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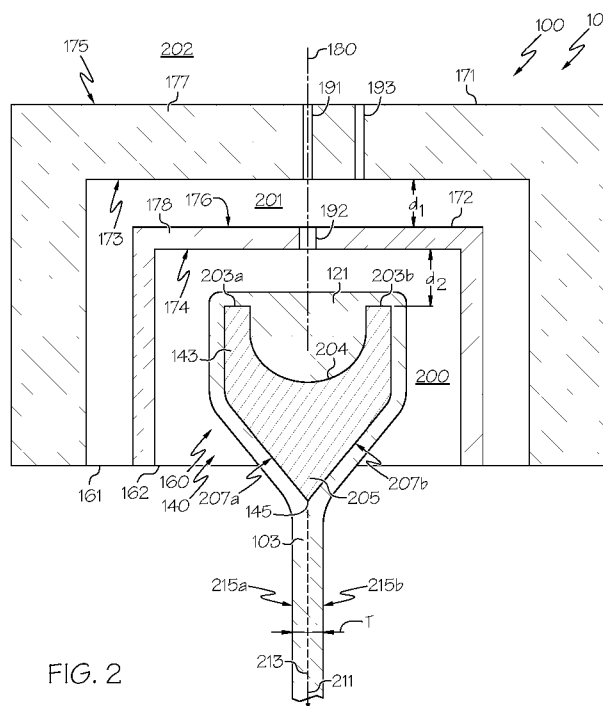


FIG. 2

(57) Abstract: A glass manufacturing apparatus can include a first aperture extending through a first enclosure, a second aperture extending through a second enclosure positioned within the first enclosure, and a vessel to contain molten material that is positioned within the second aperture. The first aperture and the second aperture define an insertion path from outside the first enclosure to inside the second enclosure. The glass manufacturing apparatus can further include a third aperture spaced from the first aperture and extending through the first enclosure, and a blocking-object including a shaft positioned within the third aperture and a protrusion extending from the shaft and oriented to selectively block the second aperture. In further embodiments, methods of blocking an aperture of a glass manufacturing apparatus can include measuring an attribute of a vessel with a device, removing the device from an aperture, and blocking the aperture with a blocking-object.

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GLASS MANUFACTURING APPARATUS AND METHODS

[0001] This application claims the benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Application Serial No. 62/340622 filed on May 24, 2016.

FIELD

[0002] The present disclosure relates generally to methods and apparatus for manufacturing glass and, more particularly, to methods and apparatus for blocking an aperture in a glass manufacturing apparatus with a blocking-object.

BACKGROUND

[0003] It is known to manufacture glass with a glass manufacturing apparatus. It is further known to measure temperatures of the glass manufacturing apparatus with a thermocouple.

SUMMARY

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

[0005] In some embodiments, a glass manufacturing apparatus can include a first enclosure, a second enclosure positioned within the first enclosure, and a vessel to contain molten material that is positioned within the second enclosure. The glass manufacturing apparatus can also include a first aperture extending through the first enclosure and a second aperture extending through the second enclosure. The first aperture and the second aperture define an insertion path from outside the first enclosure to inside the second enclosure. The glass manufacturing apparatus can also include a third aperture spaced from the first aperture and extending through the first enclosure. The glass manufacturing apparatus can still further include a blocking-object including a shaft positioned within the third aperture and a protrusion extending from the shaft and oriented to selectively block the second aperture.

[0006] In some embodiments, the vessel can include a trough and a forming wedge including a pair of downwardly inclined surfaces that converge at a root of the vessel.

[0007] In some embodiments, the blocking-object can be rotatable about a longitudinal axis of the shaft.

[0008] In some embodiments, the protrusion of the blocking-object can be positioned between the first enclosure and the second enclosure.

[0009] In some embodiments, the protrusion of the blocking-object can be oriented to selectively abut an outer surface of the second enclosure along a path circumscribing the second aperture.

[0010] In some embodiments, the second aperture can be spaced a distance from an inner surface of the first enclosure.

[0011] In some embodiments, the insertion path can include a linear axis extending from the first aperture to the second aperture.

[0012] In some embodiments, the glass manufacturing apparatus can include a cover positioned outside the first enclosure, and the cover can be oriented to block the third aperture.

[0013] In some embodiments, the glass manufacturing apparatus can include a spring oriented to bias the cover in a direction toward the first enclosure.

[0014] In some embodiments, the cover can engage the shaft of the blocking-object.

[0015] In some embodiments, the blocking-object can be rotatable about a longitudinal axis of the shaft based at least in part on a corresponding rotation of the cover.

[0016] In some embodiments, a method of blocking an aperture in a glass manufacturing apparatus can include inserting a device through a first aperture in a first enclosure and a second aperture in a second enclosure along an insertion path from outside the first enclosure to inside the second enclosure, where the second enclosure is positioned within the first enclosure. The method can include measuring an attribute of a vessel to contain molten material with the device, where the vessel is positioned within

the second enclosure, removing the device from the second aperture, and blocking the second aperture with a blocking-object.

[0017] In some embodiments, the device can include a thermocouple.

[0018] In some embodiments, the attribute can include a temperature.

[0019] In some embodiments, measuring an attribute can be performed without molten material contained in the vessel.

[0020] In some embodiments, the method can include containing molten material in the vessel after measuring the attribute of the vessel.

[0021] In some embodiments, blocking the second aperture can be performed without molten material contained in the vessel.

[0022] In some embodiments, the method can include removing the device from the first aperture and the second aperture, and then blocking the first aperture.

[0023] In some embodiments, blocking the second aperture can include rotating the blocking-object.

[0024] In some embodiments, the blocking-object can be rotated by rotating a cover positioned outside the first enclosure.

[0025] In some embodiments, blocking the second aperture can include moving the blocking-object within a third aperture in the first enclosure.

[0026] In some embodiments, moving the blocking-object can include rotating the blocking-object within the third aperture.

[0027] In some embodiments, the method can include blocking the third aperture with a cover positioned outside the first enclosure.

[0028] In some embodiments, the blocking-object can be moved within the third aperture by moving the cover.

[0029] In some embodiments, the method can include biasing the cover against the first enclosure to seal the third aperture with the cover.

[0030] The above embodiments are exemplary and can be provided alone or in any combination with any one or more embodiments provided herein without departing from the scope of the disclosure. Moreover, it is to be understood that both the foregoing general description and the following detailed description present embodiments of the

present disclosure, and are intended to provide an overview or framework for understanding the nature and character of the embodiments as they are described and claimed. The accompanying drawings are included to provide a further understanding of the embodiments, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments of the disclosure, and together with the description, serve to explain the principles and operations thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] These and other features, embodiments, and advantages of the present disclosure can be further understood when read with reference to the accompanying drawings:

[0032] **FIG. 1** illustrates a schematic view of an exemplary glass manufacturing apparatus in accordance with embodiments of the disclosure;

[0033] **FIG. 2** shows a cross-sectional view of the exemplary glass manufacturing apparatus along line 2-2 of **FIG. 1**;

[0034] **FIG. 3** shows a perspective cross-sectional view of the exemplary glass manufacturing apparatus of **FIG. 2**, including an exemplary blocking-object; and

[0035] **FIG. 4** shows an embodiment of the exemplary glass manufacturing apparatus including the blocking-object of **FIG. 3**.

DETAILED DESCRIPTION

[0036] Methods will now be described more fully hereinafter with reference to the accompanying drawings in which exemplary embodiments of the disclosure are shown. Whenever possible, the same reference numerals are used throughout the drawings to refer to the same or like parts. However, this disclosure may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

[0037] Glass sheets are commonly fabricated by flowing molten glass to a forming body whereby a glass ribbon may be formed by a variety of ribbon forming processes including, float, slot draw, down-draw, fusion down-draw, up-draw, press roll or any other forming processes. The glass ribbon from any of these processes may then

be subsequently divided to provide one or more glass sheets suitable for further processing into a desired application, including but not limited to, a display application. For example, the one or more glass sheets can be used in a variety of display applications, including liquid crystal displays (LCDs), electrophoretic displays (EPD), organic light emitting diode displays (OLEDs), plasma display panels (PDPs), or the like.

