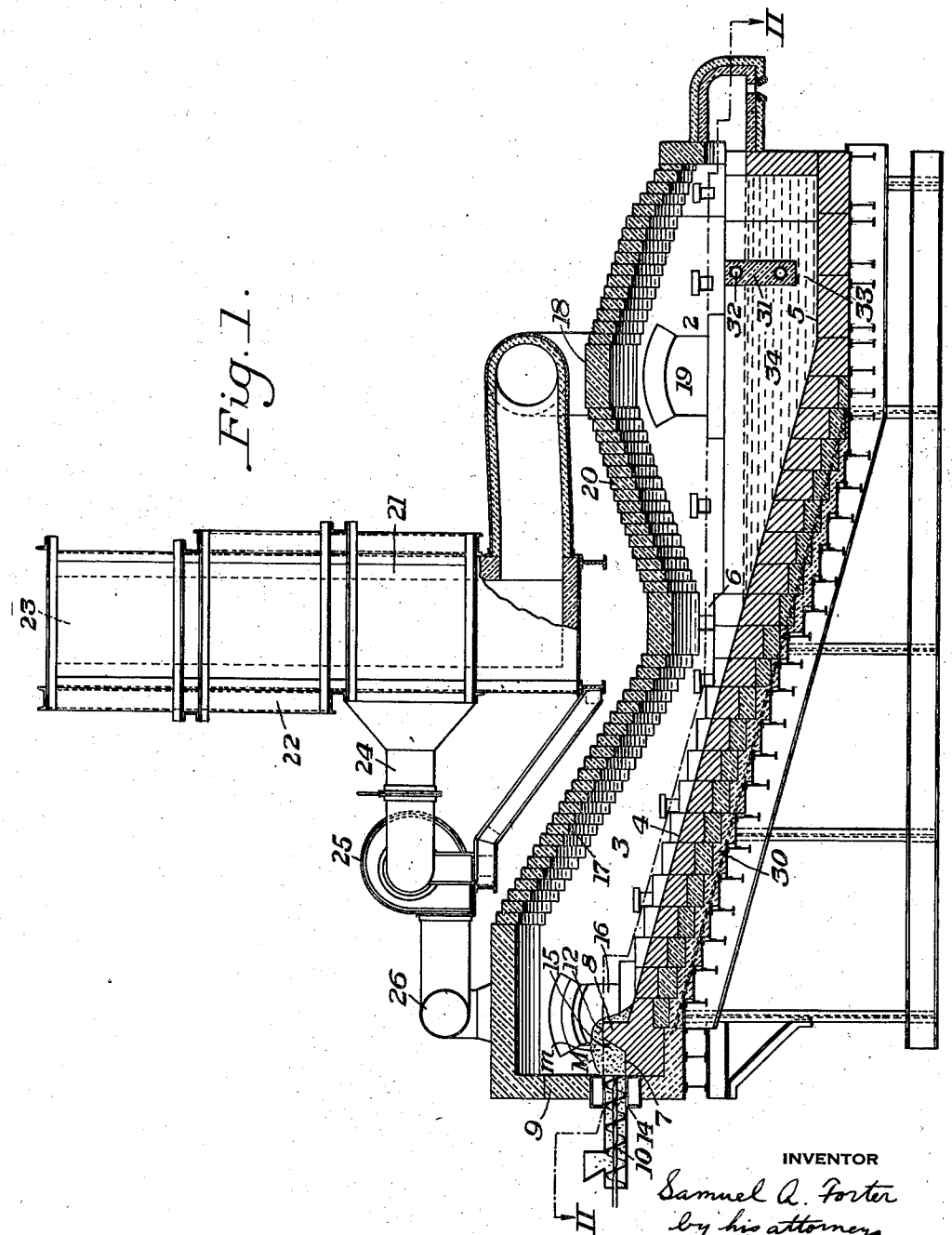
April 27, 1937. S. A. FORTER 2,078,795

METHOD AND APPARATUS FOR MELTING

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Fig. 1.



