

Description

This invention relates to the float process for forming flat glass in which molten glass is passed onto a pool of molten metal (usually consisting chiefly of molten tin) upon which the molten glass floats as it attains a smooth surface and is attenuated to the desired thickness. More particularly, the invention relates to improvements in delivering the molten glass from melting and refining means to the float-forming chamber.

In the float-forming process it has been recognized that the arrangement by which the molten glass is initially deposited onto the molten metal pool is critical for the sake of attaining the optical quality desired for flat glass. Glass that has been thoroughly refined and homogenized when passing through the canal or other vessel connecting the melting and refining apparatus with the forming chamber becomes slightly contaminated at least on its bottom portion by contact with the ceramic refractory materials from which the delivery structure is made. This contamination is known to produce distortion in the glass sheets produced from this glass. In early float processes, as typified by US-A 3 220 816 (Pilkington), the molten glass was delivered onto the molten tin by means of a spout that produces a freely falling band of molten glass, a portion of which flows rewardly and then outwardly upon initially encountering the molten metal. This flow pattern served the purpose of diverting the contaminated bottom surface portion of the molten glass stream to edge portions of the glass ribbon that subsequently formed in the float chamber. These edge portions could be trimmed away and discarded, and the central portion of the ribbon would be relatively free from refractory-induced distortion.

A different approach to this problem is disclosed in US-A 3 843 346 (Edge et al.). There, only a surface portion of the molten glass is drawn from the melting furnace into the forming chamber, thereby avoiding refractory contaminated glass in all portions of the glass ribbon being made. However, even in that arrangement, a small amount of refractory contact is necessitated by the presence of a threshold member over which the glass flows immediately prior to contacting the molten metal. Although the threshold member can be made of relatively pure non-contaminating refractory material, its gradual erosion can contribute to some distortion defects in the glass, and it requires occasional replacement in order to maintain the desired standards of quality in the glass produced. Accordingly, it would be desirable to minimize refractory contact with molten glass as it is being delivered into the forming chamber.

In US-A 3 843 344 (Galey), there is shown an arrangement in which the threshold is located upstream from the upper glass flow control member known as the tuile or "tweel." Such an arrangement may reduce the shear forces on the threshold and thus reduce erosion of the threshold, but, nevertheless, entails some refractory contact of the glass by the threshold as well as the tweel. A similar arrangement is shown in US-A 4 395 272 (Kunkle et al.).

US-A 3 468 649 (Delajarte et al.) and 3 765 857 (Lecourt) both show a cylindrical conduit delivering molten glass to a float-forming chamber. Neither patent discloses the material from which such a conduit could be fabricated nor any details of the construction or purpose of such a conduit. Since both of these patents deal primarily with other features, it appears that the conduit shown in each is merely an abstract schematic depiction of glass delivery means to a float-forming chamber.

US-A 3 318 671 (Brichard et al.); 3 488 175 (Montgomery); and 3 679 389 (Kanai) each show forming a sheet of glass which is passed in a substantially vertical direction onto a molten metal bath. In order for the glass ribbon to be self-supporting in such an arrangement, the glass viscosity must be relatively high, and, therefore, significant smoothing or attenuation of the glass ribbon on the molten metal bath cannot be achieved unless the glass is significantly reheated while it is on the molten metal. Reheating detracts from the energy efficiency of the process. In US-A 4 203 750 (Shay), a seemingly less viscous ribbon of glass is directed onto a molten metal bath where it is attenuated by means of edge rollers. Nevertheless, the viscosity of the glass would appear to be relatively high in order to permit shaping of the ribbon prior to delivery onto the bath, and the preliminary shaping of the ribbon entails significant refractory contact which may be undesirable from a contamination and optical distortion standpoint.

In US-A 4 162 907 (Anderson), discrete gobs of molten glass are extruded onto a small bath of molten tin. Because such an arrangement is discontinuous its throughput rate is limited, and it disadvantageously depends upon a complex mechanism having many moving parts to deliver molten glass onto the molten metal.

DE-A 2 846 449 shows a chamber having a substantial height from which molten glass is fed to a float forming process but the delivery on to the molten metal tool isn't vertical but is essentially horizontal between the elements 8 and 9 shown in the Figure.

US-A 1 872 664 shows a vertical stream but not as an entry into a float glass forming chamber containing molten metal. In fact, the forming means in the reference are not part of a float forming process.

US-A 4 011 070 likewise discloses vertical streams, but does not involve a float glass process.