[0038] FIG. 1 schematically illustrates an exemplary glass manufacturing apparatus **101** to process, manufacture, and form a glass ribbon **103**. The glass manufacturing apparatus **101** can operate to include a glass manufacturing process **100** that can, in some embodiments, include any one or more of the features of the glass manufacturing apparatus **101** disclosed herein to at least one of manufacture and process glass. For illustration purposes, the glass manufacturing apparatus **101** is illustrated as a fusion down-draw apparatus, although other glass manufacturing apparatus for up-draw, float, press rolling, slot draw, etc. may be provided in further embodiments. As illustrated, the glass manufacturing apparatus **101** can include a melting vessel **105** oriented to receive batch material **107** from a storage bin **109**. The batch material **107** can be introduced by a batch delivery device **111** powered by a motor **113**. An optional controller **115** can be operated to activate the motor **113** by which batch delivery device **111** can introduce a desired amount of batch material **107** into the melting vessel **105**, as indicated by arrow **117**. A glass melt probe **119** can be used to measure a level of molten material **121** within a standpipe **123** and communicate the measured information to the controller **115** by way of a communication line **125**.

[0039] The glass manufacturing apparatus **101** can also include a fining vessel **127** located downstream from the melting vessel **105** and coupled to the melting vessel **105** by way of a first connecting conduit **129**. In some embodiments, molten material **121** may be gravity fed from the melting vessel **105** to the fining vessel **127** by way of the first connecting conduit **129**. For example, gravity may act to drive the molten material **121** to pass through an interior pathway of the first connecting conduit **129** from the melting vessel **105** to the fining vessel **127**. Within the fining vessel **127**, bubbles may be removed from the molten material **121** by various techniques.

[0040] The glass manufacturing apparatus **101** can further include a mixing chamber **131** that may be located downstream from the fining vessel **127**. In some embodiments, the mixing chamber **131** can include a mixing shaft **150** including mixing blades **151** to mix molten material **121** within the mixing chamber **131**. The mixing chamber **131** can be used to provide a homogenous composition of molten material **121**, thereby reducing or eliminating inhomogeneity that may otherwise exist within the molten material **121** exiting the fining vessel **127**. As shown, the fining vessel **127** may be coupled to the mixing chamber **131** by way of a second connecting conduit **135**. In some embodiments, molten material **121** may be gravity fed from the fining vessel **127** to the mixing chamber **131** by way of the second connecting conduit **135**. For instance, gravity may drive the molten material **121** to pass through an interior pathway of the second connecting conduit **135** from the fining vessel **127** to the mixing chamber **131**.

[0041] The glass manufacturing apparatus **101** can further include a delivery vessel **133** that may be located downstream from the mixing chamber **131**. The delivery vessel **133** can condition the molten material **121** to be fed into a glass former **140**. For example, the delivery vessel **133** can function as an accumulator and/or flow controller to adjust and provide a consistent flow of molten material **121** to the glass former **140**. As shown, the mixing chamber **131** may be coupled to the delivery vessel **133** by way of a third connecting conduit **137**. In some embodiments, molten material **121** may be gravity fed from the mixing chamber **131** to the delivery vessel **133** by way of the third connecting conduit **137**. For instance, gravity may drive the molten material **121** to pass through an interior pathway of the third connecting conduit **137** from the mixing chamber **131** to the delivery vessel **133**. As further illustrated, a delivery pipe **139** can be positioned to deliver molten material **121** to the glass former **140** of the glass manufacturing apparatus **101**. The glass former **140** may draw the molten material **121** into the glass ribbon **103** off of a root **145** of a forming vessel **143**. In the illustrated embodiment, the forming vessel **143** can be provided with an inlet **141** oriented to receive molten material **121** from the delivery pipe **139** of the delivery vessel **133**.

[0042] As shown in **FIGS. 1** and **2**, in some embodiments, the forming vessel **143** can include a trough **204** (see **FIG. 2**) oriented to receive the molten material **121** from

the inlet **141** (see **FIG. 1**). As shown in **FIG. 2**, the forming vessel **143** can further include a forming wedge **205** including a pair of downwardly inclined converging surface portions **207a**, **207b** extending between opposed ends of the forming wedge **205**. In some embodiments, the molten material **121** can flow from the inlet **141** into the trough **204** of the forming vessel **143**. The molten material **121** can then overflow from the trough **204** by simultaneously flowing over corresponding weirs **203a**, **203b** and downward over the outer surfaces of the corresponding weirs **203a**, **203b**. Respective streams of molten material **121** can then flow along the downwardly inclined converging surface portions **207a**, **207b** of the forming wedge **205** to be drawn off the root **145** of the forming vessel **143**, where the flows converge and fuse into the glass ribbon **103**. The glass ribbon **103** may then be drawn off the root **145** along a draw plane **213** in a draw direction **211** with a width “**W**” of the glass ribbon **103** (shown in **FIG. 1**) extending between a first vertical edge **147a** of the glass ribbon **103** and a second vertical edge **147b** of the glass ribbon **103**.

[0043] Turning back to **FIG. 2**, in some embodiments, a thickness “**T**” of the glass ribbon **103** defined between a first major surface **215a** and a second major surface **215b** of the glass ribbon **103** can be, for example, from about 40 micrometers (μm) to about 1 millimeter (mm), for example, from about 40 micrometers to about 0.5 millimeters, for example from about 40 micrometers to about 400 micrometers, for example, from about 40 micrometers to about 300 micrometers, for example, from about 40 micrometers to about 200 micrometers, for example, from about 40 micrometers to about 100 micrometers, or, for example, about 40 micrometers, although other thicknesses may be provided in further embodiments. In addition, the glass ribbon **103** can include a variety of compositions including but not limited to glass, ceramic, glass-ceramic, soda-lime glass, borosilicate glass, alumino-borosilicate glass, an alkali-containing glass, an alkali-free glass, or any combination thereof.

[0044] In addition, as shown in **FIGS. 2-4**, in some embodiments, the glass manufacturing apparatus **101** can include a first enclosure **171** and a second enclosure **172**, where the second enclosure **172** can be positioned within the first enclosure **171**. In some embodiments, a vessel **160** to contain material (e.g., molten material **121**) can be

positioned within the second enclosure 172. The vessel 160 can include a container to contain material and can, in some embodiments, include an open container providing access to a free surface of material contained within the vessel 160. For example, in some embodiments, the vessel 160 can include the forming vessel 143 including the trough 204 and the forming wedge 205 including the pair of downwardly inclined converging surface portions 207a, 207b that converge at the root 145 of the forming wedge 205. In some embodiments, any one or more vessels can be positioned within the second enclosure 172 without departing from the scope of the disclosure. For example, the vessel 160 positioned within the second enclosure 172 can include any one or more features of the glass manufacturing apparatus 101 including, but not limited to, the melting vessel 105, the storage bin 109, the standpipe 123, the fining vessel 127, the first connecting conduit 129, the mixing chamber 131, the delivery vessel 133, the second connecting conduit 135, the third connecting conduit 137, and the delivery pipe 139.

[0045] The first enclosure 171 can include a first outer surface 175 facing an exterior area 202 that is outside of the first enclosure 171. In some embodiments, the exterior area 202 can include an environment or room in which the first enclosure 171 is positioned. The first enclosure 171 can include a first enclosure wall 177 extending between the first outer surface 175 of the first enclosure 171 and a first inner surface 173 of the first enclosure 171. In some embodiments, the second enclosure 172 can include a second outer surface 176 spaced a first distance “d1” from the first inner surface 173 of the first enclosure 171, defining an intermediate space 201 between the first enclosure 171 and the second enclosure 172. The second enclosure 172 can include a second enclosure wall 178 extending between the second outer surface 176 of the second enclosure 172 and a second inner surface 174 of the second enclosure 172. The second inner surface 174 can face an interior area 200 that is inside the second enclosure 172.

[0046] As shown, the vessel 160 can be positioned within (e.g., at least partially within, entirely within) the second enclosure 172 in the interior area 200 and can be spaced a second distance “d2” from the second inner surface 174 of the second enclosure 172. In some embodiments, each of the first enclosure 171 and the second enclosure 172 can one or more walls connected together to form the respective enclosure. It is to be

understood that in some embodiments, an enclosure defined as positioned within another enclosure may include features that extend outside of a boundary of the enclosure, and such embodiments, unless otherwise noted, are intended to be within the scope of disclosure. In addition, in some embodiments, the first enclosure **171** and the second enclosure **172** can include an opening to provide bulk access into or out of the enclosure. For example, in some embodiments, the first enclosure **171** can include a first bottom opening **161** and the second enclosure **172** can include a second bottom opening **162** from which the glass ribbon **103** can extend as the glass ribbon **103** is provided from the vessel **160** positioned within the second enclosure **172**.