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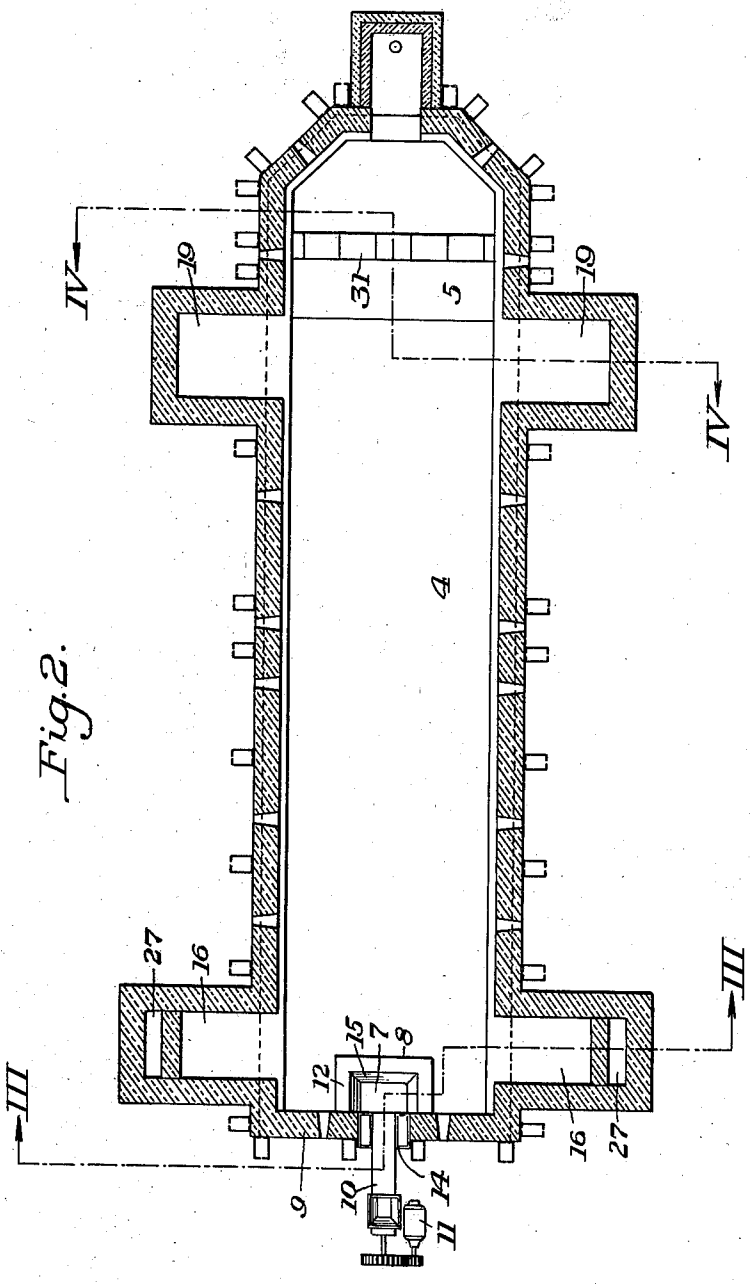


Fig. 2.