The stream 30 at the exit is part of a fiber forming process.

US-A 3 450 516 and US-A 3 764 287 both melt glass on a molten metal bath, but there is no vertical delivery of molten glass on to the molten metal.

US-A 3 615 315 forms the glass into a sheet and then deposits it horizontally onto a molten metal bath.

FR-A 1 365 876 and the corresponding US-A 3 243 275 respectively relate to the production of a sheet glass wherein a stream of glass is vertically fed to partially or wholly immersing forming means in a

molten metal bath. The glass is then transferred along the molten bath where it is cooled to a point where it may be transferred to a lehr without harm to the glass surface.

It would be desirable if an arrangement could be provided for delivering molten glass continuously on to a molten metal pool for forming into flat glass by a float process that avoids the drawbacks of the prior art set forth above and which does not need a structure within the forming chamber for directing or shaping the stream into the glass ribbon.

The claims are distinguished over FR-A 1 365 876 as the closest prior art.

This object is attained by a method for forming a flat ribbon of glass by feeding a vertically falling stream of molten glass from a source of molten glass through a roof portion of a forming chamber on to a pool of molten metal within the forming chamber, characterized in that the falling stream enters the forming chamber as an uncontained stream and is initially received in the forming chamber in a reservoir in which the glass is relatively deep and from which the glass flows and spreads to form a relatively thin ribbon while supported on the molten metal in the forming chamber.

Alternatively the object is attained by a method of forming glass into a flat ribbon wherein a stream of molten glass is fed on to a pool of molten metal in a forming chamber, characterized by gathering the incoming stream of molten glass in a first zone of the forming chamber at a relatively narrow width and large depth with glass in contact with side walls, metering glass from the first zone to a second zone of the forming chamber where the glass is permitted to spread to an increased width in contact with side walls and wherein the glass depth is reduced, and passing the glass to a third zone of the forming chamber where the glass is separated from the side walls and is attenuated to form a glass ribbon of desired thickness.

The falling stream enters the forming chamber preferably at a temperature above 1150°C, more preferably above 1200°C.

In the preferred embodiments spreading of the molten glass to approximately the desired width of the product ribbon is accomplished in an intermediate zone where the glass is permitted to flow into contact with relatively widely spaced side walls, whereby the glass layer is substantially reduced in thickness. Subsequently, the glass is drawn into a downstream portion of the forming chamber of even greater width, in which the glass is spaced from the side walls and is drawn with traction means so as to achieve the final desired thickness in the glass ribbon.

The vertical delivery, the gathering of glass in the reservoir, and the spreading in the intermediate zone entail glass temperatures higher than those employed in a conventional float forming chamber. Because the glass in those stages is required to flow freely, its viscosity must be relatively low. Thus, for soda-lime-silica flat glass of conventional commercial composition, the temperature of the glass in the reservoir is preferably at least 1150°C (2100°F) and optimally around 1310°C (2400°F). The glass temperature is permitted to fall as the glass progresses through the intermediate spreading stage, and as the ribbon separates from the side walls, its temperature is typically 980°C to 1150°C (1800°F to 2100°F).

Permitting the glass to flow to substantially the final ribbon width at high temperatures is advantageous because at low viscosities wave type surface defects decay relatively rapidly, thereby enabling production of glass of improved optical quality. The free flow of low viscosity glass, and thus the rapid attainment of ribbon width, permits the use of relatively short, economical forming chambers. Providing glass to a forming chamber at the high temperatures involved in such a process would cause rapid erosion of conventional glass delivery arrangements. The erosion not only objectionably contaminates the glass, but also entails costly replacement of delivery region refractories.

Therefore, the vertical delivery system is advantageous for introducing high temperature glass to that type of forming operation.

Because the glass stream entering the forming chamber need not be shaped by flow guide means and is freely falling, the system is freed from the need to provide a channel structure or the like for carrying molten glass from the melter to the forming chamber. This not only avoids a potential source for contaminating the glass, but also provides greater freedom for selecting materials at the melter outlet.

Specifically, the melter outlet orifice and valve arrangement may be fabricated from platinum, which is normally precluded from use in a forming chamber entrance structure due to the reducing atmosphere conventionally maintained in a forming chamber to preserve the molten metal. Although platinum possesses excellent corrosion resistance in contact with molten glass, it is not durable under reducing conditions. A valve arrangement at the melter outlet may be employed to control the flow of molten glass to the reservoir section of the forming chamber. A tuile (or "tweel") may be provided to adjustably regulate flow of molten glass from the reservoir to the intermediate chamber, but the tweel and the refractory contact it entails may be eliminated by relying on the melter outlet valve for controlling the glass flow rate.