[0047] In some embodiments, the first enclosure **171** can include a refractory material (e.g., refractory brick) that can provide an insulated barrier between the exterior area **202** and an interior of the first enclosure **171**. The first enclosure **171** can therefore prevent dust, debris, and other contaminants that may be present in the exterior area **202** from coming into contact with the second enclosure **172** and the vessel **160** including any material that may be contained within the vessel **160**. In addition, the intermediate space **201** and the interior area **200** provided by the first enclosure **171** and the second enclosure **172** can provide a controlled atmosphere in which at least one of a temperature and a pressure can be regulated, changed, and maintained. The first enclosure **171** can be positioned within the exterior area **202** with one or more brackets that attach to the first enclosure **171** and connect the first enclosure **171** to a frame, wall, or other support structure (not shown).

[0048] In some embodiments, the second enclosure **172** can be manufactured from a material that includes properties that distribute heat evenly relative to the vessel **160**. For example, in some embodiments, the second enclosure **172** can include silicon carbide to distribute and maintain an even temperature profile above the vessel **160**. By controlling and reducing temperature fluctuations and temperature gradients in the interior area **200** of the second enclosure **172**, a temperature of the material contained in the vessel **160** can be likewise controlled. For example, in some embodiments, the second enclosure **172** can provide a uniformly heated region around the vessel **160** to provide the molten material **121** within the vessel **160** with a uniform temperature. The

uniform, controlled temperature of the molten material **121** can, in some embodiments, provide a better quality glass ribbon **103** relative to glass ribbons formed with molten material **121** that includes temperature gradients when contained in the vessel **160**. The second enclosure **172** can be positioned within the first enclosure **171** with one or more brackets that attach to the second enclosure **172** and connect the second enclosure **172** to the first enclosure **171**, a frame, wall, or other support structure (not shown).

[0049] The first distance “**d1**” between the first enclosure **171** and the second enclosure **172** can provide the first enclosure **171** and the second enclosure **172** in spaced relationship relative to each other. The spaced relationship between the first enclosure **171** and the second enclosure **172** can permit thermal expansion and contraction of at least one of the first enclosure **171** and the second enclosure **172** such that the first enclosure **171** and the second enclosure **172** do not interfere and contact when the at least one of the first enclosure **171** and the second enclosure **172** may, for example, expand and contract based at least in part on thermal expansion when subjected to heat and corresponding temperature changes. Likewise, the second distance “**d2**” between the second enclosure **172** and the vessel **160** can provide the second enclosure **172** and the vessel **160** in spaced relationship relative to each other. The spaced relationship between the second enclosure **172** and the vessel **160** can permit thermal expansion and contraction of at least one of the second enclosure **172** and the vessel **160** independent of the other such that the second enclosure **172** and the vessel **160** do not contact when the at least one of the second enclosure **172** and vessel **160** may, for example, expand and contract based at least in part on thermal expansion when subjected to heat and corresponding temperature changes. In addition to compensating for thermal mismatch between the first enclosure **171**, the second enclosure **172**, and the vessel **160**, the spaced relationship between the first enclosure **171** and the second enclosure **172**, and between the second enclosure **172** and the vessel **160** can prevent mechanical loading of one component from another component. For example, in some embodiments, at least one of the first enclosure **171** and the second enclosure **172** can include a brittle material that, when subjected to external loading, may crack, fracture, and be unable to support the external load. In some embodiments, a brittle material can be defined at least in part as a

material that, when subjected to stress, may fail (e.g., fracture, break) without deformation (e.g., strain). In some embodiments, a brittle material can be defined as having relatively little or no ductility and as absorbing relatively little or no energy prior to failure.

[0050] In some embodiments, a first aperture **191** can extend through the first enclosure **171**, and a second aperture **192** can extend through the second enclosure **172**. For example, the first aperture **191** can extend from the first outer surface **175** of the first enclosure **171**, through the first enclosure wall **177**, to the first inner surface **173** of the first enclosure **171**. Likewise, the second aperture **192** can extend from the second outer surface **176** of the second enclosure **172**, through the second enclosure wall **178**, to the second inner surface **174** of the second enclosure **172**. In some embodiments, the second aperture **192** can be spaced a distance (e.g., first distance “**d1**”) from the first inner surface **173** of the first enclosure **171**. In some embodiments, the first aperture **191** and the second aperture **192** can define an insertion path **180** from outside the first enclosure **171** (e.g., from the exterior area **202**) to inside the second enclosure **172** (e.g., to the interior area **200**). In some embodiments, the insertion path **180** can include a linear axis extending from the first aperture **191** to the second aperture **192**. In some embodiments, the insertion path **180** can include a non-linear, curved path, and any other path extending from the exterior area **202** to the interior area **200** between the first aperture **191** and the second aperture **192**.

[0051] In some embodiments, the insertion path **180** can be provided for insertion of a device **350**. For example, as shown in **FIG. 3**, in some embodiments, a thermocouple **350** can be inserted along the insertion path **180** from the exterior area **202** to the interior area **200**. In some embodiments, any one or more of a sensor, camera, measurement tool, probe, detector, and any other device can be provided for insertion along the insertion path **180** from the exterior area **202** to the interior area **200**. In some embodiments, access to the vessel **160** (e.g., access to the trough **204** of the forming vessel **143**) may be restricted or difficult based at least in part on the presence of any one or more of the first enclosure **171** and the second enclosure **172** within which the vessel **160** can be positioned. Thus, advantageously, the insertion path **180** can allow access

from the exterior area **202** through the first enclosure **171** to the intermediate space **201** and through the second enclosure **172** to the interior area **200** including the vessel **160** positioned within the second enclosure **172**.

[0052] In some embodiments, contents (e.g., fluid, liquid, gas, vapor, particulates, debris, heat, condensate, etc.) within the exterior area **202** outside of the first enclosure **171** can pass from the exterior area **202** through the first aperture **191** in the first enclosure **171** to the intermediate space **201**. In some embodiments, contents can pass from the intermediate space **201** through the second aperture **192** in the second enclosure **172** to the interior area **200**. Likewise, in some embodiments, contents within the interior area **200** inside the second enclosure **172** can pass from the interior area **200** through the second aperture **192** in the second enclosure **172** to the intermediate space **201**. In some embodiments, contents can pass from the intermediate space **201** through the first aperture **191** in the first enclosure **171** to the exterior area **202**. In some embodiments, it may be desirable to prevent contents from passing from the exterior area **202** to the intermediate space **201** through the first aperture **191** and from the intermediate space **201** to the interior area **200** through the second aperture **192**. For example, in some embodiments, it may be desirable to prevent contamination of the intermediate space **201** and the interior area **200** including the material in the vessel **160** with contents from the exterior area **202**. Likewise, in some embodiments, it may be desirable to prevent contents from passing from the interior area **200** to the intermediate space **201** through the second aperture **192** and from the intermediate space **201** to the exterior area **202** through the first aperture **191**. For example, in some embodiments, it may be desirable to prevent contamination of the intermediate space **201** and the exterior area **202** with contents from the interior area **200**.

[0053] For example, in some embodiments, vapors (e.g., boron vapors) can be produced in the interior area **200** during the glass manufacturing process **100** when molten material **121** is contained in the vessel **160**. The vapors can pass from the interior area **200** through the second aperture **192** in the second enclosure **172** to the intermediate space **201**, where the vapors can, in some embodiments, condense on the first inner surface **173** of the first enclosure **171**. The condensing vapors can form a condensate that

can attack and corrode the structural integrity and material characteristics of the first inner surface **173** of the first enclosure **171** as well as, in some embodiments, the second outer surface **176** of the second enclosure **172**. In some embodiments, the first inner surface **173** of the first enclosure **171** can include a refractory brick that can be porous and brittle and therefore susceptible to structural degradation from condensation of the vapors on the first inner surface **173** of the first enclosure **171**. In some embodiments, the structural degradation of the first inner surface **173** of the first enclosure **171** can cause any one or more of the first inner surface **173**, the first enclosure wall **177**, and the first outer surface **175** of the first enclosure **171** to deform, fracture, crumble, and break. Likewise, in some embodiments, the structural degradation of the second outer surface **176** of the second enclosure **172** can cause any one or more of the second outer surface **176**, the second enclosure wall **178**, and the second inner surface **174** of the second enclosure **172** to deform and fracture. In some embodiments, deformation, fracture, crumbling, and breaking of the any one or more of the first inner surface **173**, the first enclosure wall **177**, and the first outer surface **175** of the first enclosure **171** can impact the structural integrity of the second enclosure **172**. For example, in some embodiments, pieces of the first enclosure **171** may fall onto the second enclosure **172** causing any one or more of the second outer surface **176**, the second enclosure wall **178**, and the second inner surface **174** of the second enclosure **172** to deform and fracture.

