

[54] **METHOD OF CONTINUOUS FABRICATION
OF GLASS-CRYSTALLINE MATERIALS
WITH RIB CONFIGURATION**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 148,984, June 1,
1971, abandoned, which is a continuation of Ser. No.
746,386, July 22, 1968, abandoned.

[52] **U.S. Cl.**..... **65/33, 65/94, 65/95,**
65/101, 65/253, 65/255, 106/39.6, 106/39.8,
106/51

[51] **Int. Cl.**..... **C03b 29/00, C03b 13/00**

[58] **Field of Search**..... **65/33, 255, 253, 101, 94,**
65/95; 106/51, 39.6, 39.8, 39 DV

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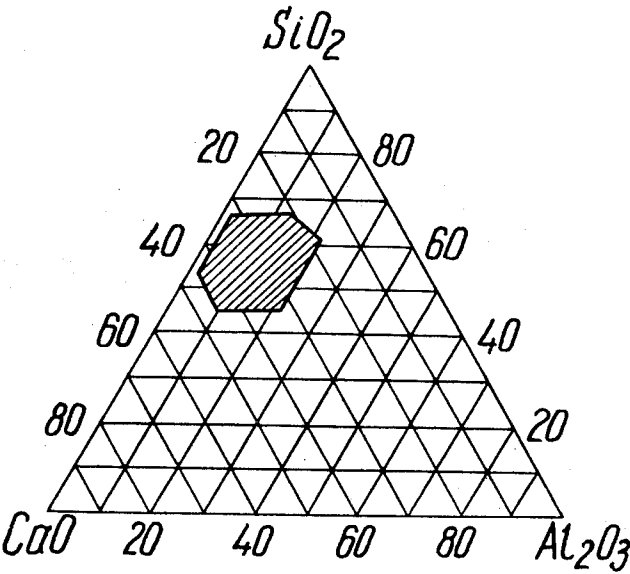
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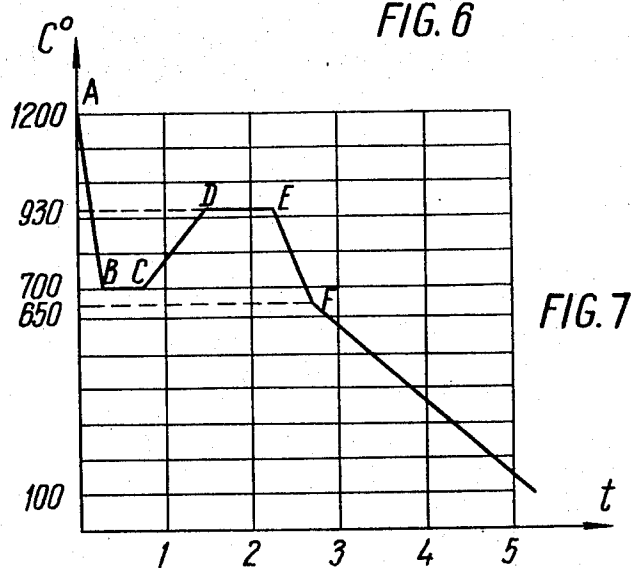
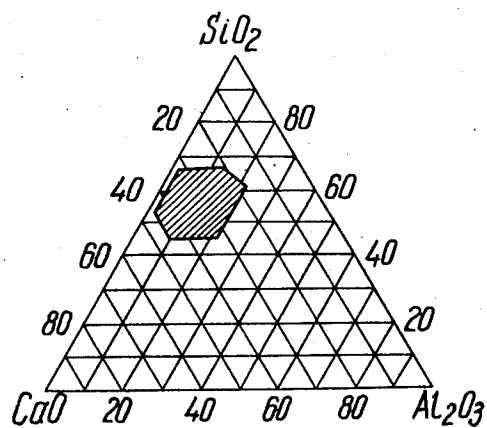
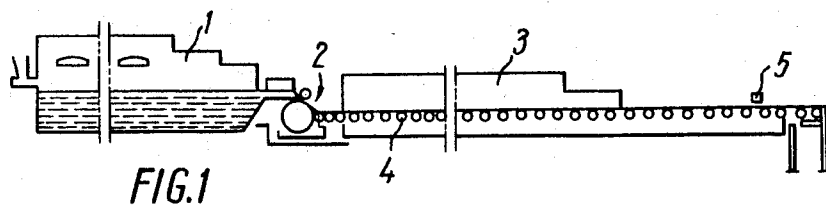
[57] **ABSTRACT**

