

Nov. 3, 1942.

L. S. LONGENECKER

2,300,426

GLASS MELTING FURNACE

Filed June 29, 1940

2 Sheets-Sheet 1

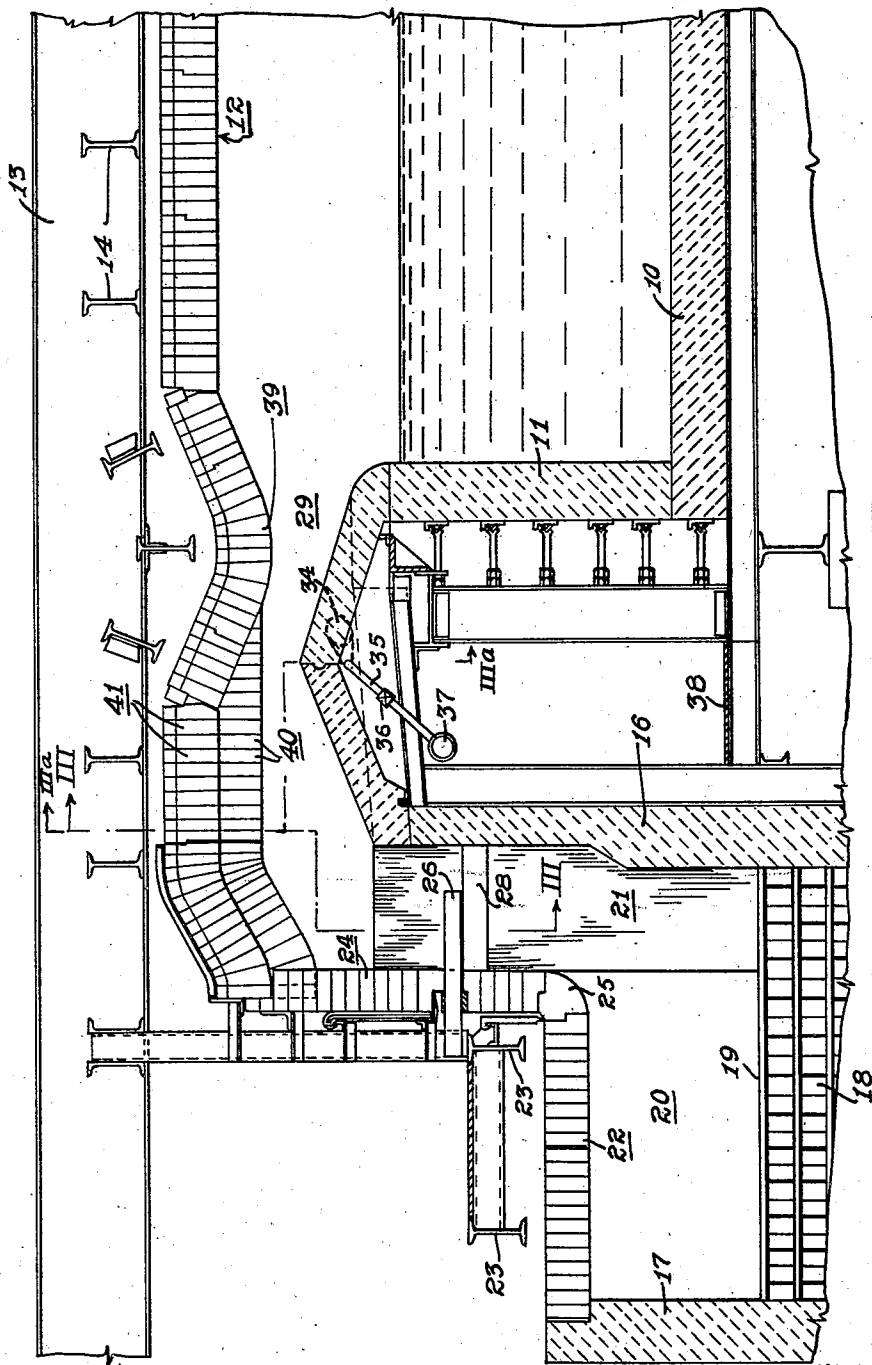


Fig. 1.

