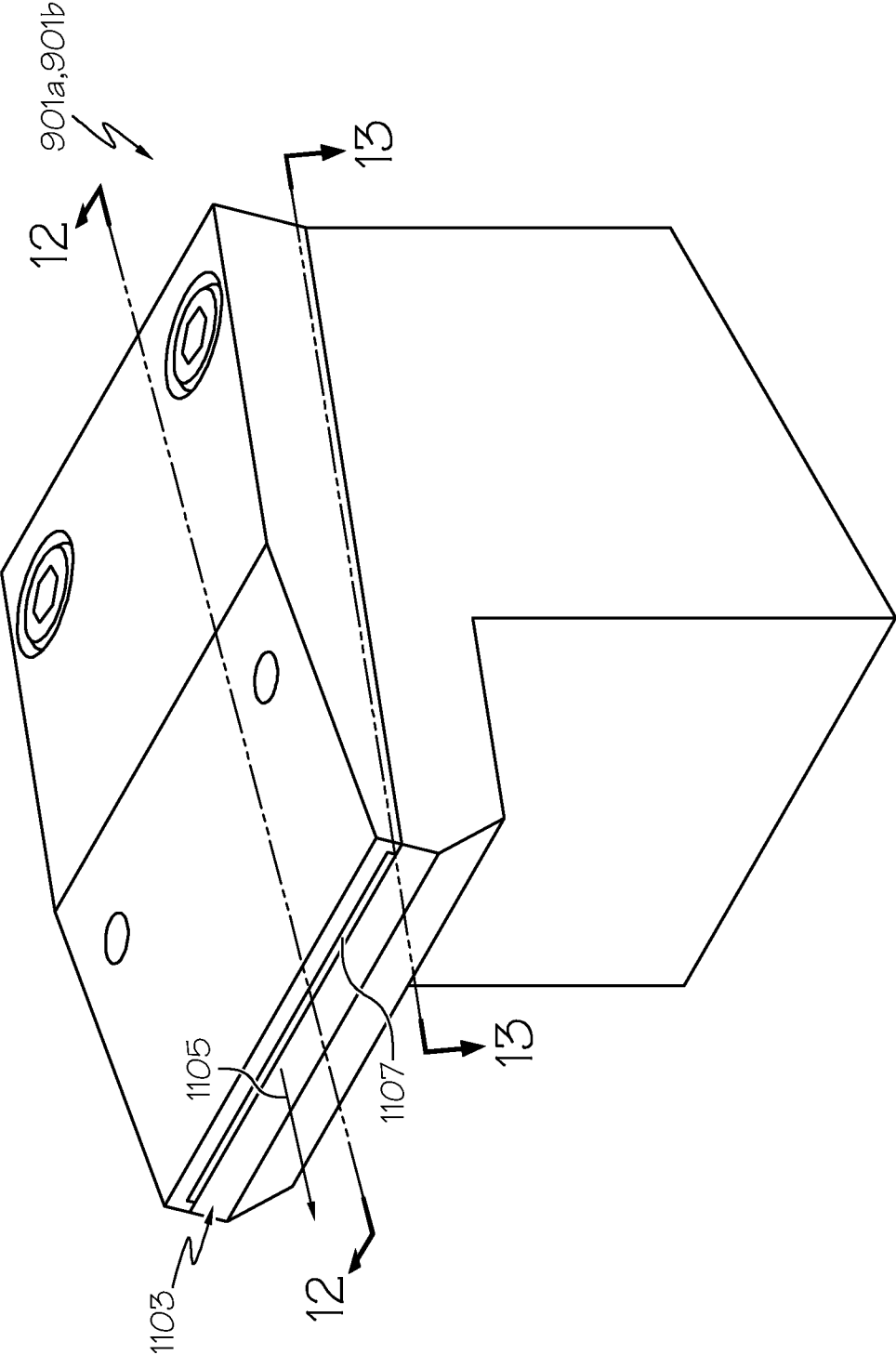


FIG. 11

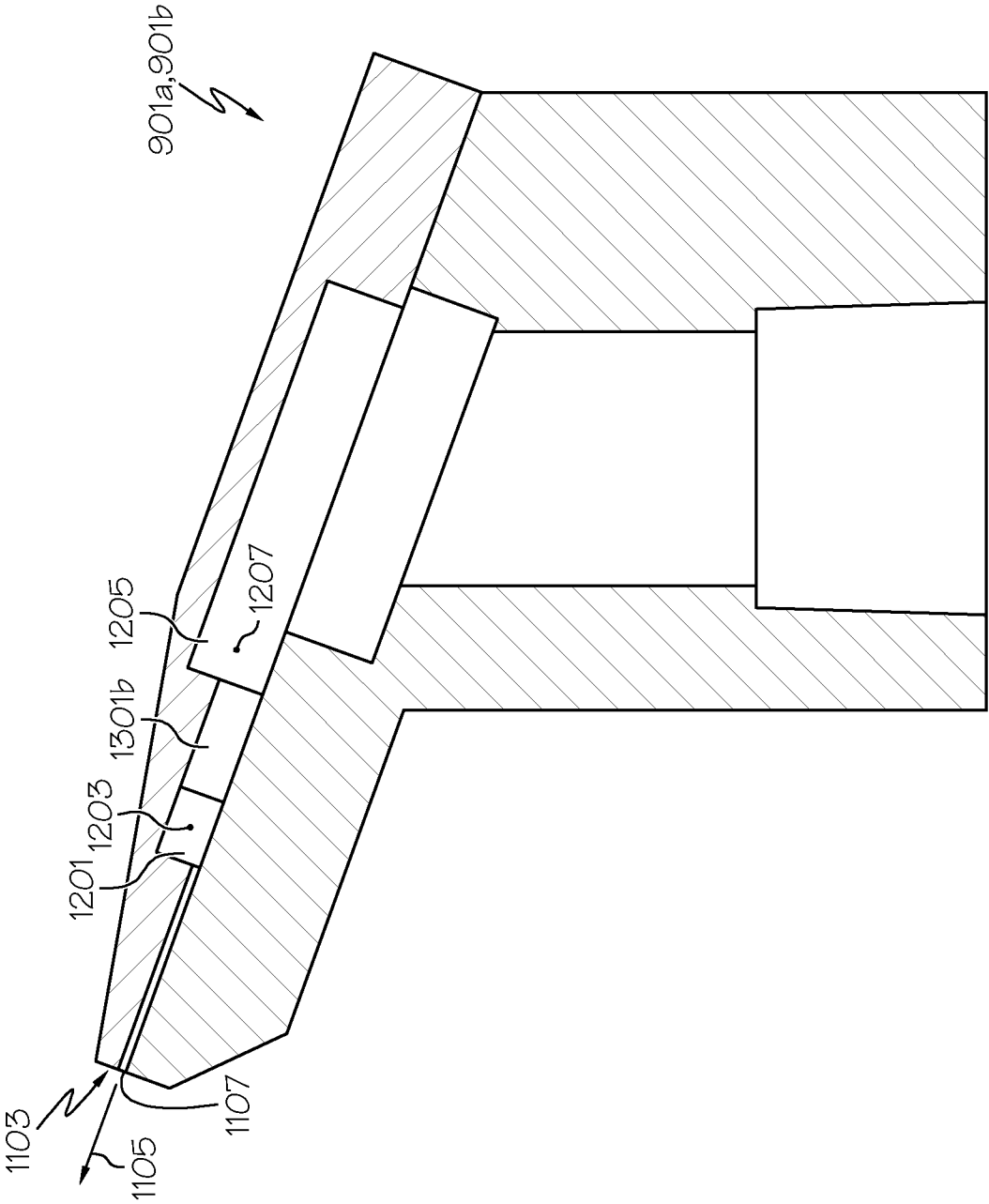