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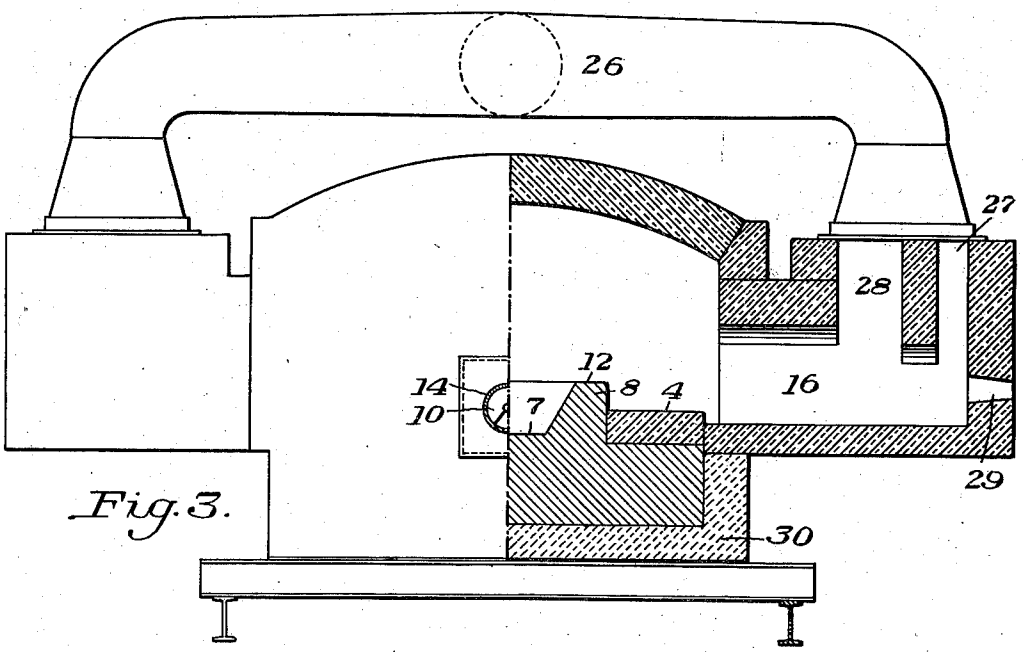


Fig. 3.

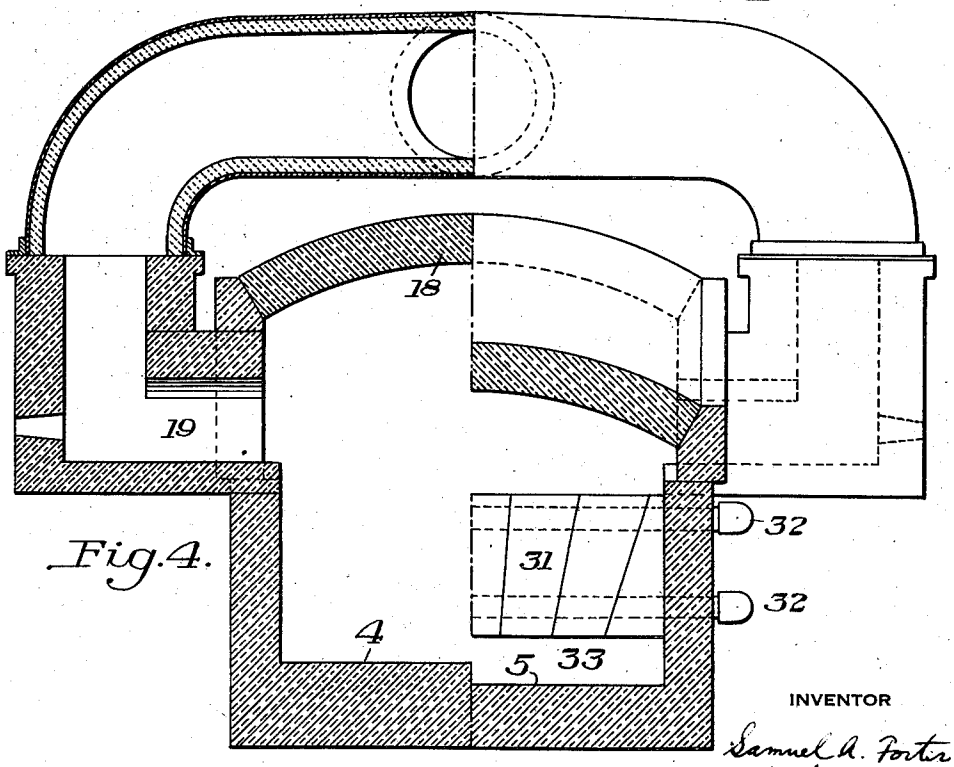


Fig. 4.