INVENTOR  
Levi S. Longenecker  
By Green & McCallister  
His Attorneys

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2 Sheets-Sheet 2

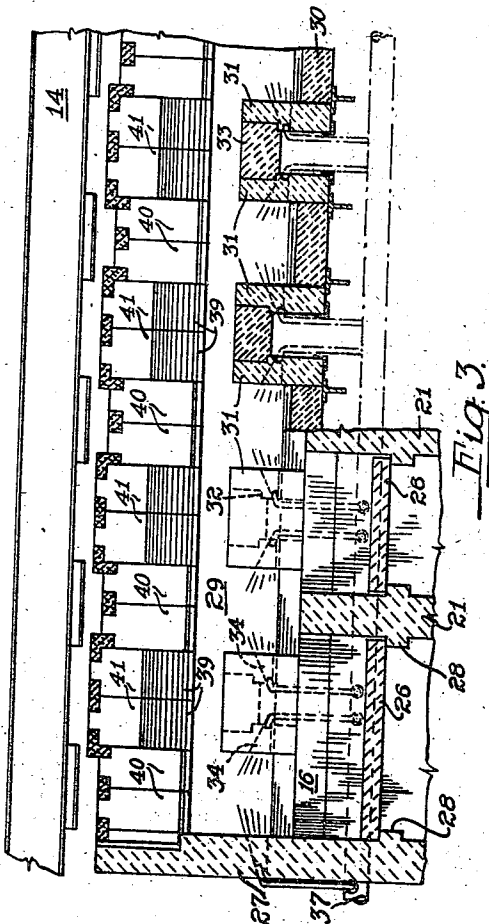


Fig. 3.

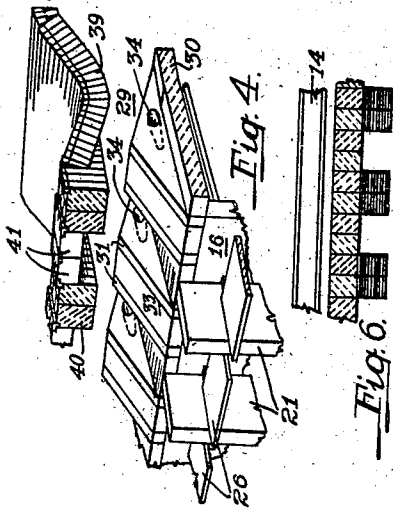


Fig. 4.

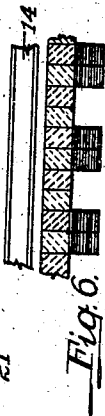


Fig. 6.