[0054] In some embodiments, structural degradation of the first enclosure **171** can cause the first enclosure **171** to fail to provide, among other features, the insulation characteristics for which the first enclosure **171** may be provided. In addition, in some embodiments, structural degradation of the first enclosure **171** can cause pieces of the first enclosure **171** to separate from the first enclosure **171** and pass from the intermediate space **201** through the second aperture **192** in the second enclosure **172** into the interior area **200** of the second enclosure **172**, contaminating, for example, the material contained in the vessel **160**. Contamination of the material contained in the vessel **160** can, in some embodiments, reduce the quality of glass produced from the molten material **121**. Therefore, in some embodiments, the passage of contents from the interior area **200** in the second enclosure **172** through the second aperture **192** in the second enclosure **172** to the

intermediate space **201** can cause problems in the glass manufacturing process **100** of the glass manufacturing apparatus **101**. Such problems can include repairs and replacement of components resulting in shut-down of the glass manufacturing apparatus **101** and delay of the glass manufacturing process **100**.

[0055] Methods and apparatus of blocking the second aperture **192** will now be described. Advantageously, in some embodiments, blocking the second aperture **192** can block contents from passing through the second aperture **192** in the second enclosure **172** between at least one of the interior area **200** in the second enclosure **172** and the intermediate space **201** outside the second enclosure **172** and between the intermediate space **201** outside the second enclosure **172** and the interior area **200** in second enclosure **172**. In some embodiments, blocking the second aperture **192** can, for example, block vapors produced in the interior area **200** during the glass manufacturing process **100** when molten material **121** is contained in the vessel **160** from passing from the interior area **200** through the second aperture **192** in the second enclosure **172** to the intermediate space **201**. Accordingly, blocking the second aperture **192** can prevent the vapors from contacting the first inner surface **173** of the first enclosure **171** thus preventing the corresponding production of condensate on the first inner surface **173** of the first enclosure **171**. Accordingly, blocking the second aperture **192** can reduce and prevent attack and corrosion of the first inner surface **173** of the first enclosure **171** that may otherwise occur when the vapors condense and form condensate on the first inner surface **173** of the first enclosure **171**. In addition, blocking the second aperture **192** can prevent contents from passing from the intermediate space **201** through the second aperture **192** into the interior area **200** and contaminating, for example, material contained within the vessel **160**.

[0056] As shown in **FIGS. 3** and **4**, in some embodiments, the glass manufacturing apparatus **101** can include a blocking-object **300**. In some embodiments, the blocking-object **300** can include a shaft **301** and a protrusion **302** extending from the shaft **301**. The blocking-object **300** can be provided to selectively block the second aperture **192**. For example, in some embodiments, the protrusion **302** of the blocking-object **300** can be oriented to selectively block the second aperture **192**. In some

embodiments, the blocking-object **300** can be rotatable about a longitudinal axis **380** of the shaft **301**. In some embodiments, the protrusion **302** of the blocking-object **300** can be positioned between the first enclosure **171** and the second enclosure **172** (e.g., within the intermediate space **201**). In some embodiments, the protrusion **302** of the blocking-object **300** can be oriented to selectively abut the second outer surface **176** of the second enclosure **172** along a path circumscribing the second aperture **192**. By abutting the second outer surface **176** of the second enclosure **172** along a path circumscribing the second aperture **192**, the protrusion **302** of the blocking-object **300** can provide a seal around the second aperture **192** to block the second aperture **192**.

[0057] In some embodiments, the blocking-object **300** can be inserted into the second aperture **192** to block the second aperture **192**. In some embodiments, blocking the second aperture **192** by inserting the blocking-object **300** into the second aperture **192** can provide an air-tight seal in the second aperture **192**. In some embodiments, the blocking-object **300** can be positioned to block the second aperture **192** by at least one of obstructing a first opening of the second aperture **192** (e.g., abutting the second outer surface **176** of the second enclosure **172**) to block the second aperture **192** and by abutting a second opening of the second aperture **192** (e.g., abutting the second inner surface **174** of the second enclosure **172**) to block the second aperture **192**. In some embodiments, blocking the second aperture **192** by obstructing the second aperture **192** with the blocking-object **300** can provide an air-tight seal around the second aperture **192**. In addition, in some embodiments, blocking the second aperture **192** by obstructing the second aperture **192** with the blocking-object **300** (e.g., as opposed to inserting the blocking-object **300** into the second aperture **192**) can provide an air-tight seal around the second aperture **192** that is relatively unaffected by structural changes caused by thermal mismatch (e.g., expansion, contraction) of at least one of the blocking-object **300** and the second enclosure **172**. In addition, in some embodiments, the blocking-object **300** and the second enclosure **172** can be manufactured from a same or similar material (e.g., silicon carbide) to reduce the effects of thermal mismatch (e.g., expansion, contraction) of at least one of the blocking-object **300** and the second enclosure **172** when the blocking-object **300** and the second enclosure **172** are subjected to temperature changes.

[0058] In some embodiments, obstructing the second aperture **192** with the blocking-object **300** by positioning the protrusion **302** of the blocking-object **300** to abut the second outer surface **176** of the second enclosure **172** (e.g., as opposed to inserting the blocking-object **300** into the second aperture **192** or as opposed to abutting the second inner surface **174** of the second enclosure **172** with the blocking-object **300**) can reduce, and in some embodiments prevent, the blocking-object **300** (e.g., pieces of the blocking-object **300**) from falling into the interior area **200** within the second enclosure **172**, if the blocking-object **300** including any pieces of the blocking-object **300** were to break, chip, and separate. In some embodiments, it may therefore be desirable to avoid risk of contaminating the interior area **200** within the second enclosure **172** (e.g., the molten material **121** contained in the vessel **160**) by positioning the protrusion **302** of the blocking-object **300** to abut the second outer surface **176** of the second enclosure **172** to obstruct the second aperture **192**.

[0059] Accordingly, unless otherwise noted, embodiments in which the blocking-object **300** is positioned to block (e.g., partially block, entirely block) the second aperture **192**, irrespective of whether the blocking-object **300** is inserted into (e.g., inserted partially into, inserted entirely into) the second aperture **192**, or positioned to obstruct (e.g., partially obstruct, entirely obstruct) the second aperture **192** are considered to be within the scope of the disclosure.

[0060] In some embodiments, a method of blocking an aperture in a glass manufacturing apparatus **101** can include inserting a device **350** through the first aperture **191** in the first enclosure **171** and through the second aperture **192** in the second enclosure **172** along the insertion path **180** from the exterior area **202** outside the first enclosure **171** to the interior area **200** inside the second enclosure **172**. For the purposes of explanation and not limitation, the following description will be presented in the context that the device **350** is a thermocouple to measure a temperature. However, it is to be understood that, in some embodiments, the device **350** may be any other device, including but not limited to, any one or more of a sensor, camera, measurement tool, probe, detector, etc. to measure an attribute (e.g., characteristic, quality, value, image, video, composition, etc.).

[0061] Accordingly, in some embodiments, the method can include measuring a temperature of the vessel 160 to contain molten material 121 with the thermocouple 350. In some embodiments, measuring a temperature can be performed without molten material 121 contained in the vessel 160. For example, in some embodiments, it may be desirable to measure a temperature of the vessel 160 during a preheating operation of the glass manufacturing apparatus 101 before molten material 121 is contained in the vessel 160. In some embodiments, a temperature of the interior area 200 inside the second enclosure 172 can correspond to a temperature of the vessel 160. In some embodiments, the thermocouple 350 can measure the temperature at least one of instantaneously, periodically, and continuously to, for example, monitor the temperature as the vessel 160 is heating-up from a cooler temperature to a hotter temperature. In some embodiments, the thermocouple 350 can measure a temperature of the trough 204 of the forming vessel 143, the temperature of which can be compared to a temperature of the root 145 of the forming vessel 143 to determine a temperature difference between the trough 204 and the root 145 of the forming vessel 143. In some embodiments, the temperature difference between the trough 204 and the root 145 of the forming vessel 143 can be monitored, for example during the preheating operation, to determine when any one or more of the vessel 160, the first enclosure 171, the second enclosure 172, and any other component of the glass manufacturing apparatus 101 achieves a predetermined temperature.