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UNITED STATES PATENT OFFICE

2,078,795

METHOD AND APPARATUS FOR MELTING

Samuel A. Forter, Bellevue, Pa., assignor, by mesne assignments, to Hartford-Empire Company, Hartford, Conn., a corporation of Delaware

Application September 6, 1932, Serial No. 631,818
Renewed October 13, 1936

13 Claims. (Cl. 49—54)

The present invention relates broadly to the art of melting, and more particularly to the melting of pulverulent or partly pulverulent material such as glass batch and the like. The present application relates to similar subject matter as that disclosed in my copending application Serial No. 620,651, filed July 2, 1932.

With the usual type of glass furnace, it is customary to charge the batch into the furnace adjacent one end thereof and directly into the bath of molten glass therein. Such a charging operation usually takes place through a doghouse located at one end of the furnace, and as the batch melts it travels progressively from the charging end to the working end. During such travelling, the mass of unmelted batch gradually decreases, it being contemplated that by the time the working end of the furnace is reached the batch will be entirely melted. In some cases, however, complete melting of the glass is not accomplished before the working end of the furnace is reached, with the result that the glass which is being worked from the furnace is not in proper condition for fabrication into sheets, plates or the like, or articles of a blown or pressed nature.

Charging operations of the character referred to are further objectionable for the reason that a portion of the fines constituting the batch are subjected to the draughts within the furnace under such conditions that they are carried about in the furnace atmosphere and, in many cases completely out of the furnace. This is particularly true of the lime and soda content to such an extent that in many factories it is customary to compensate for the quantity of lime and soda thus pulled away by increasing their percentage in the original batch.

With some of the later installations an attempt has been made to overcome difficulties of the character referred to by charging batch material into a furnace adjacent an inclined surface and subjecting it to a melting temperature while maintaining it in a relatively thin and spread out condition. While such a spread out condition is highly desirable from the standpoint of effective melting of the batch, I have found that in order to obtain the best results several conditions must be properly correlated. In the first place, the quantity of batch in unmelted condition should be maintained substantially constant. This requires the fresh batch to be charged into the furnace at substantially the melting rate of the furnace.

In the second place, I have found that the most efficient results can only be obtained where the batch is fed into the furnace in substantially the zone of highest temperature, so that it is initially subjected within the furnace to the highest temperature conditions. While the point of charging the batch is preferably higher than the normal glass level in the working end of the furnace, I have found that the operation of the furnace is materially improved if the feed of batch into the high temperature zone takes place through a side wall of the melting chamber preferably in a plane above the hearth level, and in a plane below the plane of previously charged glass batch within the furnace. In this manner the freshly charged batch moving in a lateral direction into a body of unmelted glass batch continuously displaces the same from the position in which it is supported in substantially the plane of the hearth floor into a plane above the floor.

In the third place, the body of glass batch maintained within the melting chamber should be confined in such manner that the exposed surfaces thereof may be continuously covered by a layer or surface of batch which is at such a consistency as to preclude dissipation of fines in the manner referred to. This condition may be most effectively obtained by imposing an obstacle to the lateral travel of the glass batch, so that the glass batch is maintained within a definite area within the melting chamber, and progressively displacing the glass batch at substantially the rate at which the exposed portion thereof is melted.

The glass batch having been initially subjected to the highest temperature, is then permitted to flow by gravity over the confining wall or walls onto an inclined surface in generally spread out or film-like condition, and is subjected, during its travel over such surface, to the heating action of gases travelling in the direction of glass flow and preferably at a substantially constant velocity.

With a furnace answering the above requirements, it is possible to initiate a charging operation by the use of cullet which is not susceptible to blowing around as is the case with lime, soda and the like. After the desired glazed conditions have been formed on the exposed surface of the charge, batch, or the constituent materials which it is desired to melt, may be substituted for the cullet and the operation continued with the assurance that at all times the upper surface of the unmelted mass within the melting zone or chamber will present a substantially glazed semi-

liquid condition which precludes undesirable dissipation of the constituent materials, and particularly the fines, throughout the furnace.

The desired melting having been obtained, it is desirable that the molten glass be fed into the main body of glass in the working chamber without any abrupt change in its direction, such for example as would be occasioned by movement over a shoulder, edge surface or the like. Such a movement, which is in the nature of a miniature cataract, tends to trap air in the glass. In accordance with my invention, the film of molten glass gradually merges with the main body of glass in the working chamber without any abrupt change in its direction of flow.