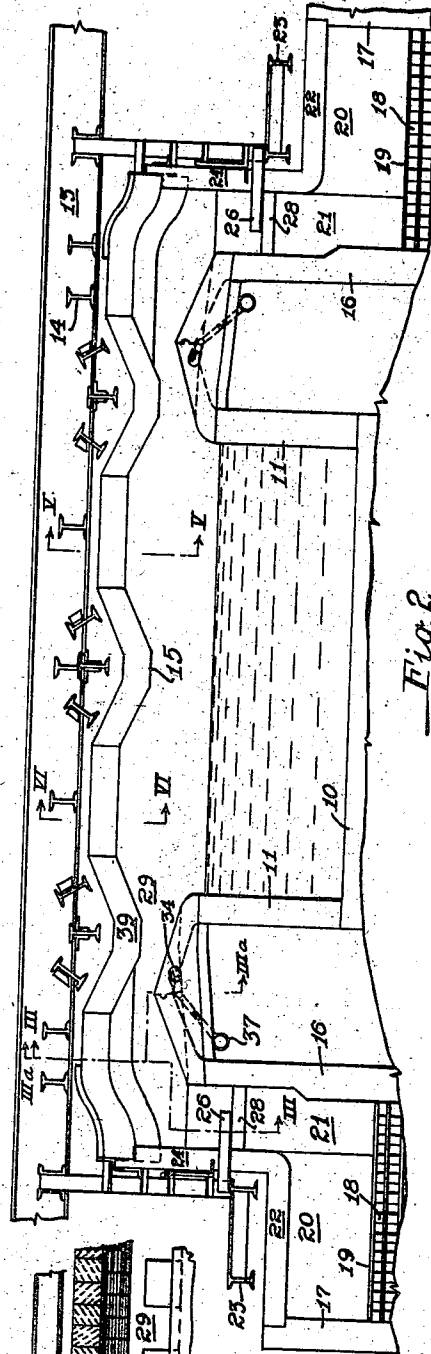


Fig. 2.

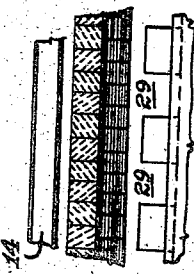


Fig. 5.

INVENTOR  
Levi S. Longenecker  
By  
Green & McCallister  
His Attorneys

## UNITED STATES PATENT OFFICE

2,300,426

## GLASS MELTING FURNACE

Levi S. Longenecker, Mount Lebanon, Pa.

Application June 29, 1940, Serial No. 343,186

23 Claims. (Cl. 49—54)

This invention relates to continuous tank type glass melting furnaces, to ports and roofs for such furnaces, and to the roofs of the regenerators forming part of such furnaces.

While the prior patent art discloses furnaces of this type which are provided with what may be termed long continuous ports, none of these structures, so far as I am aware, are used in commercially successful furnaces.

Among the patents referred to are such as Crowley Patent 1,828,830 and Drake Patent 1,828,833, of October 27, 1931; Mambourg Patent 1,860,045, of May 24, 1932, and Showers et al. Patent 2,010,419, of August 6, 1935.

The Crowley, Drake and Mambourg patents disclose roofs of the sprung arch type for both the furnace and regenerators, while the Showers et al. patent discloses suspended roof structures both for the furnace chamber and the regenerators.

While the advantages of so-called long continuous ports have been recognized, and designs for the same have been known for some years, as witnessed by the above patents, no furnaces utilizing any such ports are, so far as I am aware, in actual use today. The furnaces in use today employ individual relatively short ports, and while suspended roofs for the furnace and regenerative chambers are disclosed in at least one of said patents, no commercial furnace employing roofs of this type and long continuous ports, so far as I am aware is now in operation.

Since furnaces of the type here contemplated are reversed during operation, the ports not only serve to deliver the combustible mixture—made up of fuel and preheated air—to the furnace chamber, but serve as outlet ports for the hot products of combustion as they leave the furnace chamber on their way to the regenerative chambers adjacent thereto.

If not in all, at least in a large majority of the commercially successful furnaces of the type here contemplated using natural gas or oil as fuel the fuel is introduced through burner blocks placed in the side walls of the ports in such a way as to direct the fuel jets or streams into the preheated stream of air passing through the port. It has been found by experience that the burner blocks when placed in the sides of the ports have a much longer effective life than when placed where they are directly in the path of the outgoing hot products of combustion.

In commercial practice, the individual ports have been lengthened from time to time until

some have now reached a length of about seven feet, but these are still using burner blocks which are located in the sides, or what may be more properly termed the ends thereof. This, however, has necessitated a much increased velocity in the fuel passing through the burner blocks, and, as a result, has quite materially shortened the life of the ports and the furnace roof. Aside from this, this high port velocity is the cause of a shadow or cold spot on the glass bath immediately in front of each port. The burner blocks at the ends of these seven foot ports are not able to provide a flame which reaches from end to end of the said ports. There are in fact two distinct flame streams, one located adjacent each port end, with an air stream located between them.

An object of this invention is to produce a practical long substantially continuous port structure for furnaces of this type, by means of which it is possible to obtain a ribbon of flame extending throughout the length of the port and which will cover the whole surface of the glass bath, thereby eliminating shadows or idle glass surfaces found between individual ports in present day commercial furnaces.