Continuous fabrication of sheet glass-crystalline material in which a glass melt is formed into a strip whose lower surface is covered with intersecting ribs forming a square-faced polycisson structure with the rib height and width not in excess of 2 mm and with the spacings between two adjacent ribs amounting to at least 5 mm.

The formed strip undergoes a heat-treating operation, assuring the crystallizing and subsequent tempering of the strip travelling over the lehr conveying rollers.

1 Claim, 7 Drawing Figures





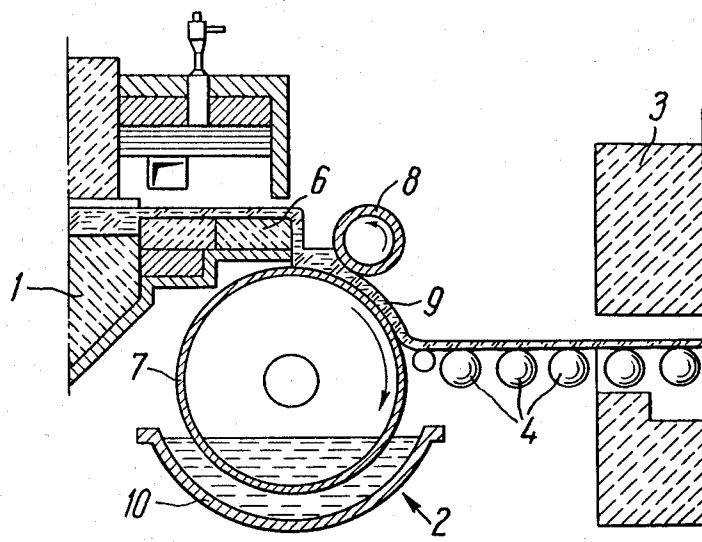


FIG. 2

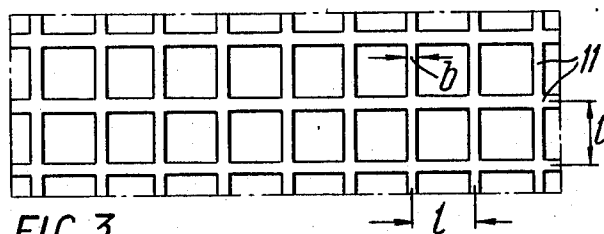


FIG. 3

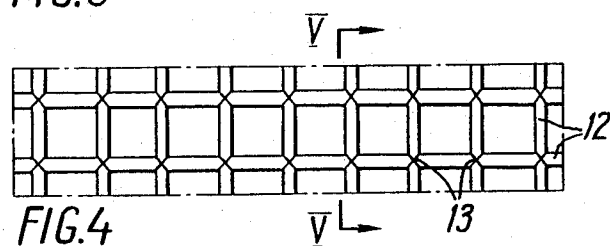


FIG. 4

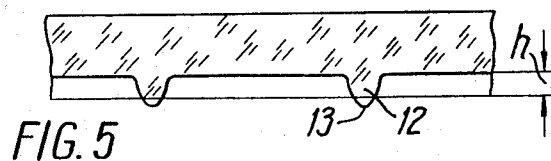


FIG. 5

METHOD OF CONTINUOUS FABRICATION OF GLASS-CRYSTALLINE MATERIALS WITH RIB CONFIGURATION

CROSS RELATED APPLICATIONS

This application is a continuation in part of application Ser. No. 148,984 filed June 1, 1971, and now abandoned which in turn was a continuation of application Ser. No. 746,386 filed July 22, 1968 and also now abandoned.