The reservoir provides a convenient location for stirring the molten glass after delivery into the forming chamber so as to alleviate the optical distortion effects caused by inhomogeneities in the glass. Glass that has been thoroughly refined and delivered to the forming chamber without significant contamination from the refractory vessel need not be homogenized. Glass that is intended for use other than as transparent glazing may have lower standards for optical uniformity and thus may also avoid the need for stirring. Although the delivery of molten glass to the forming chamber of the present invention substantially reduces the potential for refractory contamination, it may be found that inhomogeneities are present in the glass prior to entering the delivery zone. Since the delivery arrangement of the

present invention does not provide for diverting the more contaminated portions of the glass to marginal portions of the glass ribbon, the use of stirring in combination with the present invention is preferred when producing flat glass for transparency use.

Other features of the invention will be evident from the drawings and the following description of specific embodiments.

The Drawings

Figure 1 is a schematic plan view of a forming chamber in accordance with the present invention, with the top cut away.

Figure 2 is a schematic cross-sectional side view of the forming chamber of Figure 1.

Figure 3 is an enlarged cross-sectional side view of the delivery section of the forming chamber of Figure 1 and 2, showing one embodiment for vertical delivery of molten glass to the forming chamber in accordance with the present invention.

Figure 4 is an enlarged cross-sectional side view of the delivery and reservoir section of the forming chamber of Figures 1 and 2, showing a preferred embodiment for vertical delivery of molten glass to the forming chamber in accordance with the present invention, also showing an arrangement for stirring the glass.

Figure 5 is an enlarged cross-sectional side view of the delivery section of the forming chamber of Figure 1 and 2, showing an alternative embodiment of the present invention.

Detailed Description

Referring to Figures 1 and 2, there is shown a general layout of a forming chamber 10 in accordance with one embodiment of the present invention. The forming chamber is associated with a source of molten glass 11 which may be a melting furnace of any type known in the art. More specifically, molten glass delivered to the forming chamber in most cases will have been subjected to a refining process subsequent to melting, and in some cases to a thermal conditioning step as well. Therefore, it should be understood that the source of molten glass 11 could be a refining vessel or conditioning vessel, any of which may be referred to herein as "melter" for the sake of simplicity. A vertically falling stream of glass 12 flows from the melter 11 and passes through an opening in the roof of the forming chamber 10, and is received in a first zone 13 of the forming chamber. A reservoir of molten glass 14 is retained in the first zone 13 behind a vertically adjustable tweel 15 which adjustably regulates the flow of molten glass from the first zone to an intermediate zone 20. Figure 2 depicts the preferred arrangement wherein a layer of molten metal 22 extends throughout the forming chamber, including the first chamber 13. The molten metal is preferably tin which may include minor amounts of other elements, such as iron and copper. In the first zone 13 the provision of molten metal is preferred for the sake of providing a non-contaminating contact surface on the bottom of the glass reservoir 14. Some aspects of the present invention do not require the presence of the molten metal in zone 13.

The intermediate zone 20 is provided with greater width than the first zone 13, and molten glass 21 within the intermediate zone is provided with sufficiently low viscosity so that the glass spreads into contact with the side walls. The width attained by the glass in the intermediate zone 20 is preferably approximately that of the final glass ribbon being produced. As the regulated amount of glass flows under the tweel 15 and spreads in the intermediate zone 20, its thickness decreases, approaching or equaling the equilibrium thickness at the end of the intermediate zone. An option is to provide a seal barrier 23 shown in phantom in Figures 1 and 2 at the end of the intermediate zone 20, so as to permit the gas above the glass 21 in the intermediate zone to be pressurized above atmospheric pressure, whereby the glass thickness may be reduced below the equilibrium thickness in the intermediate zone. This optional technique is in accordance with US-A 4 395 272 (Kunkle et al.).