[0062] In some embodiments, when it is determined that any one or more of the vessel 160, the first enclosure 171, the second enclosure 172, and any other component of the glass manufacturing apparatus 101 has attained a predetermined temperature, for example, during the preheating operation of the glass manufacturing apparatus 101, the thermocouple 350 can then be removed from the second enclosure 172. The method can also include removing the thermocouple 350 from the second aperture 192, and then blocking the second aperture 192 with the blocking-object 300 after the thermocouple 350 has been removed from the second aperture 192. In some embodiments, the method can include containing molten material 121 in the vessel 160 after measuring the temperature of the vessel 160. In some embodiments, blocking the second aperture 192 can be performed without molten material 121 contained in the vessel 160. In some

embodiments, the method can include removing the thermocouple **350** from the first aperture **191** and the second aperture **192**, and then blocking the first aperture **191** with a plug **321** (as shown in **FIG. 4**). In some embodiments, the plug **321** can be positioned to block the first aperture **191** to block contents from passing through the first aperture **191** from the exterior area **202** outside the first enclosure **171** into the intermediate space **201**. For example, in some embodiments, the first aperture **191** can be blocked during the glass manufacturing process **100** when the glass manufacturing apparatus **101** may be operating to manufacture the glass ribbon **103** to block contents from passing through the first aperture **191**.

[0063] In some embodiments, blocking the second aperture **192** can include moving the blocking-object **300** to block the second aperture **192**. For example, in some embodiments, moving the blocking-object **300** can include moving the blocking-object **300** from an unblocking position **340** (e.g., as illustrated in **FIG. 3**) where the blocking-object **300** does not block the second aperture **192** to a blocking position **345** (e.g., as illustrated in **FIG. 4**) where the blocking-object **300** blocks the second aperture **192**. In some embodiments, the blocking-object **300** can be selectively moved between the unblocking position **340** and the blocking position **345** any number of times to selectively block and unblock the second aperture **192**. In some embodiments, moving the blocking-object **300** can include any one or more of a translation, rotation, and reflection of the blocking-object **300**, including but not limited to sliding, pushing, pulling, lifting, flipping, rotating, turning, and any other movement of the blocking-object **300**.

[0064] In some embodiments, the glass manufacturing apparatus **101** can include a third aperture **193** spaced from the first aperture **191** and extending through the first enclosure **171**. For example, the third aperture **193** can extend from the first outer surface **175** of the first enclosure **171**, through the first enclosure wall **177**, to the first inner surface **173** of the first enclosure **171**. It is to be understood that any one or more of the first aperture **191**, the second aperture **192**, and the third aperture **193** can include a cross-sectional profile having any shape, including but not limited to, circular, oval, square, rectangular, triangular, and any other geometric, prismatic, or polygonal shape. In some embodiments, a cross-section of any one or more of the first aperture **191**, the

second aperture **192**, and the third aperture **193** can include a constant dimension cross-sectional profile or a variable cross-sectional profile. In some embodiments, any one or more of the first aperture **191**, the second aperture **192**, and the third aperture **193** can extend perpendicular to at least one of the first outer surface **175**, the first inner surface **173**, the second outer surface **176**, and the second inner surface **174**. In some embodiments, any one or more of the first aperture **191**, the second aperture **192**, and the third aperture **193** can extend at any angle relative to at least one of the first outer surface **175**, the first inner surface **173**, the second outer surface **176**, and the second inner surface **174**. In some embodiments, any one or more of the first aperture **191**, the second aperture **192**, and the third aperture **193** can include a same, similar, or different shape, size, orientation, cross-sectional profile, etc. as any of another of the first aperture **191**, the second aperture **192**, and the third aperture **193**.

[0065] In some embodiments, the shaft **301** of the blocking-object **300** can be positioned within the third aperture **193**. For example, the shaft **301** can extend from the intermediate space **201** to the first inner surface **173** of the first enclosure **171** and into the third aperture **193**. In some embodiments, the shaft **301** can extend from the intermediate space **201** through the third aperture **193**, past the first outer surface **175** of the first enclosure **171** and into the exterior area **202**. Accordingly, the third aperture **193** can provide access for an operator (e.g., human operator, mechanical or mechanized operator, computer controlled operator, etc.) to move the blocking-object **300** to block the second aperture **192** from outside the first enclosure **171**. Advantageously, the operator can be located in the exterior area **202** outside the first enclosure **171**, for example, and can therefore block the second aperture **192** with the blocking-object **300** without interfering with and without disrupting the glass manufacturing process **100** occurring within at least one of the first enclosure **171** and the second enclosure **172**. Similarly, in some embodiments, the thermocouple **350** can likewise be selectively inserted along the insertion path **180** without interfering with and without disrupting the glass manufacturing process **100** occurring within at least one of the first enclosure **171** and the second enclosure **172**. Accordingly, embodiments of the present disclosure include features that provide advantageous benefits including selectively blocking the second

aperture **192** with a blocking-object **300** while the glass manufacturing apparatus **101** and the glass manufacturing process **100** are fully operational, without having to disassemble the first enclosure **171** and the second enclosure **172** and without interfering with and without disrupting the glass manufacturing process **100** occurring within at least one of the first enclosure **171** and the second enclosure **172**.

[0066] In some embodiments, blocking the second aperture **192** can include moving the blocking-object **300** within the third aperture **193** in the first enclosure **171**. For example, in some embodiments, an operator can move a first end **311** of the shaft **301** causing a second end **312** of the shaft **301** including the protrusion **302** to likewise move. In some embodiments, moving the blocking-object **300** can include rotating the blocking-object **300** within the third aperture **193**. Accordingly, in some embodiments, blocking the second aperture **192** can include rotating the blocking-object **300**. For example, as represented by arrow **341** in **FIG. 3**, the blocking-object **300** can be rotated from the unblocking position **340** to the blocking position **345** (**FIG. 4**) to block the second aperture **192**. Likewise, as represented by arrow **346** in **FIG. 4**, the blocking-object **300** can be rotated from the blocking position **345** to the unblocking position **340** (**FIG. 3**) to unblock the second aperture **192**.

[0067] For example, in some embodiments, an operator can rotate a first end **311** of the shaft **301** of the blocking-object **300** causing a second end **312** of the shaft **301** including the protrusion **302** to likewise rotate. Movement of the first end **311** of the shaft **301** can therefore result in a corresponding movement of the second end **312** of the shaft **301**, including the protrusion **302**, such that the protrusion **302** can be selectively positioned to block (or unblock) the second aperture **192**. Advantageously, the blocking-object **300** can therefore be selectively positioned to block (or unblock) the second aperture **192** when direct access from the exterior area **202** is not feasible. For example, in some embodiments, the presence of the first enclosure **191** and the second enclosure **192** can prevent direct access from the exterior area **202** to the interior area **200**. In addition, in some embodiments, the blocking-object **300** can be selectively positioned to block the second aperture **192**, thus blocking contents from passing from the interior area **200** to the intermediate space **201** and from the intermediate space **201** to the interior area

200. Likewise, in some embodiments, the blocking-object **300** can be selectively positioned to unblock the second aperture **192** when access from the exterior area **202** to the interior area **200** is desired to, for example, permit insertion of the thermocouple **350** into the interior area **200** through the first aperture **191** in the first enclosure **171** and through second aperture **192** in the second enclosure **172** along the insertion path **180**.

[0068] In some embodiments, the glass manufacturing apparatus **101** can include a cover **320** positioned outside the first enclosure **171**. The cover **320** can be oriented to block the third aperture **193**. Similar to blocking the first aperture **191** and the second aperture **192**, blocking the third aperture **193** can likewise block contents from passing through the third aperture **193**, for example, from the exterior area **202** to the intermediate space **201** and from the intermediate space **201** to the exterior area **202**. In some embodiments, the glass manufacturing apparatus **101** can include a spring **325** oriented to bias the cover **320** in a direction toward the first enclosure **171**. In some embodiments, the cover **320** can abut the first outer surface **175** of the first enclosure **171** along a path circumscribing the third aperture **193** to block the third aperture **193**. Accordingly, in some embodiments, the spring **325** can apply a biasing force on the cover **320** to maintain the abutting relationship between the cover **320** and the first outer surface **175** of the first enclosure **171** along the path circumscribing the third aperture **193** to block the third aperture **193**.