Another object is to produce a port and roof for glass melting furnaces which will not only simplify the construction of such furnaces, but which will establish a stream line flow of air and gas and thus permit greatly increased operating efficiency.

A still further object is to produce improved suspended roof structures, not only for the heating chamber, but for the regenerative chambers as well.

A still further object is to produce a suspended roof structure for glass melting furnaces of the type under consideration which will cause a turbulence in the heating flames adjacent the longitudinal center line of the furnace for the purpose of insuring complete combustion of the unburned fuel passing the longitudinal center line of the furnace so that the temperature will be uniform across the heating chamber from port to port.

A still further object is to produce a suspended port roof and knuckle by means of which the flame can be so anchored as to eliminate any cold spots in front of the port.

A still further object is to produce a port construction such that the distance between the port floor and roof can be accurately based on the desired port velocity.

Another object is to produce a heating furnace chamber roof structure by means of which it is possible to place the roof at the proper height above the glass level to obtain the maximum permissible B. t. u. release per cubic foot of furnace volume.

Another object is to produce a suspended roof and port knuckle structure for glass melting furnaces by means of which maximum B. t. u. release may be uniformly obtained throughout the furnace heating chamber above the glass bath.

In the present day commercial glass melting furnaces because of the type of ports and the type of furnace roof used, the heating chamber from incoming to outgoing ports is not of uniform temperature. The temperature in the heating chamber above the bath adjacent the outgoing ports may vary from that adjacent the incoming ports as much as from 400° to 500° and due to the spotty method of firing utilized in commercial furnaces, certain local spots obtain the maximum B. t. u. release while other spots obtain no appreciable B. t. u. release. This makes a spotty and inefficient operation, and a further object of this invention is to produce a glass melting furnace in which a uniform and high B. t. u. release may be obtained throughout the entire width of the combustion space between ports.

These and other objects, which will be apparent to those skilled in this particular art, I attain by means of the structures described in the specification and illustrated in the drawings accompanying and forming part of this specification.

In the drawings:

Figure 1 is a fragmentary transverse vertical section of a continuous tank type glass melting furnace embodying this invention. This view illustrates about one half of the furnace above the regenerator checkers.

Fig. 2 is a transverse vertical section similar to Fig. 1 but illustrates the full width of the furnace above the regenerator checkers and embodies a modification in the roof structure adjacent the longitudinal center line of the furnace, whereby the turbulence above referred to is obtained.

Fig. 3 is a composite view in vertical section with the left-hand half taken on the line III—III of Figs. 1 and 2 and the right-hand half taken on line IIIa—IIIa of Figs. 1 and 2 with portions of the support structures omitted.

Fig. 4 is a perspective view illustrating the port floor and roof structure as viewed from the left side of Figs. 1 and 2.

Fig. 5 is a view partially in section and partially in elevation and is taken on line V—V of Fig. 2 looking toward the outlet side of the port on the right-hand side of Fig. 2; and

Fig. 6 is a fragmentary sectional view of still another modified form of roof structure for producing turbulence adjacent the longitudinal center line of the furnace and is taken on line VI—VI of Fig. 2.

In the furnace chosen as an embodiment of this invention, 10 represents the refractory floor or bottom of a furnace tank of usual construction. 11—11 represent the refractory side walls of the tank. 12 represents my flat suspended roof made up of interlocking refractory tile or blocks such as broadly disclosed in Patent 1,590,303 issued to me on June 29, 1926. The tile or roof blocks are preferably supported from transverse and longitudinal beams 13 and 14, by

means of hangers as disclosed in Patent 1,913,168 issued to me on June 6, 1933.

In the modified form of roof structure disclosed in Fig. 2, the knuckle 15 which preferably extends along or adjacent the longitudinal center line of the roof throughout the length of the boiling and degassing zones of the furnace, is made up of refractory blocks or tile as broadly disclosed in my Patent 1,890,303, and are supported by hangers as disclosed in my Patent 1,913,168.