With continued reference to Figures 1 and 2, the third zone 25 of the forming chamber resembles a conventional float forming chamber. The side walls of the third zone 25 are spaced apart further than those in the intermediate zone 20 so that the edges of the ribbon of glass 26 are spaced therefrom. Edge gripping means such as conventional toothed wheels 27 may engage opposite marginal edge portions of the ribbon 26 in the third zone so as to control ribbon width. In those embodiments where the glass enters the third zone at or slightly above the equilibrium thickness, the edge gripping devices maintain the ribbon width or reduce the loss of ribbon width as the ribbon is stretched longitudinally when thicknesses below equilibrium are being produced. In those embodiments where the glass thickness has been reduced below equilibrium in the intermediate zone, the edge gripping devices serve to maintain the ribbon width and thereby to preserve the reduced thickness. The number and spacing of the edge gripping devices may vary considerably in accordance with particular production requirements.

The free flowing nature of the molten glass in the first and second zones of the forming process of the present invention are indicative of lower viscosity and higher temperatures than conventionally employed in float forming processes. Glass temperatures throughout the first zone 13 and at least the upstream portion of the intermediate zone 20 are at least 1150°C (2100°F). As the glass exits the intermediate zone 20, its temperature may have fallen to as low as 980°C (1800°F). Since the glass is cooling as it

progresses through the forming chamber, considerably higher temperatures will be present in upstream portions of the forming chamber. For example, the glass in the reservoir 14 is preferably at a temperature of at least 1200°C (2200°F). Such temperatures are particularly preferred if the glass is to be stirred in the first zone. The stream of glass 12 entering the forming chamber may be at correspondingly higher temperatures, typically falling in the vicinity of 1260°C (2300°F) to 1315°C (2400°F). There is no essential upper limit on the temperature of the glass entering the first zone, but as a practical matter it is most likely that the glass would be somewhat below the peak refining temperature imparted to the glass in the upstream melting and refining process, which would typically be no greater than about 1500°C (2800°F). As a further practical matter, permitting the glass to cool substantially before entering the forming chamber would be preferred in some cases to extend the life of elements such as the valve means and the refractory side walls of the forming chamber. At these relatively high temperatures, a significant advantage is provided by the layer of molten metal 22 beneath the glass in the first and second zones of the forming chamber for the sake of isolating the molten glass from contact with ceramic refractory materials which would have a significant contaminating effect on the molten glass at those temperatures. Likewise, it is significant that the high temperature stream of glass 12 need not contact ceramic refractory structural elements.

The temperatures given herein are with reference to a conventional soda-lime-silica commercial float glass composition. For other compositions the appropriate temperatures will vary in accordance with the temperature/viscosity relationship of the particular glass composition. In order to extrapolate the temperatures disclosed herein to other glass compositions, the relationship between temperature and viscosity of a specific example of soda-lime-silica float glass is set forth below:

Viscosity Pa.s (Poise)	Temperature
10 (100)	1443°C (2630°F)
100 (1000)	1184°C (2164°F)
1000 (10,000)	1024°C (1876°F)
10,000 (100,000)	906°C (1663°F)

Figure 3 shows details of an example of a valve arrangement for regulating the flow of molten glass from the melter or refiner 11 into the forming chamber. In this example, a tube 30 of refractory metal such as platinum extends through the floor of the refractory vessel 11 and defines a drain orifice through which passes the stream of glass 12. A vertically adjustable plunger 31, which may also be fabricated of or clad with a refractory metal such as platinum, serves to regulate the flow of molten glass through the tube 30. The plunger and drain tube arrangement is conventional in some portions of the glass industries, such as bottle making and the components are readily available commercially, but the use of such an arrangement in a flat glass forming operation is novel. The source of molten glass 11 depicted in Figure 3 represents the end portion of a horizontal tank-type melting furnace commonly employed in the glass industry. The terminal portion of such a furnace may constitute a forehearth in which the glass may be thermally conditioned and homogenized.

In order to prevent the molten metal in a float forming chamber from oxidizing excessively, it is conventional to maintain a non-oxidizing atmosphere within the forming chamber, typically consisting of an inert gas such as nitrogen and small amounts of a reducing gas such as hydrogen. In the present invention, where the molten glass 14 completely covers the molten metal 22 in the first zone 13, and the wheel 15 isolates the first chamber atmosphere from the remainder of the forming chamber, it may be unnecessary to provide a reducing atmosphere in the first zone. In that case the tube 30 of the Figure 3 embodiment may extend into the first zone 13 of the forming chamber since the platinum from which it is preferably constructed will not be subjected to the corrosive effects of a reducing atmosphere. Extending the tube 30 to within a short distance above the surface of the reservoir of glass 14 is preferred in order to prevent toiling and entrapment of air as the stream 12 enters the reservoir. It would also be feasible for the tube to extend below the surface of the glass 14. It should be understood that reference to platinum herein is intended to include alloys of platinum, in particular the alloys of platinum with rhodium commonly employed for glass contact applications.