[0069] In some embodiments, the spring **325** can be positioned between the cover **320** and a bracket **326**, where the bracket **326** can be positioned to abut a surface **330**. In some embodiments, the surface **330** can include a wall, ceiling, grating, frame, support structure, and any other structure against which the bracket **326** can abut to provide a biasing force (e.g., spring force) in the spring **325** that biases the cover **320** in a direction toward the first outer surface **175** of the first enclosure **171**. In some embodiments, the method can include biasing the cover **320** against the first enclosure **171** to seal the third aperture **193** with the cover **320**. In some embodiments, a piece of paper **313** (e.g., refractory paper) can be positioned between the cover **320** and the first outer surface **175** to provide a seal around the third aperture **193** and to reduce the coefficient of friction between the contacting surfaces of the cover **320** and the first outer surface **175** of the

first enclosure 171. For example, the piece of paper 313 can provide less resistance between the cover 320 and the first outer surface 175 of the first enclosure 171 in some embodiments where the cover 320 may be moved relative to the first outer surface 175 while in contact with the first outer surface 175.

[0070] In some embodiments, the method can include blocking the third aperture 193 with the cover 320 positioned outside the first enclosure 171. In some embodiments, the cover 320 can be removed from blocking the third aperture 193 to provide access to the shaft 301 of the blocking-object 300 such that the blocking-object 300 can be moved to block (or unblock) the second aperture 192. After the blocking-object 300 has been moved to block (or unblock) the second aperture 192, the cover 320 can then be replaced to block the third aperture 193. Conversely, in some embodiments, the cover 320 can remain in place, blocking the third aperture 193. For example, in some embodiments, the blocking-object 300 can be moved within the third aperture 193 by moving the cover 320. In some embodiments, the blocking-object 300 can be rotated by rotating the cover 320 positioned outside the first enclosure 171. For example, in some embodiments, the blocking-object 300 can be rotatable about a longitudinal axis 380 of the shaft 301 based at least in part on a corresponding rotation of the cover 320. In some embodiments the longitudinal axis 380 of the shaft 301 can be parallel to the insertion path 180. In some embodiments, the longitudinal axis 380 of the shaft 301 can extend at an angle relative to the insertion path 180.

[0071] In some embodiments, the cover 320 can engage the shaft 301 of the blocking-object 300. For example, in some embodiments, the cover 320 can include a recess 315 that can mate with the first end 311 of the shaft 301 of the blocking-object 300. In some embodiments, the recess 315 can include a keyed-slot in which the first end 311 of the shaft 301 of the blocking-object 300 can be positioned. In some embodiments, movement of the cover 320 can produce a corresponding movement of the blocking-object 300. Accordingly, in some embodiments, the blocking-object 300 can be positioned to block the second aperture 192 without removing the cover 320 from blocking the third aperture 193. Accordingly, the blocking-object 300 can be selectively moved between the unblocking position 340 and the blocking position 345 any number of

times without removing the cover **320** from blocking the third aperture **193**. Although not shown, in some embodiments, a spring or other biasing device may be provided in the recess **315** to bias the blocking-object **300** away from the cover **320**, thereby biasing the protrusion **302** against the second outer surface **176** of the second enclosure **172** to enhance the sealed closure of the second aperture **192** in the blocking position **345**.

[0072] In addition, in some embodiments, an indicator can be provided to indicate the position of the blocking-object **300** such that an operator may view the indicator to determine whether the blocking-object **300** is positioned in the unblocking position **340** or the blocking position **345**. For example, in some embodiments, an indicator can be provided on the cover **320**, and the indicator can correspond to a position (e.g., rotated position) of the cover **320** that likewise corresponds to a position of the blocking-object **300**. In some embodiments, a limiting structure (e.g., mechanical stop) can be provided to limit movement (e.g., rotation) of the cover **320** between the unblocking position **340** and the blocking position **345**. For example, full travel of the cover **320** toward the limiting structure in one direction can correspond to the unblocking position **340**, and full travel of the cover **320** in another direction away from the limiting structure can correspond to the blocking position **345**. In some embodiments, the indicator can include any one or more of a graphical mark, a notch, an electronic image, and any other indication to communicate a position of the blocking-object **300** to an operator.

[0073] It will be appreciated that the various disclosed embodiments may involve particular features, elements or steps that are described in connection with that particular embodiment. It will also be appreciated that a particular feature, element or step, although described in relation to one particular embodiment, may be interchanged or combined with alternate embodiments in various non-illustrated combinations or permutations.

[0074] It is to be understood that, as used herein the terms "the," "a," or "an," mean "at least one," and should not be limited to "only one" unless explicitly indicated to the contrary. Thus, for example, reference to "a component" includes embodiments having two or more such components unless the context clearly indicates otherwise.

[0075] Ranges can be expressed herein as from "about" one particular value, and/or to "about" another particular value. When such a range is expressed, embodiments include from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about," it will be understood that the particular value forms another aspect. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint.

[0076] Unless otherwise expressly stated, it is in no way intended that any method set forth herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not actually recite an order to be followed by its steps or it is not otherwise specifically stated in the claims or descriptions that the steps are to be limited to a specific order, it is no way intended that any particular order be inferred.

[0077] While various features, elements or steps of particular embodiments may be disclosed using the transitional phrase "comprising," it is to be understood that alternative embodiments, including those that may be described using the transitional phrases "consisting" or "consisting essentially of," are implied. Thus, for example, implied alternative embodiments to an apparatus that comprises A+B+C include embodiments where an apparatus consists of A+B+C and embodiments where an apparatus consists essentially of A+B+C.

[0078] It will be apparent to those skilled in the art that various modifications and variations can be made to the present disclosure without departing from the spirit and scope of the disclosure. Thus, it is intended that the present disclosure include the modifications and variations of this disclosure provided they come within the scope of the appended claims and their equivalents.

CLAIMS

What is claimed is:

1. A glass manufacturing apparatus comprising:
 - a first enclosure;
 - a second enclosure positioned within the first enclosure;
 - a vessel to contain molten material, wherein the vessel is positioned within the second enclosure;
 - a first aperture extending through the first enclosure;
 - a second aperture extending through the second enclosure, wherein the first aperture and the second aperture define an insertion path from outside the first enclosure to inside the second enclosure;
 - a third aperture spaced from the first aperture and extending through the first enclosure; and
 - a blocking-object comprising a shaft and a protrusion extending from the shaft, wherein the shaft is positioned within the third aperture and the protrusion is oriented to selectively block the second aperture.
2. The glass manufacturing apparatus of claim 1, wherein the vessel comprises a trough and a forming wedge comprising a pair of downwardly inclined surfaces that converge at a root of the vessel.
3. The glass manufacturing apparatus of claim 1, wherein the blocking-object is rotatable about a longitudinal axis of the shaft.
4. The glass manufacturing apparatus of claim 1, wherein the protrusion of the blocking-object is positioned between the first enclosure and the second enclosure.

5. The glass manufacturing apparatus of claim 1, wherein the protrusion of the blocking-object is oriented to selectively abut an outer surface of the second enclosure along a path circumscribing the second aperture.
6. The glass manufacturing apparatus of claim 1, wherein the second aperture is spaced a distance from an inner surface of the first enclosure.
7. The glass manufacturing apparatus of claim 1, wherein the insertion path comprises a linear axis extending from the first aperture to the second aperture.
8. The glass manufacturing apparatus of claim 1, further comprising a cover positioned outside the first enclosure, wherein the cover is oriented to block the third aperture.
9. The glass manufacturing apparatus of claim 8, further comprising a spring oriented to bias the cover in a direction toward the first enclosure.
10. The glass manufacturing apparatus of claim 8, wherein the cover engages the shaft of the blocking-object.
11. The glass manufacturing apparatus of claim 10, wherein the blocking-object is rotatable about a longitudinal axis of the shaft based at least in part on a corresponding rotation of the cover.
12. A method of blocking an aperture in a glass manufacturing apparatus comprising:
 - inserting a device through a first aperture in a first enclosure and a second aperture in a second enclosure along an insertion path from outside the first enclosure to inside the second enclosure, wherein the second enclosure is positioned within the first enclosure,
 - measuring an attribute of a vessel to contain molten material with the device, the vessel is positioned within the second enclosure,

removing the device from the second aperture; and
blocking the second aperture with a blocking-object.

13. The method of claim 12, wherein the device is a thermocouple.
14. The method of claim 13, wherein the attribute is a temperature.
15. The method of claim 12, wherein measuring an attribute is performed without molten material contained in the vessel.
16. The method of claim 15, further comprising containing molten material in the vessel after measuring the attribute of the vessel.
17. The method of claim 12, wherein blocking the second aperture is performed without molten material contained in the vessel.
18. The method of claim 12, further comprising removing the device from the first aperture and the second aperture, and then blocking the first aperture.
19. The method of claim 12, wherein blocking the second aperture comprises rotating the blocking-object.
20. The method of claim 19, wherein the blocking-object is rotated by rotating a cover positioned outside the first enclosure.
21. The method of claim 12, wherein blocking the second aperture comprises moving the blocking-object within a third aperture in the first enclosure.
22. The method of claim 21, wherein moving the blocking-object comprises rotating the blocking-object within the third aperture.