A vertically extending refractory wall 16 spaced from each tank side wall 11 forms one vertical wall of one of the regenerative chambers, which are shown as of the horizontal type and which have an outer wall 17, checker bricks 18 and a horizontal floor 19 extending over the top of the checker bricks and which divides the regenerative chambers into checkerwork chambers and upper longitudinally extending chambers 20 thereabove and which serve as the manifold for feeding the regenerator uptakes.

The regenerator uptakes are provided with vertically extending partition walls 21 which enter the chamber 20 and have the effect of vanes for causing an even upward flow of the air which is preheated in the checker chambers. The roof 22 of each regenerative chamber is preferably formed by refractory tile or blocks such as broadly disclosed in my Patent 1,590,303 and these are preferably suspended from longitudinal beams 23 in the manner disclosed in Patent 2,126,901 issued to me on August 16, 1938.

The vertical wall 24 of each regenerator uptake portion is formed of interlocking refractory blocks such as above referred to and these are preferably supported in the manner disclosed in Patent 1,977,799 issued to me on October 23, 1934. A row or course of nose blocks 25 joins roof 22 and vertical wall 24 and is preferably constructed and supported in the manner disclosed in said last patent.

Adjustable sliding dampers or gates 26 positioned between vertical partitions 21 of each regenerator uptake portion and between the end partitions 21 and the end walls 27 of the regenerative chamber, are slidably supported on ledges formed for that purpose in said partitions and end walls.

Port 29 which embodies this invention, is preferably of a length equalling the length of the boiling zone of the furnace or the degassing zone thereof as the case may be; there preferably being separate ports for each of these zones, but if desired my continuous port may embrace both such zones. Of course, each such zone has ports on opposite sides thereof which alternately serve as inlet ports and outlet ports as is usual.

The floor of each port 29 is formed of alternately arranged high and low portions as shown in Fig. 4 which bridge the gap between vertically extending walls 11 and 16 of the tank and regenerators respectively.

The low portions are formed by refractory slabs 30 which in the main are horizontal, but which incline somewhat from wall 11 to wall 16 as shown in the drawings, in order to provide suitable drainage for refuse deposited thereon during the time the ports serve as outlet ports.

Each high portion of the floor is formed of two triangularly shaped blocks 31—31 which are spaced apart and which are supported by vertical walls 11 and 16 and bridge the gap therebetween. These tile are provided with shoulders 32 which parallel their top edges and which form

supports for tile or blocks 33 which close in the space therebetween and form covers or roofs for the high portions of the floor. Tile or blocks 31 are in effect burner blocks, since each is provided with an outwardly tapering fuel orifice 34 into the narrow end of which a fuel pipe 35 discharges a spray of fuel such as oil or a stream of natural gas. These sprays or streams can be regulated by means of valve 36. A fuel supply line 37 which extends through the space between walls 11 and 16 beneath the port floor connects with fuel pipe 35.

Walls 11 and 16 of the tank and checker chambers respectively are supported and braced in the usual manner as diagrammatically illustrated in Fig. 1. The space between said walls, which is provided as usual with a cat walk 38, gives access to the burner pipes and valves as well as to the furnace blocks and the support means for walls 11 and 16.

From the above, it will be seen that my port floor is crenelated and that the crenelles and merlones or cops extend through the port from the inlet to the outlet side thereof. It will also be apparent that the fuel sprays or streams are fed into those portions of the air stream which traverse the crenelles and that the burner orifices being located as they are in the side walls of the merlones or cops are as favorably positioned as are the fuel orifices in the present day commercial furnaces of the type here contemplated. In other words, the burner blocks do not form target walls for the hot products of combustion while ports 29 are being used as outlet ports.