It is further desirable that the depth of glass in the pool or main body of glass in the working chamber be gradually increased, and that the velocity of the flow be gradually decreased so as to approach, as closely as possible, a condition that will force a uniform flow of the entire mass of glass through the furnace, without the possibility of pocketing cold or stagnant glass in any part of the unit. To this end, I have found that advantageous results are obtained if the inclined melting surface before referred to is extended continuously downwardly until it intersects the floor in the working chamber. The hearth inclination is preferably constant from the point at which it initially receives the molten glass to such point of intersection, the angle being determined by the rate of flow of glass in molten condition, and such that unmelted glass cannot reach the working chamber.

The present invention further contemplates a construction embodying novel features with respect to the control of the combustion gases, the relative location of the firing ports, charging ports, throat between the melting and working zones, and the position of the offtake port or ports.

In the accompanying drawings I have shown more or less diagrammatically, by way of illustration only, a preferred embodiment of the invention. In the drawings—

Figure 1 is a longitudinal sectional view through one form of furnace constructed in accordance with my invention;

Figure 2 is a horizontal sectional view along the line II—II of Figure 1, looking in the direction of the arrows;

Figure 3 is a transverse sectional view along the line III—III of Figure 2; and

Figure 4 is a detail sectional view along the line IV—IV of Figure 2.

In accordance with the present invention there is provided a glass furnace which comprises generally a working zone **2** and a melting zone **3**. The working zone may be of any usual construction depending upon the particular form of apparatus to be utilized with the furnace, and effective for maintaining the desired body of molten glass therein. The melting zone is of novel construction. It preferably comprises an inclined hearth or melting floor **4**, as clearly shown in Figure 1, which is gradually and uniformly inclined downwardly in a direction toward the working zone, the inclination being continued until the floor **5** of the working zone is intersected.

Intermediate the melting zone and the working zone is a restricted throat **6** constituting a flow connection between the hearth **4** and the body of glass in the working zone **2**, it being noted from Figure 1 that the surfaces **4** and **5** gradually merge one into the other without any abrupt change in the direction of flow thereover, and that the hearth **4** extends throughout an appreciable length of the melting chamber so that the glass therein for such portion of the length of the melting chamber gradually increases in depth.

Such a construction precludes any corners or pockets within which stagnant or cold glass may be collected or pocketed, and insures a substantially uniform flow of the entire mass of glass through the furnace. The velocity of such flow gradually decreases as the depth of glass increases, but the uniformity of flow throughout the width of the melting zone, i. e., from one side thereof to the other, is maintained.

Adjacent its extreme upper end, the hearth is preferably shaped to provide a substantially flat portion **7** which carries an upwardly projecting wall forming a dam **8**. Extending through the end wall **9** of the furnace in a substantially horizontal direction, and preferably in substantially the plane of the level portion **7**, and therefore entirely above the hearth level, is a batch charger **10**. This batch charger is herein illustrated as being of the screw type driven by a suitable motor **11** for continuously feeding batch in regulable quantities depending upon the speed of rotation of the screw.

As will be apparent more particularly from Figure 1 of the drawings, the upper surface **12** of the dam **8** is approximately as high, and preferably higher, than the top of the charging opening **14** within which the screw **10** operates. By reason of this construction, batch charged into the furnace above the level of the hearth through one of the side walls of the melting chamber is caused to impinge against a dam surface, such as the inclined surface **15** in such manner that its direction of movement is changed from a horizontal direction into a generally vertical direction. The dam thus forms a feeding obstruction, and a confining means, which is effective for maintaining a mass of unmelted batch M within the melting chamber the upper surface *m* of which is continually in such condition as to preclude dissipation of the batch materials.

This confined mass of unmelted and previously charged glass batch is subjected to high temperature combustion obtained by the admission of gases through opposed ports **16** on opposite sides of the dam and substantially in line therewith. The burning gases discharged from these two ports meet substantially over the dam, thereby continuously subjecting the upper portion of the mass M to a melting temperature, while the lower portion is supported out of contact with the gases and by freshly charged batch moved laterally into the mass M below the top thereof.