The present invention relates to a method and apparatus for the continuous production of sheet glass-crystalline material.

The known methods for the production of glass-crystalline workpieces involve forming a glass melt into the workpieces, whereupon the formed pieces undergo a heat-treating operation assuring both crystallization of the workpiece material and its tempering.

The production of the glass-crystalline workpieces presents certain difficulties caused by a reduction in material viscosity at a maximum crystallization temperature.

It is this reason, in particular, which makes impractical the fabrication of sheet glass-crystalline material by the conventional continuous rolling technique.

In an endeavour to manufacture a continuous strip of glass-crystalline material in conventional rolling facilities comprising a glass tank furnace, sheeting rolls and a tunnel lehr with a roller conveying means, under the effect of the high temperature necessary to obtain crystallized material, the rolled glass strip obtained such a degree of plasticity that while travelling on the conveying means it slacks between the rollers and sticks to their surface. On account of this sticking to the rollers the glass strip, and at a later stage of the process the strip of crystalline material, tends to wind onto the rollers thus making the strip transportation impossible.

An object of the present invention is to devise a method for the fabrication of sheet glass-crystalline material by the application of continuous rolling techniques in which the glass strip does not slack between the conveying rollers and stick to them.

Another object of this invention is also to develop a plant meeting the specified requirements.

According to the present invention the proposed method for the continuous fabrication of sheet glass-crystalline material involves the following operations: the melting of the batch (charge) applicable to the production of glass-crystalline material, forming a glass melt produced of the said batch into a strip, producing during the forming operation on the lower surface of the strip intersecting ribs which define on the said surface a square-faced polycisson structure, crystallizing the formed strip by heating it to 900°-980°C while it is moved on the lehr conveying means and tempering the crystallized strip. The ribs are trapezoidal in cross-section, not more than 2 mm high and wide and spaced at a distance of at least 5 mm between two adjacent ribs, by virtue of the ribs acquire mechanical strength in the course of crystallization more rapidly than the remaining glass stock, the polycisson structure formed by the ribs on the lower surface of the strip imparting the requisite rigidity to the latter.

The apparatus proposed for the continuous fabrication of sheet glass-crystalline material comprises: a glass tank furnace with a lip for pouring glass melt, a forming means comprising an upper and lower sheeting

rolls of various diameter to form the glass melt flowing from the said glass tank furnace into a strip, said lower sheeting roll being of greater diameter and having on its surface a pattern of intersecting grooves to form ribs on the said strip; a continuous lehr where the strip is treated to obtain crystallized and tempered material; a roller conveying means to feed the said strip through the said lehr; the said grooves on the foregoing sheeting roll being of trapezoidal cross-section and not more than 2 mm in depth and width on top and spaced at a distance of at least 5 mm between two adjacent grooves.

In forming the glass strip, the above profile of the lower sheeting roll makes it possible to produce on its lower surface intersecting ribs forming square caissons adjacent to each other.

Since the ribs on the lower surface of the strip constitute a negligible volume of the glass mass with a developed surface which, all other conditions being equal, cools down to ambient temperature more rapidly than the remaining mass of the strip stock, with the process of crystallization of the ribs, per se, terminating before the rest of the material will crystallize, whereby the ribs are first to acquire mechanical strength.

The polycisson structure of the lower surface of the strip tends to impart rigidity to the strip and at high temperatures exceeding the glass softening point, in the initial stage of crystallization, the strip moves over the lehr roller conveying means practically without slackening between the rollers.

In addition, in forming the strip at the places of intersection of the grooves on the surface of the lower sheeting-roll, the glass material has a smaller area of contact with the groove walls than the stock formed in the grooves.