Figure 4 shows the preferred embodiment of the present invention and includes a plurality of stirrers 40 for stirring the reservoir of glass 14 within the first zone 13 of the forming chamber. The stirrers are preferably provided in an array, with a plurality of stirrers in each of a plurality of rows. The precise number of stirrers required will depend upon the degree of homogenization desired and the stirring action of the particular stirrer design selected. The stirrers depicted in Figure 4 are a helical type, but any glass stirrer design known in the art may be employed. When stirring is employed, it is feasible to add colorants or other additives to the glass upstream from the stirrers in the first zone 13. For this purpose, a screw feeder 41 may be provided extending into the chamber through a side wall.

A source of molten glass 42 in the Figure 4 embodiment may be of the type previously described in connection with other embodiments, or it may be a less conventional type of melter or refiner. For exam-

ple, a vertically oriented refiner such as that disclosed in US-A 4 610 711 (Matesa et al.) may be employed to deliver molten glass to the forming process of the present invention. The source of molten glass 42 is provided with an outlet tube 43 which is preferably fabricated of a refractory metal such as platinum. In this embodiment an arrangement to regulate the flow of molten glass is provided on the exterior of the molten glass source 42. This valve arrangement is in accordance with US-A 4 600 426 (Schwenninger) and includes a bulbous member 44 supported on a laterally extending arm 45, which is, in turn, supported with provision for vertical adjustment. In order to prevent coiling of the glass and entrapment of air therein, an elongated tail piece 46 may extend downwardly from the bulbous member 42 into the forming chamber to an elevation slightly above or preferably at or below the level of the glass 14 held in the first chamber. The elements of this valve arrangement are preferably fabricated from a refractory metal such as platinum or molybdenum.

Turning now to Figure 5, there is shown an embodiment that foregoes many of the preferred features, but nevertheless represents a novel arrangement for delivering molten glass to a flat glass forming operation within the scope of the broadest aspects of the present invention. The variations shown in Figure 5 may be used together as shown or may be used separately in the other embodiments disclosed. Figure 5 shows a conventional melter or refiner 50 from which a stream of glass 51 is drained from an end portion rather than a bottom drain orifice. In the example depicted, the glass is drained through a narrow trough 52 having a vertically adjustable gate 53 for varying the rate of flow. The width of the trough 52 is preferably minimized so as to minimize the surface area of refractory contact, but may be somewhat rectangular in cross-section. However, the vertically falling stream of glass 51 will tend to assume a cylindrical shape due to surface tension and the relatively large distance of free fall. If desired the trough 52 could be lined with platinum or other non-contaminating material. The first zone 55 of the forming chamber holds a reservoir of glass 56, but is not provided with the preferred molten metal layer between the glass and the refractory bottom. Some or all of the glass contact surfaces within the zone 55 may be clad with platinum or other non-contaminating refractory material. The reservoir 56 is relatively deep and narrow as in previous embodiments. The flow of glass from the first zone 55 to a second zone 57 is regulated between a vertically adjustable wheel 58 and a threshold member 59 which is preferably of a non-contaminating refractory material such as fused quartz. The glass in the intermediate zone 57 is permitted to flow to a greater width on a pool of molten metal 60 as in previous embodiments.

Claims

1. A method for forming a flat ribbon (26) of glass by feeding a vertically falling stream (12) of molten glass from a source of molten glass (11) through a roof portion of a forming chamber (10) on to a pool of molten metal (22) within the forming chamber (10) characterized in that the falling stream (12) enters the forming chamber (10) as an uncontained stream and is initially received in the forming chamber (10) in a reservoir (14) in which the glass is relatively deep and from which the glass flows and spreads to form a relatively thin ribbon while supported on the molten metal (22) in the forming chamber (10).

2. The method of claim 1 wherein the falling stream (12) has a free surface that is substantially cylindrical.

3. The method of claim 1 wherein the configuration of the molten stream (12) is defined at the outlet orifice of the source of molten glass (11) and the stream falls without modification into the forming chamber (10).

4. The method of claim 1 wherein the falling stream (12) enters the forming chamber at a temperature above 1150°C (2100°F).