By reference to Figure 1 of the drawings, it will be noted that the entire port area **16** is above the top of the throat **6**, and that the roof **17** of the melting zone gradually converges downwardly until it joins with the roof **18** of the throat **6**. Thus the combustion gases in order to pass from the ports **16** through the throat **6** are caused to move in a definite downward direction which insures maintaining them in intimate heat conducting relationship to the film of melting batch gradually flowing downwardly over the hearth **4**, in such manner that completion of the melting is definitely insured by the time the glass reaches the throat **6**.

In accordance with the preferred embodiment of my invention, the downward sloping of the roof **17** is preferably determined substantially by the rate at which the hot products of com-

bustion, due to cooling, decrease in volume. With such a condition, the velocity of gas flow from the ports 16 to the throat 6 is substantially constant, the decrease in volume of the gases being offset by the decrease in the flow area thus provided.

The batch having been melted, the molten glass and the hot gases travel in intimate contact through the restricted area of the throat 6. During this time, the freshly molten glass gradually merges with the body of glass in the working zone 2, while the products of combustion are permitted to pass to suitable outlet ports 19 communicating with the working zone. During the travel of the molten glass from the throat 6 onwardly through the working zone, the depth of glass gradually increases so that the velocity of the flow gradually decreases to that corresponding to the flow occasioned by the demands on the working chamber. In this manner abrupt velocity changes and the formation of stagnant pools or pockets of glass are obviated.

To those skilled in the art, it will be apparent that the working zone constitutes a refining chamber in which a relatively lazy flow of gases is desirable. To insure this condition, the roof 20 of the working zone slopes upwardly to provide a gradually increasing space for the products of combustion before they reach the discharge ports.

In accordance with the preferred embodiment of my invention, the outlet ports 19 are preferably so disposed that their complete outlet area lies below the inlet area of the ports 16, thereby further insuring a continuous down-draft condition of the products of combustion from the inlet to the outlet ports, with an intimate heat transfer relationship continuously maintained between the heating gases and the batch or melted glass.

In the drawings I have diagrammatically illustrated the outlet gases as passing into a suitable regenerator or recuperator 21 having a suitable air admission opening (not shown) into the space 22 surrounding the hot gas chamber, and a combustion gas outlet 23 at the upper end thereof. In this heat transfer unit the combustion gases give up a large portion of their heat to the air supplied thereto, which air in heated condition is taken off through a suitable connection 24 to an exhauster 25 and delivered to conduits 26 feeding the ports 16. In Figure 3, I have shown the combustion ports as being of such a construction as to provide a primary air flow passage 27 and a secondary air flow passage 28. Communicating with each primary air passage 27 is a gas inlet port 29, so that the gases initially come into contact with a primary portion of the highly heated air, and subsequently mix with the major or secondary portion of this air.

From the foregoing description it will be understood that a furnace constructed in the manner described is characterized by the charging of material to be melted into the melting zone in the region of highest temperature, and then feeding the melting material downwardly in distributed or film-like condition in intimate contact with gases travelling in the same direction and at a substantially constant velocity. By having the point of charge of the materials, such as batch, higher than the normal glass level, and preferably entirely above the highest part of the hearth 4, a gravity feed over the hearth may be continuously maintained.

By properly correlating the speed of the batch charger to the melting rate of the furnace, I may maintain the position and quantity of the mass M substantially constant, the melting surface *m* being continuously re-supplied as the exposed portion thereof melts away.

The downward slope of the roof 17 in the melting zone, in addition to insuring a substantially uniform gas velocity, is further desirable by reason of the fact that as it gradually approaches the hearth, it comes into better and better heat radiating relationship to the film of glass on the hearth. I have found that with a slope such that the flow area varies substantially directly as the decrease in the volume of gases, that the rate of radiation to the glass increases with sufficient rapidity so that substantially the same temperature can be maintained throughout that portion of the hearth extending from the dam 8 to the throat 6. This increased heating by radiation compensates for the decreased heat transfer by convection as the heating gases drop in temperature.