FIG. 12

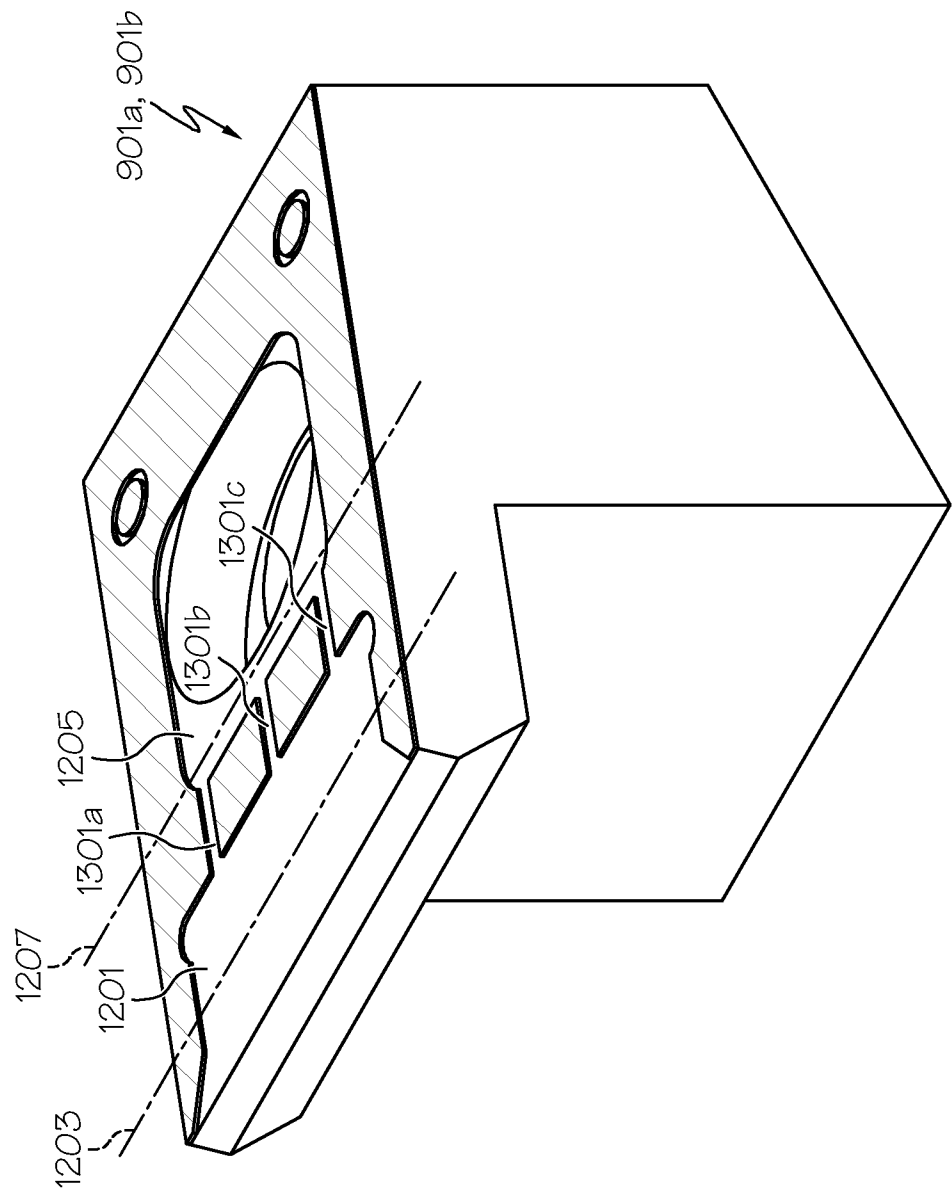


FIG. 13