23. The method of claim 21, comprising blocking the third aperture with a cover positioned outside the first enclosure.

24. The method of claim 23, wherein the blocking-object is moved within the third aperture by moving the cover.

25. The method of claim 23, further comprising biasing the cover against the first enclosure to seal the third aperture with the cover.

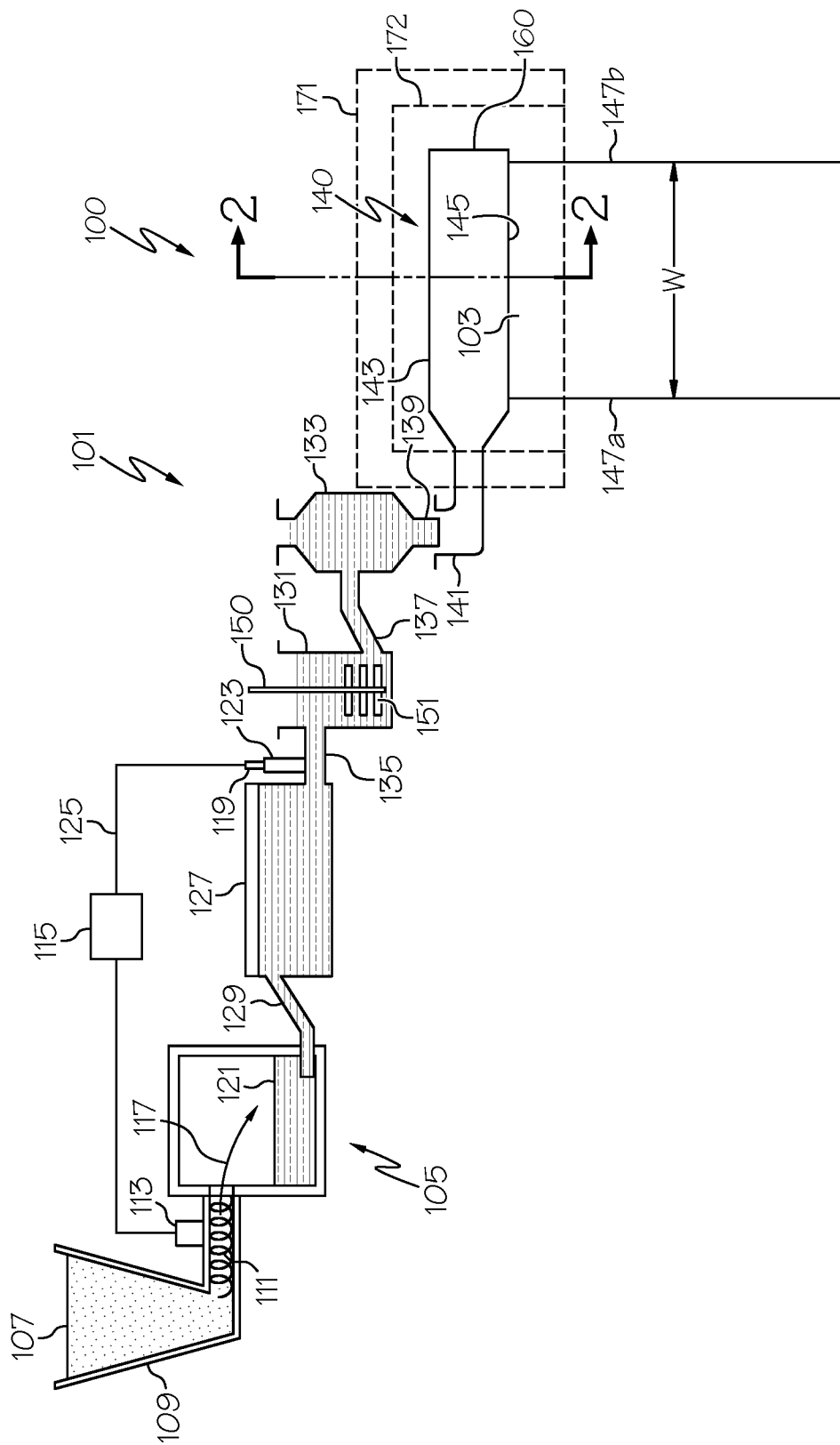


FIG. 1

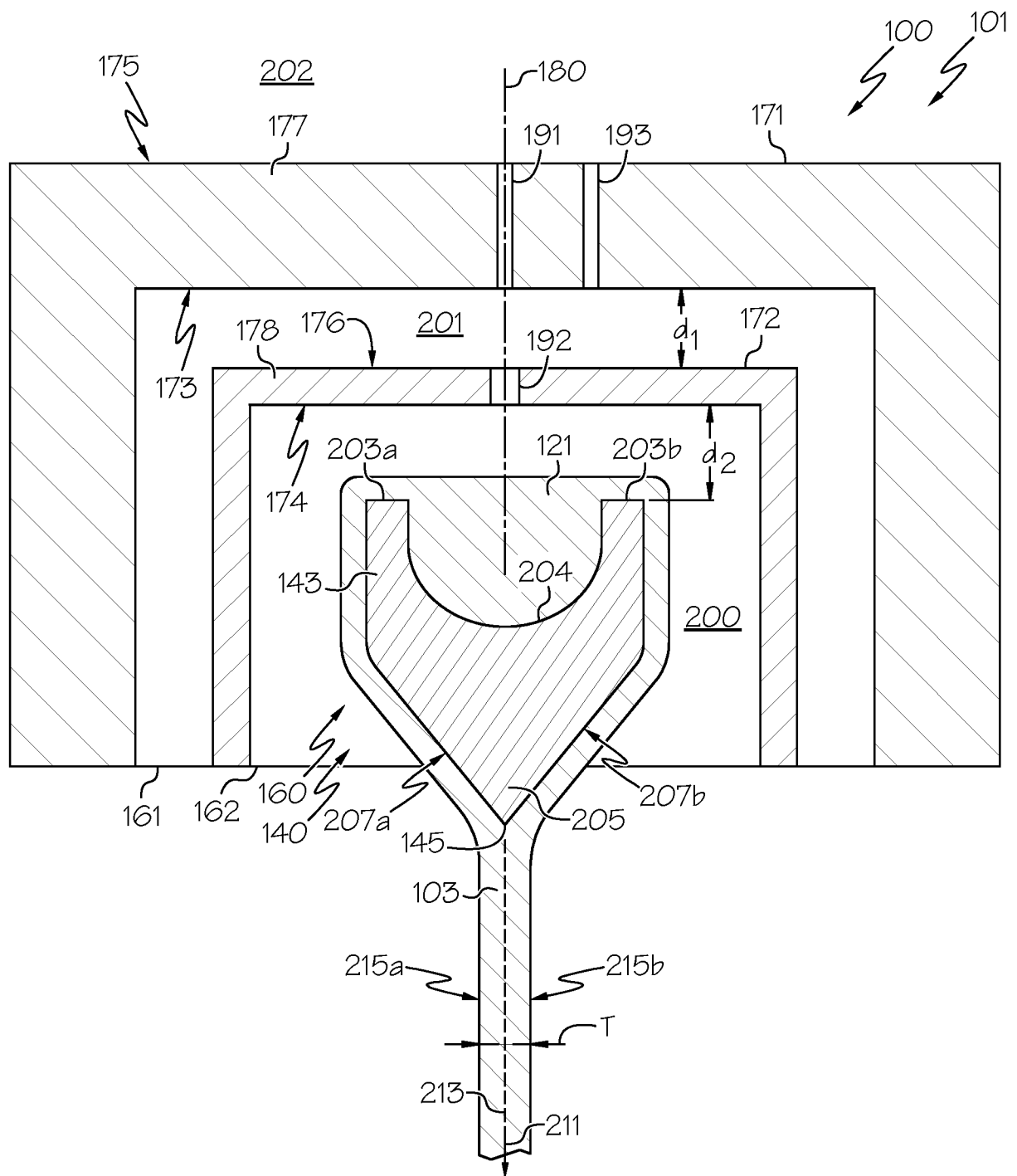
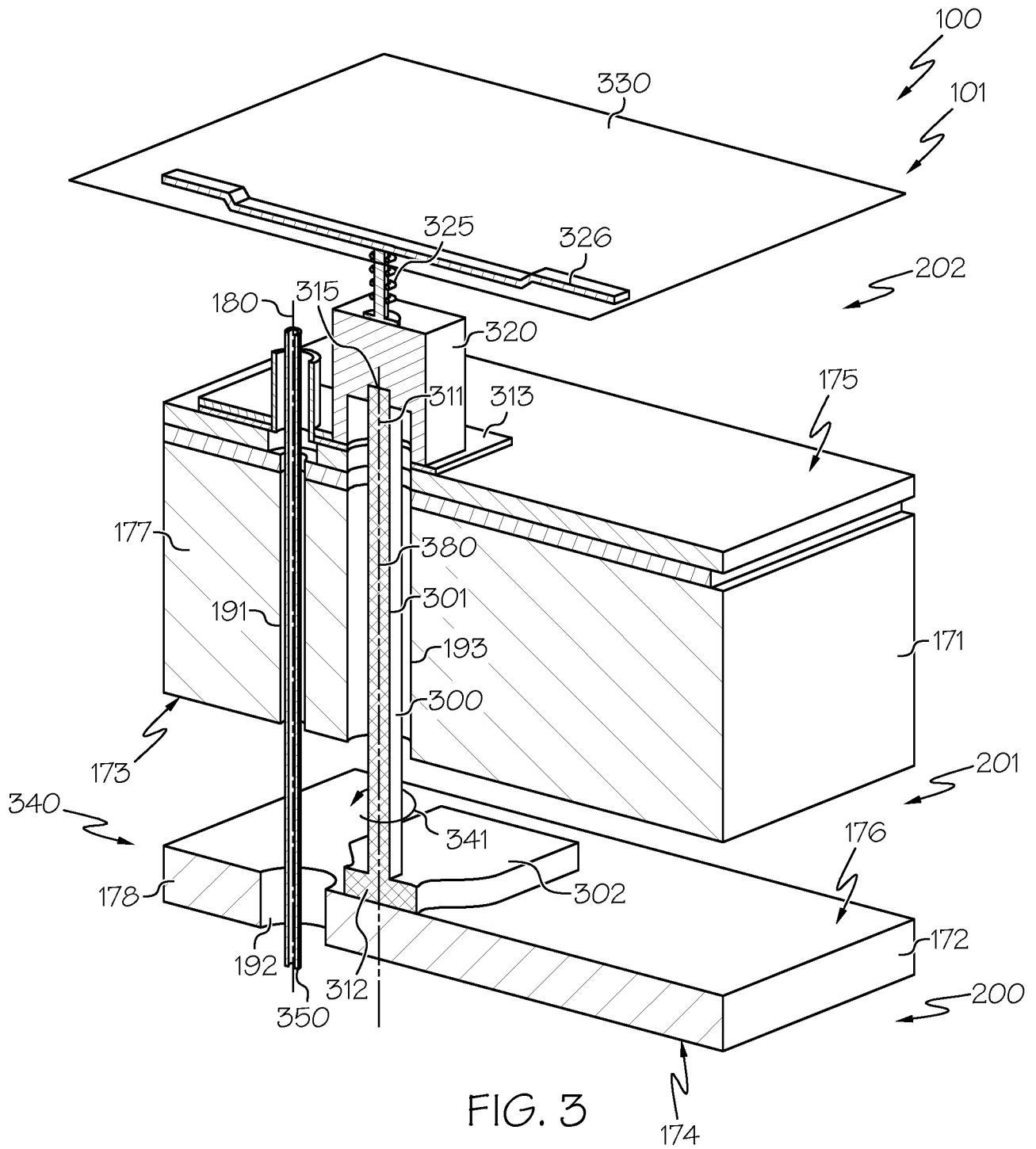
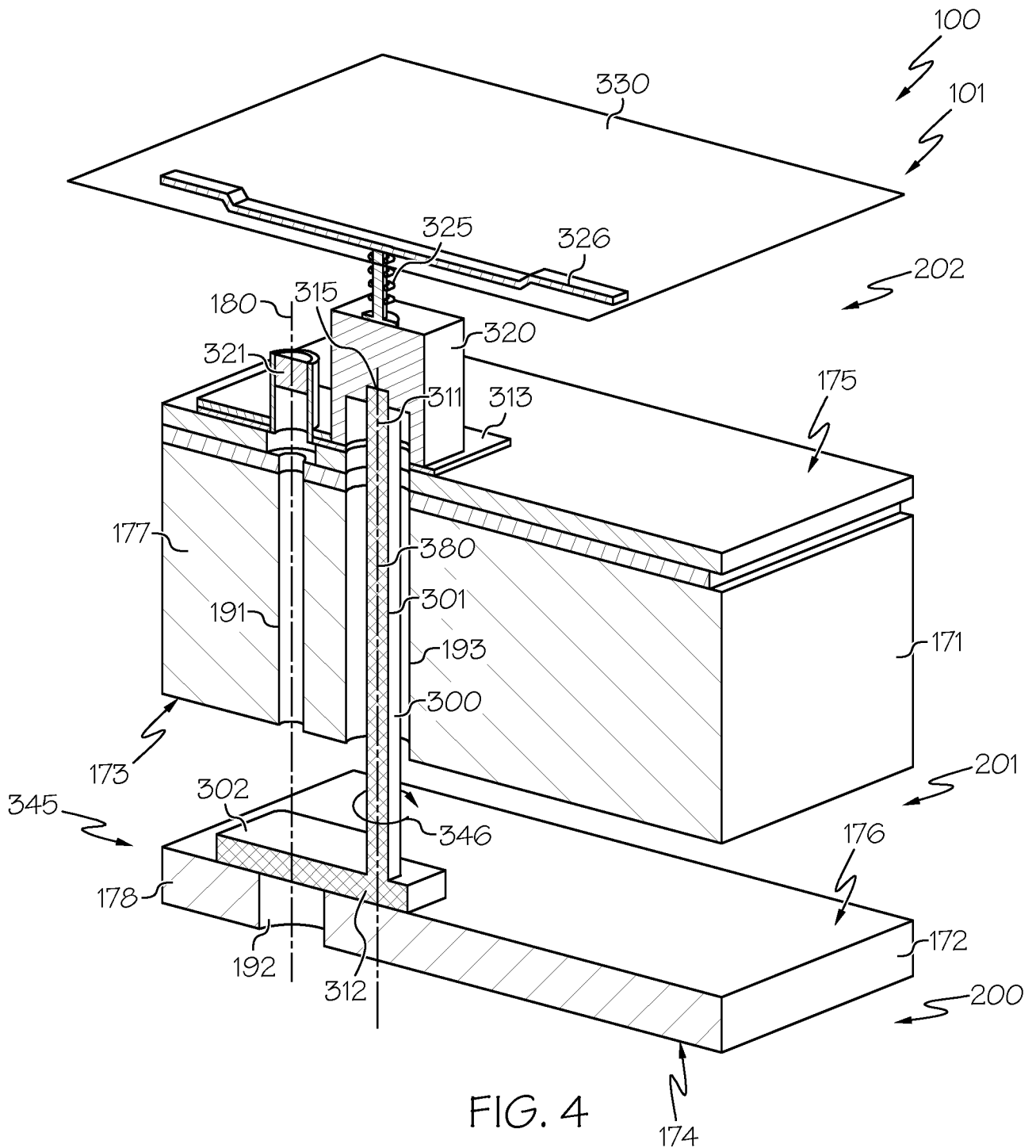


FIG. 2





INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/033509**A. CLASSIFICATION OF SUBJECT MATTER****C03B 17/06(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C03B 17/06; C03B 5/26; C03B 5/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: glass, blocking, shaft, protrusion, aperture, temperature, thermocouple

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012-0159990 A1 (TSUDA, MASAHIRO et al.) 28 June 2012 See paragraphs [0032], [0036], [0076]; figure 1.	1-25
A	JP 05-046929 U (HOYA CORP. et al.) 22 June 1993 See the entire document.	1-25
A	US 2013-0327092 A1 (CHARBONNEAU, MARK WILLIAM) 12 December 2013 See the entire document.	1-25
A	JP 06-227822 A (NIPPON SHEET GLASS CO., LTD.) 16 August 1994 See the entire document.	1-25
A	US 2014-0137601 A1 (CORNING INCORPORATED) 22 May 2014 See the entire document.	1-25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

08 August 2017 (08.08.2017)

Date of mailing of the international search report

08 August 2017 (08.08.2017)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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