By reference more particularly to Figure 1 of the drawings, it will be noted that the relationship of the parts in the melting zone, the throat, and the portion of the working zone adjacent the throat is such as to provide a generally Venturi shaped structure. In this Venturi shaped structure the contracting portion of the venturi comprises the melting zone wherein the gases are caused to travel with the glass and in intimate contact therewith, and preferably at a substantially constant velocity due to the rate of contraction of this portion. In the throat of the venturi, which throat constitutes the point of gas offtake for the melting zone, and which is lower than the point of inlet for the heating gases to the melting zone, the same intimate relationship is continued. In the expanding portion which is formed by the roof 20 and the continuation of the hearth 4, the velocity flow of both the glass and the gases is gradually decreased. This gives the desired lazy flow conditions to the gases in the working zone and accomplishes the decrease in glass velocity without any abrupt changes or disturbance in the direction or manner of flow such as would tend to trap air or otherwise disturb the desired conditions.

By initially charging a furnace of this construction with cullet so as to obtain a glaze substantially continuously over the hearth 4, and particularly on top of the incoming batch characterized by the batch M, I can thereafter maintain a molten or glazed surface continuously by substituting batch for cullet.

By charging the batch into the melting chamber above the hearth level, and providing a dam or the like which opposes the uncontrolled scattering of the charge, it is always possible to maintain within the melting chamber an unmelted mass into one side of which, and below the top of which the fresh charge may be fed into the melting chamber.

In order to minimize to as great an extent as possible any heat losses through the hearth 4, I preferably shield it by a suitable layer of insulation 30.

By reference to Figure 2 of the drawings, it will be noted that the furnace herein provided in addition to having a hearth which gradually merges with the bottom of the working chamber, also has a substantially constant width throughout the melting zone, the throat and the working zone. This constancy is desirable in

that it eliminates the possibility of more or less stagnant bodies of glass wherein devirtrification is likely to occur. While the working zone, as before pointed out, may be of any desired construction, depending upon the conditions under which the furnace is to operate, I have herein illustrated a construction including a jack arch **31** extending transversely of the furnace and preferably comprising refractory blocks through which extend water cooling pipes **32** not only for giving increased life to the arch, but for the purpose of supporting it rigidly in position. This arch serves to effectively skim the glass flowing through the restricted opening **33** between the bottom of the arch and the bottom **5** of the working zone, thereby maintaining a body of molten material **34** in the best possible condition for use.

For purposes of a better understanding of the invention, I have illustrated and described it as applied specifically to the melting of glass wherein the constituent batch materials are fed to the melting zone. The construction of the parts is such, however, that many of the features may be advantageously utilized in the melting of other materials, and to this end it will be noted that many of the claims are directed broadly to a method or apparatus for melting without regard to the particular material which is being melted.

In the preceding description, the advantages of the invention have been fully pointed out.

While I have herein illustrated and described a preferred method and apparatus for carrying out my invention, it will be understood that changes in the construction and relationship of the parts may be made without departing either from the spirit of my invention or the scope of my broader claims.

I claim:

1. In the method of making molten material, the steps comprising subjecting constituent material to a melting temperature while maintaining it in a relatively thin and spread out condition, maintaining a bath of like material of gradually increasing depth for working purposes, and gradually merging the thin and spread out material with the molten material in said bath while decreasing the rate of flow of the merging materials.

2. In the method of making molten material, the steps comprising supplying constituent material to a furnace, thereafter feeding the material in thin and spread out condition in a downwardly inclined direction away from the point of supply while subjecting the thinly spread-out material to a melting temperature, maintaining a bath of the molten material, and causing the flow of molten material to join such bath and gradually deepen therein at such uniform rate that the underside of the moving mass of molten material is downwardly inclined continuously to the base of said bath.