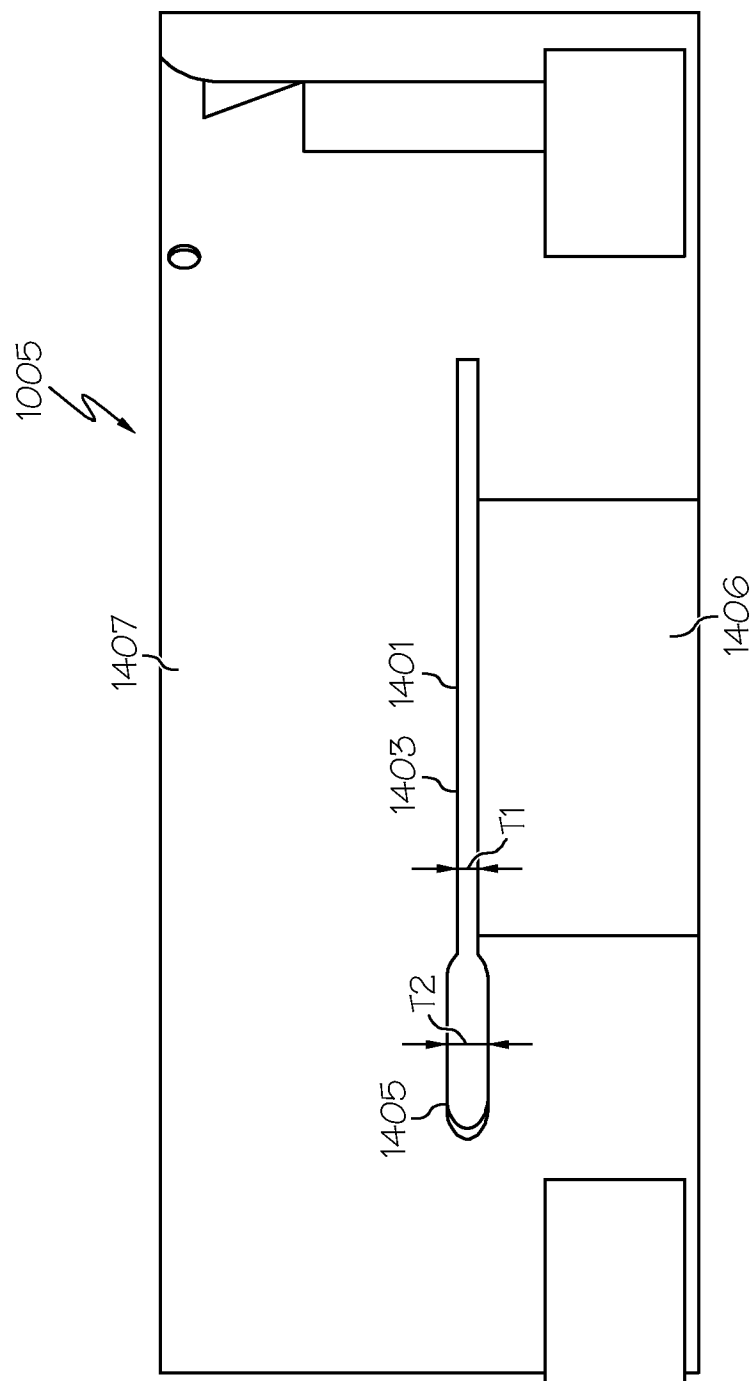


FIG. 14

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