5. The method of claim 1 wherein the falling stream (12) enters the forming chamber at a temperature above 1200°C (2200°F).

6. The method of claim 1 wherein the molten glass entering the forming chamber (10) from the falling stream (12) enters a reservoir of glass (14) that is in contact with the forming chamber walls.

7. The method of claim 1 wherein the reservoir of molten glass (14) is supported on a layer of molten metal (22).

8. The method of claim 1 wherein the falling stream (12) is not in contact with ceramic refractory material.

9. A method of forming glass into a flat ribbon (26) wherein a stream of molten glass (12) is fed on to a pool of molten metal (32) in a forming chamber (10), characterized by gathering the incoming stream of molten glass (12) in a first zone (13) of the forming chamber (10) at a relatively narrow width and large depth with glass in contact with side walls, metering glass from the first zone (13) to a second zone (20) of the forming chamber (10) where the glass is permitted to spread to an increased width in contact with side walls and wherein the glass depth is reduced, and passing the glass to a third zone (25) of the forming chamber (10) where the glass is separated from the side walls and is attenuated to form a glass ribbon (26) of desired thickness.

10. The method of claim 9 wherein the glass is supported on molten metal (22) in the third zone (25).

11. The method of claim 9 wherein the glass is supported on molten metal (22) in the second zone (20).

12. The method of claim 9 wherein the glass is supported on molten metal (22) in the first zone (13).

ple, a vertically oriented refiner such as that disclosed in US-A 4 610 711 (Matesa et al.) may be employed to deliver molten glass to the forming process of the present invention. The source of molten glass 42 is provided with an outlet tube 43 which is preferably fabricated of a refractory metal such as platinum. In this embodiment an arrangement to regulate the flow of molten glass is provided on the exterior of the molten glass source 42. This valve arrangement is in accordance with US-A 4 600 426 (Schwenninger) and includes a bulbous member 44 supported on a laterally extending arm 45, which is, in turn, supported with provision for vertical adjustment. In order to prevent coiling of the glass and entrapment of air therein, an elongated tail piece 46 may extend downwardly from the bulbous member 42 into the forming chamber to an elevation slightly above or preferably at or below the level of the glass 14 held in the first chamber. The elements of this valve arrangement are preferably fabricated from a refractory metal such as platinum or molybdenum.

Turning now to Figure 5, there is shown an embodiment that foregoes many of the preferred features, but nevertheless represents a novel arrangement for delivering molten glass to a flat glass forming operation within the scope of the broadest aspects of the present invention. The variations shown in Figure 5 may be used together as shown or may be used separately in the other embodiments disclosed. Figure 5 shows a conventional melter or refiner 50 from which a stream of glass 51 is drained from an end portion rather than a bottom drain orifice. In the example depicted, the glass is drained through a narrow trough 52 having a vertically adjustable gate 53 for varying the rate of flow. The width of the trough 52 is preferably minimized so as to minimize the surface area of refractory contact, but may be somewhat rectangular in cross-section. However, the vertically falling stream of glass 51 will tend to assume a cylindrical shape due to surface tension and the relatively large distance of free fall. If desired the trough 52 could be lined with platinum or other non-contaminating material. The first zone 55 of the forming chamber holds a reservoir of glass 56, but is not provided with the preferred molten metal layer between the glass and the refractory bottom. Some or all of the glass contact surfaces within the zone 55 may be clad with platinum or other non-contaminating refractory material. The reservoir 56 is relatively deep and narrow as in previous embodiments. The flow of glass from the first zone 55 to a second zone 57 is regulated between a vertically adjustable wheel 58 and a threshold member 59 which is preferably of a non-contaminating refractory material such as fused quartz. The glass in the intermediate zone 57 is permitted to flow to a greater width on a pool of molten metal 60 as in previous embodiments.

Claims

1. A method for forming a flat ribbon (26) of glass by feeding a vertically falling stream (12) of molten glass from a source of molten glass (11) through a roof portion of a forming chamber (10) on to a pool of molten metal (22) within the forming chamber (10) characterized in that the falling stream (12) enters the forming chamber (10) as an uncontained stream and is initially received in the forming chamber (10) in a reservoir (14) in which the glass is relatively deep and from which the glass flows and spreads to form a relatively thin ribbon while supported on the molten metal (22) in the forming chamber (10).

2. The method of claim 1 wherein the falling stream (12) has a free surface that is substantially cylindrical.

3. The method of claim 1 wherein the configuration of the molten stream (12) is defined at the outlet orifice of the source of molten glass (11) and the stream falls without modification into the forming chamber (10).