3. In a glass melting apparatus, a furnace comprising a working zone effective for containing a body of molten glass in molten condition, and a melting zone for supplying glass thereto, said melting zone comprising an inclined hearth extending down to the glass level of the working zone and said working zone having an inclined glass flow surface for receiving the molten material from the hearth and extending from the hearth in substantially the plane thereof to intersect the bottom of the working zone, there being a restricted throat intermediate said zone.

4. In a method of melting glass in which a body of molten glass is maintained in working condition, the steps comprising subjecting the constituent material to a melting heat in a melting zone on an inclined hearth extending downwardly to the glass level of the working zone, and receiving the molten material in the working zone from said hearth on a flow surface inclined downwardly below the glass level in substantially the plane of the hearth.

5. In a method of melting glass, the steps comprising maintaining a body of molten glass in working condition in a working zone, subjecting constituent material to a melting heat on an inclined hearth extending downwardly to the level of the glass in the working zone, receiving the molten material from said hearth in said working zone on an inclined flow surface extending beneath the glass level in substantially the plane of the hearth, and passing hot gases over the material on the hearth in the direction of flow of the material and at substantially a constant rate of flow throughout at least a portion of the travel of the hot gases.

6. In the method of making molten material, the steps comprising supplying constituent material to a furnace in substantially the zone of highest temperature therein, and causing it to flow from said zone over a downwardly inclined refractory support while subjecting it to a melting temperature and while maintaining it in thin and spread-out condition, maintaining a working zone of molten material, and merging the flowing material in thin and spread-out condition with the molten material in the working zone without abrupt change in its direction of flow.

7. In the method of melting, the steps comprising charging constituent material into a furnace at substantially the melting rate of the furnace, directing hot gases onto the material to melt the same, spreading the material out, passing it downwardly over an inclined refractory support in thin spread-out condition, and merging the flow over said support into a body of molten material in a working zone without abrupt change in its direction of flow.

8. In the method of melting, the steps comprising charging constituent material into a furnace at substantially the hottest portion thereof, directing hot gases onto the constituent material to melt the same, spreading the material out, causing it to flow over an inclined support in thin and spread-out condition, and merging the thin and spread-out body of material with a molten mass without abrupt change in its direction of flow.

9. In the method of melting, the steps comprising charging constituent material into a furnace at substantially the hottest portion thereof, directing hot gases onto the constituent material to melt the same, spreading the material out, causing it to flow over an inclined support in thin and spread-out condition, causing the heating gases to travel in contact with said material and in substantially the direction of flow thereof, and merging the thin and spread-out body of material with a molten mass without abrupt change in its direction of flow.

10. In a glass melting apparatus, a furnace comprising a working zone effective for containing a body of molten glass in working condition,

and a melting zone for supplying glass thereto, said melting zone having a downwardly inclined glass flow surface and said working zone having a receiving portion with a bottom continuing the inclination of said glass flow surface without abrupt change in the direction of flow as the glass is received therefrom within the working zone.

11. In a glass melting apparatus, a furnace comprising a working zone effective for containing a body of molten glass in working condition, and a melting zone for supplying glass thereto, said melting zone having a downwardly inclined glass flow surface and said working zone having a receiving portion with a bottom continuing the inclination of said glass flow surface without abrupt change in the direction of flow as the glass is received therefrom within the working zone, there being a restricted throat intermediate the melting zone and the working zone.

12. In a glass melting apparatus, a furnace comprising a working zone effective for containing a body of molten glass in working condition, and a melting zone for supplying glass thereto, said melting zone having a downwardly inclined glass flow surface and said working zone having a receiving portion with a bottom continuing the inclination of said glass flow surface without abrupt change in the direction of flow as the glass is received therefrom within the working zone, means for supplying combustion gases in the melting zone at one elevation, and means for withdrawing the combustion gases from the melting zone at a lower elevation.

13. In the method of making molten material, the steps comprising subjecting constituent material to a melting temperature and causing it to flow along a downwardly inclined supporting surface while still subjecting it to a melting temperature and while maintaining it in a relatively thin and spread-out condition, maintaining a bath of like material in molten condition for working purposes, and merging the thin and spread-out material with the molten material in said bath without abrupt change in its direction of flow.

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