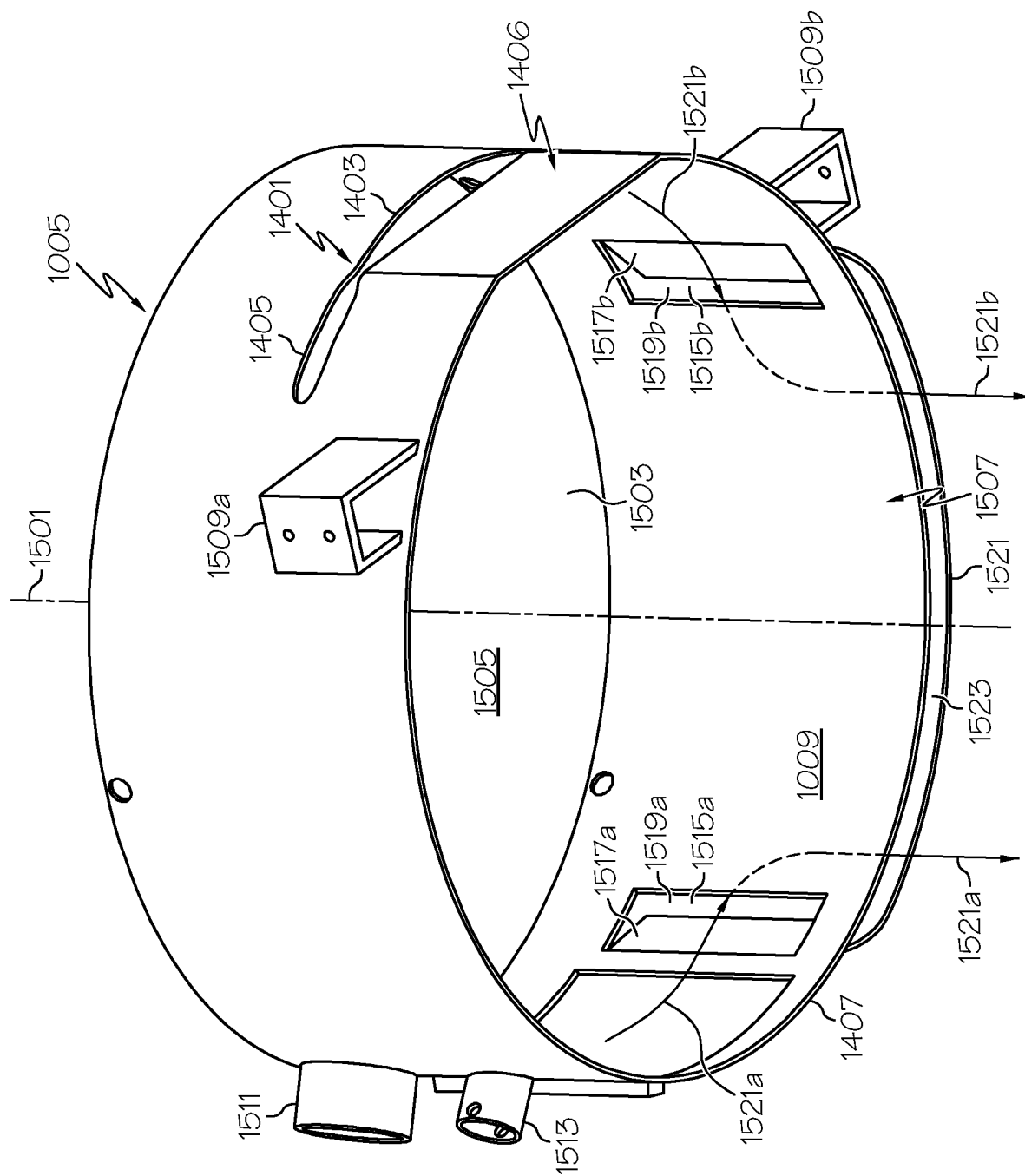


FIG. 15