4. The method of claim 1 wherein the falling stream (12) enters the forming chamber at a temperature above 1150°C (2100°F).

5. The method of claim 1 wherein the falling stream (12) enters the forming chamber at a temperature above 1200°C (2200°F).

6. The method of claim 1 wherein the molten glass entering the forming chamber (10) from the falling stream (12) enters a reservoir of glass (14) that is in contact with the forming chamber walls.

7. The method of claim 1 wherein the reservoir of molten glass (14) is supported on a layer of molten metal (22).

8. The method of claim 1 wherein the falling stream (12) is not in contact with ceramic refractory material.

9. A method of forming glass into a flat ribbon (26) wherein a stream of molten glass (12) is fed on to a pool of molten metal (32) in a forming chamber (10), characterized by gathering the incoming stream of molten glass (12) in a first zone (13) of the forming chamber (10) at a relatively narrow width and large depth with glass in contact with side walls, metering glass from the first zone (13) to a second zone (20) of the forming chamber (10) where the glass is permitted to spread to an increased width in contact with side walls and wherein the glass depth is reduced, and passing the glass to a third zone (25) of the forming chamber (10) where the glass is separated from the side walls and is attenuated to form a glass ribbon (26) of desired thickness.

10. The method of claim 9 wherein the glass is supported on molten metal (22) in the third zone (25).

11. The method of claim 9 wherein the glass is supported on molten metal (22) in the second zone (20).

12. The method of claim 9 wherein the glass is supported on molten metal (22) in the first zone (13).



13. The method of claim 9 wherein the glass in the first zone (13) is at a temperature of at least 1150°C (2100°F).

14. The method of claim 9 wherein a pressure greater than atmospheric pressure is maintained in the second zone (20) as to reduce the glass thickness.

Revendications

1. Procédé de formation d'un ruban plat (26) de verre par le dépôt d'un courant descendant verticalement (12) de verre fondu à partir d'une source de verre fondu (11) à travers le toit d'une chambre de façonnage (10) sur un bassin de métal fondu dans la chambre de formage (10) caractérisé en ce que le courant descendant (12) pénètre dans la chambre de formage (10) sous forme d'un courant non contenu et la chambre de formage (10) le reçoit à l'origine dans un réservoir (14) dans lequel le niveau atteint par le verre est relativement élevé et d'où le verre s'écoule et s'étale pour former un ruban relativement mince cependant que le métal fondu (22) le supporte dans la chambre de formage (10).

2. Procédé suivant la revendication 1, caractérisé en ce que le courant descendant (12) possède une surface libre qui est sensiblement cylindrique.

3. Procédé suivant la revendication 1, caractérisé en ce que la configuration du courant fondu (12) est définie à l'orifice de sortie de la source de verre fondu (11) et le courant descend dans la chambre de formage (10) sans modification.

4. Procédé suivant la revendication 1, caractérisé en ce que le courant descendant (12) pénètre dans la chambre de formage à une température supérieure à environ 1150°C (2100°F).

5. Procédé suivant la revendication 1, caractérisé en ce que le courant descendant (12) pénètre dans la chambre de formage à une température supérieure à 1200°C (2200°F).

6. Procédé suivant la revendication 1, caractérisé en ce que le verre fondu qui entre dans la chambre de formage (10) à partir du courant descendant (12) pénètre dans un réservoir de verre (14) en contact avec les parois de la chambre de formage.

7. Procédé suivant la revendication 1, caractérisé en ce qu'une couche de métal fondu (22) supporte le réservoir de verre fondu (14).

8. Procédé suivant la revendication 1, caractérisé en ce que le courant descendant (12) n'est pas en contact avec de la matière réfractaire céramique.

9. Procédé de formage de verre en un ruban plat (26) caractérisé en ce que l'on dépose du verre fondu (12) sur un bassin de métal fondu (32) dans une chambre de formage (10), caractérisé en ce que on rassemble le courant entrant de verre fondu (12) dans une première zone (13) de la chambre de formage (10) en une largeur relativement étroite et jusqu'à un niveau important de verre en contact avec les parois latérales, on débite le verre de manière dosée de la première zone (13) dans une seconde zone (20) de la chambre de formage (10), où l'on permet au verre de s'étaler sur une plus grande largeur en contact avec les parois latérales et dans laquelle le niveau de hauteur du verre est réduit et on fait passer le verre dans une troisième zone (25) de la chambre de formage (10) où l'on sépare le verre des parois latérales et on l'étire pour former un ruban de verre (26) d'épaisseur souhaitée.