This is why the above sections of the glass material are prone to give off smaller amount of heat and, hence, remain more hot and less sticky. In the initial period when the strip is detached from the surface of the sheeting roll, the glass material, being less sticky, is liable to sag in the places of intersection of the grooves, forming point bulges equal in number to that of the intersections of the grooves on the surface of the lower sheeting roll. Subsequently the glass strip when moving on the conveying rollers of the lehr rests first of all on these bulges with the lower surface of the strip establishing a minimum contact with the conveying rollers, which prevents the strip to a larger degree from sticking to the rollers.

The details of the present invention will become more fully apparent from a consideration of the following description of an exemplary embodiment of the proposed method apparatus conforming to the invention, to be taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic elevation view of the apparatus according to the invention;

FIG. 2 shows, on enlarged scale and in longitudinal section, a forming means and a portion of a glass tank furnace and a lehr;

FIG. 3 is a plan view of a portion of the surface of a lower sheeting roll;

FIG. 4 is a plan view of a portion of the lower surface of the formed glass strip;

FIG. 5 is a cross-section of the strip given in FIG. 4 and on an enlarged scale; FIG. 6 diagrammatically shows a CaO-Al₂O₃-SiO₂ system with a restricted range

of glass compositions most preferable for realizing the invention and;

FIG. 7 is a graph illustrating the heat-treating parameters including the forming, crystallizing and tempering of the glass strip.

Referring to FIG. 1 of the drawings, therein is seen apparatus for the continuous fabrication of glass-crystalline material which comprises the following elements arranged in the direction of the process flow sheet: glass tank furnace 1 for processing glass melt, forming means 2 for producing a glass strip, lehr 3 for crystallizing and tempering the strip lying on a roller conveying means 4 which passes through the lehr, and a cutting means 5 following the lehr for severing the strip of glass-crystalline material into separate sheets.

For discharge of glass melt, glass tank furnace 1 is provided with a lip 6 (FIG. 2) which is somewhat less in width than the length of sheeting rolls 7 and 8 of the forming means 2. Rolls 7 and 8 serve for forming the glass melt into strip 9 and are of different diameter and rotate in opposite directions.

Lower roll 7 of greater diameter, on which the glass melt is poured directly from the furnace, is partially enclosed in a housing 10 charged with a coolant, the roll 7 being partially filled with the coolant too.

The exterior of roll 7 is provided with intersecting grooves 11 (FIG. 3) due to which ribs 12 are formed on the bottom side of the strip (FIGS. 4 and 5) in the course of forming the glass melt into strip 9. It is expedient to make grooves 11 on roll 7 trapezoidal in cross-section as can be seen from the shape of the rib 12 in cross-section in FIG. 5. Depth h of the grooves (the height of rib 12) and their width b on top shall not exceed 2 mm and the spacing l between the adjacent grooves shall be at least 5 mm.

The process of fabrication of the sheet glass-crystalline material in the apparatus described hereinbefore will be described in detail with reference to the following exemplary embodiment of the invention.

The composition range of original glass stock utilized for the production of the sheet glass-crystalline material of white, grey and other color, possessing high mechanical properties, chemical and abrasive resistance and most suitable for bringing about the method of the invention, is for the most part located in a $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ system and is shown in a tri-axial diagram (FIG. 6).

Let us consider the process of manufacturing sheet glass-crystalline material of one of the possible compositions.