10. Procédé suivant la revendication 9, caractérisé en ce que du métal fondu (22) supporte le verre dans la troisième zone (25).

11. Procédé suivant la revendication 9, caractérisé en ce que du métal fondu (22) supporte le verre dans la seconde zone (20).

12. Procédé suivant la revendication 9, caractérisé en ce que du métal fondu (22) supporte le verre dans la première zone (13).

13. Procédé suivant la revendication 9, caractérisé en ce que le verre de la première zone (13) se trouve à une température d'au moins 1150°C (2100°F).

14. Procédé suivant la revendication 9, caractérisé en ce que l'on maintient une pression supérieure à la pression atmosphérique dans la seconde zone (20) de façon à réduire l'épaisseur du verre.

Patentansprüche

1. Verfahren zum Ausbilden eines Flachglasbandes (26) durch Zuführen eines senkrecht fallenden Stromes (12) geschmolzenen Glases von einer Quelle geschmolzenen Glases (11) durch ein Dachteil einer Formgebungskammer (10) auf ein Bad aus geschmolzenem Metall (22) in der Formgebungskammer (10), dadurch gekennzeichnet, daß der fallende Strom (12) in die Formgebungskammer (10) als ein ungeteilter Strom eintritt und zuerst von einem Reservoir (14) in der Formgebungskammer (10) aufgenommen wird, in dem das Glas relativ tief ist und von dem das Glas ausfließt und sich ausbreitet unter Ausbildung eines relativ dünnen Bandes, während es von dem geschmolzenen Metall (22) in der Formgebungskammer (10) getragen wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der fallende Strom (12) eine im wesentlichen zylindrische freie Oberfläche aufweist.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Form des geschmolzenen Stromes (12) durch die Auslaßöffnung der Quelle geschmolzenen Glases (11) bestimmt wird und der Strom ohne Veränderung in die Formgebungskammer (10) fällt.



4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der fallende Strom (12) in die Formgebungskammer (10) bei einer Temperatur oberhalb 1150°C (2100°F) eintritt.

5. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der fallende Strom (12) in die Formgebungskammer (10) bei einer Temperatur oberhalb 1200°C (2200°F) eintritt.

5 6. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das in die Formgebungskammer (10) aus dem fallenden Strom (12) eintretende geschmolzene Glas in ein Reservoir von Glas (14) eintritt, das in Berührung mit den Formgebungskammerwänden steht.

7. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das Reservoir geschmolzenen Glases (14) von einer Schicht geschmolzenen Metalles (22) getragen wird.

10 8. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der fallende Strom (12) nicht in Berührung mit keramischem, feuerfestem Material steht.

9. Verfahren zum Formen von Glas zu einem flachen Band (26), bei dem ein Strom geschmolzenen Glases (12) einem Bad geschmolzenen Metalles (32) in einer Formgebungskammer (10) zugeführt wird, gekennzeichnet durch Sammeln des ankommenden Stromes geschmolzenen Glases (12) in einer ersten Zone (13) der Formgebungskammer (10) in einer relativ geringen Breite und großer Tiefe, wobei Glas in Berührung mit den Seitenwänden steht, Dosieren von Glas aus der ersten Zone (13) in eine zweite Zone (20) der Formgebungskammer (10), in der sich das Glas zu einer größeren Breite in Berührung mit den Seitenwänden ausbreiten kann und in der die Glastiefe verringert ist, und Überführen des Glases in eine dritte Zone (25) der Formgebungskammer (10), in der das Glas von den Seitenwänden getrennt und ausgezogen wird, um ein Glasband (26) der gewünschten Dicke zu bilden.

20 10. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß das Glas in der dritten Zone (25) von geschmolzenem Metall (22) getragen wird.

11. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß das Glas in der zweiten Zone (20) von geschmolzenem Metall (22) getragen wird.

25 12. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß das Glas in der ersten Zone (13) von geschmolzenem Metall (22) getragen wird.

13. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß das Glas in der ersten Zone (13) eine Temperatur von mindestens 1150°C (2100°F) aufweist.

30 14. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß der in der zweiten Zone (20) aufrecht-erhaltene Druck größer ist als Atmosphärendruck, um die Glasdicke zu verringern.

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