A mixture of raw materials of the following composition (parts by weight):

metallurgical slag	49.5
quartz sand	38.5
sodium sulfate	8.0
clay	6.0
sodium fluosilicate	5.6
anthracite (coal)	0.8

is charged into glass tank furnace 1 (FIG. 1) where it is melted at a temperature of $1480^\circ \pm 10^\circ\text{C}$ and upon degassing is cooled to a temperature of $1200^\circ\text{--}1300^\circ\text{C}$ at which the glass melt, having a viscosity of 170 poise, is poured over lip 6 (FIG. 2) in a stream, whose width amounts to two-thirds of that of the strip being formed, onto the surface of roll 7 of forming means 2. The liq-

uid glass melt is free to spread along rolls 7 and 8 filling grooves 11 in the exterior surface of lower roll 7. Then it is rolled between the rolls into a strip of a specified width, e.g. 10 mm.

The lower surface of the strip will be covered with intersecting ribs 12 (FIGS. 4, 5) forming a square-faced polycisson structure.

In detaching the strip from the surface of roll 7, the glass material heated to a slightly higher temperature and having accordingly a lower viscosity than the ribs will slack a little at the points of intersection of the ribs, forming point bulges 13 (FIGS. 4 and 5).

Upon forming, the strip is passed to roller conveying means 4 which carries it through lehr 3. While moving over the conveying rollers, the glass strip rests first and foremost on the said point bulges 13, which assures a minimum area of contact of the strip with the conveying rollers.

To provide glass crystallization in the first zone of the lehr the strip is heated at a temperature of 700°C (portion AB in FIG. 7), whereupon its temperature is increased at a rate of 300°C per hour up to 930°C (portion CD). The strip is held at this temperature for 30 min.) (portion DE) which is followed by cooling at a rate of 450° per hour to a 650°C temperature. The process of crystallization will then be terminated and the crystallized strip will undergo tempering at a temperature of $60^\circ\text{--}70^\circ\text{C}$. The cooling rate during tempering amounts to $200^\circ\text{--}300^\circ\text{C}$ per hour.

As the temperature of the strip rises (portion CD), the viscosity of the glass strip tends to decrease (about 10^9 poise). At this time the ribbed construction of the lower surface of the strip, imparting the requisite degree of rigidity to the strip and keeping it from heavy slacking between the rollers, is of prime importance.

Upon completion of the tempering, the strip 9 is severed into workpieces of specified size and shape.

The glass-crystalline material produced has the following chemical composition (percent, by weight):

SiO_2	—	59.0	MnO	—	0.3
CaO	—	23.0	Fe_2O_3	—	0.2
Al_2O_3	—	8.0	Na_2O	—	4.5
MgO	—	1.5	F	—	2.5
and sulfide sulfur (S^{2-})	—	0.5			

Assuring the following properties:

weight by volume, g/cm^3 —2.6

bending strength, kg/cm^2 —1000

compressive strength, kg/cm^2 —5000

rigidity modulus, kg/cm^2 — $0.98 \cdot 10^{-4}$

specific toughness, kg cm/cm^2 —3

abrasive resistance, g/cm^2 —0.01

chemical resistance in 96% H_2SO_4 , percent—99.8

It should be borne in mind that the present invention is in no way limited to the exemplary embodiment described hereinbefore and various modifications can be resorted to by those skilled in the art which fall within the spirit and scope of this invention as defined in the claims which follow.

What is claimed is:

1. A method for the continuous fabrication of glass-crystalline material comprising: melting a $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ system charge suitable for the manufacture of glass-crystalline material; forming the glass material obtained from the melted charge into a strip; producing, in the course of forming, a pattern of intersecting ribs on the lower surface of the strip with the ribs form-

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ing on the said surface a square-faced polycrystalline structure; crystallizing the formed strip in a lehr by heating the strip to a temperature of 900°-980° while the said strip is advanced on a conveying roller through the lehr, tempering the crystallized strip; said ribs being formed with trapezoidal shape in cross-section, not more than 2 mm in depth and width and spaced at a dis-

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tance of at least 5 mm between two adjacent ribs by virtue of which the ribs acquire mechanical strength more rapidly in the course of crystallization than the remaining glass material while the polycrystalline structure formed by the ribs on the lower surface of the strip tends to impart a degree of rigidity to the latter.

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