The roof of my port 29 is formed by a depending knuckle 39 which extends the full length of the port and is made up of rows or courses of refractory tile or blocks such as broadly disclosed in my Patent 1,590,303 and which are preferably suspended as disclosed in my Patent 1,913,168. This knuckle in conjunction with the port floor acts as a venturi and increases the air velocity to a point where it is greater than the velocity of flame propagation and thus anchors the flame within or adjacent the throat of the venturi.

The furnace roof or rather that part of the furnace roof located between one of the knuckles 39 and the adjacent vertical or apron wall 24 of the uptake portion of the adjacent regenerator chamber, is made up of alternately arranged courses of long tile or blocks 40 and short tile or blocks 41. These courses of long blocks in effect provide guiding vanes which extend from knuckle 39 to vertical wall 24 and prevent side slipping of the pre-heated air stream as it flows from the regenerator uptake to port 29.

The arrangement of the long and short blocks or tile 40 and 41 with relation to the crenelles and merlones of the port floor is clearly shown in Figs. 3 and 4 of the drawings.

It will be noted that the suspended roof 22 of the regenerators is located a considerable distance below the port floor and that the regenerator uptakes which are divided into flues by partitions 21 are of materially less cross sectional area than the cross sectional area of chamber 20 which serves as a manifold for the same. From this it will be understood that the velocity of the pre-heated air flowing upwardly through the uptake is sufficiently increased to make the port and roof guiding vanes most effective in combing the top and bottom surfaces thereof into parallel lines of flow. The fuel streams, which are also parallel, contact the underside of the air stream with a minimum amount of interference. This improves

the luminosity of the flame and also prevents any localized hot spots.

The air stream preheated in the regenerator not only contacts with, and blankets the furnace roof and the knuckle 39, but portions of such stream flow through the crenelles and it is into these portions that the fuel is directed through the burner orifices.

The oppositely directed fuel streams entering each crenelle meet, and, deflecting one another, are directed toward the port outlet. The air stream portions traversing the crenelles in which combustion is initiated, and the deflection of the fuel streams, combined with the expansion due to this initial combustion, causes the fuel and air streams traversing the crenelles to fan out laterally so as to overlap the merlones or cops at the tank or outlet end of port 29, thus producing a continuous ribbon of the combustible mixture of air and fuel.

As the upper or main portion of the air stream flowing in contact with the roof of the port formed by knuckle 39 is deflected downwardly by the knuckle so that its lower portion comes in contact with the ribbon of fuel and thus aids combustion, it produces a ribbon of flame which completely covers the surface of the bath in front of the port.

The upper section of this air blanket protects the knuckle as well as the heating chamber roof from direct flame impingement. This not only prevents carbon deposits but excessive wear and tear on the refractories forming the knuckle and the furnace roof or crown.

Dampers or gates 26 for the regenerator uptakes are utilized for varying the amount of air supplied to different sections of port 29: it being readily understood that it will generally be necessary to provide heavier firing for certain sections of the port than for others, especially where the port is utilized in the boiling zone of the furnace. By using these dampers for controlling the air, and valves 36 for controlling the fuel, I in effect establish zones within each port, which zones receive different volumes of combustible mixture. These zones extend across the furnace from port to port and the combustible mixture supplied to each zone is so directed by my port floor and knuckle that a uniform mixture of fuel and air is supplied throughout the full width of each zone, whereby I secure the maximum permissible B. t. u. release above every square foot of glass or batch located therein.

The fluted structure of the port floor which in effect divides the lower portion of the air stream into parallel branches, prevents side slipping of the stream toward either end of my continuous port and causes the continuous flame issuing from the port outlet to travel straight across the furnace chamber.

These floor vanes hold the air and fuel streams in parallel lines and thus direct them across the tank, with a minimum of turbulency. This minimum of turbulency greatly increases the flame luminosity which is the type most desired in glass working. These parallel streams also serve as flame temperature controllers by holding back the too fast intermixing of air and fuel.

The guiding means formed by long roof blocks 40 also aids in preventing side slipping of the combined stream of air and fuel traversing the port.

By introducing the fuel into the crenelles of my continuous port, I am able to operate with a

much lower fuel pressure than used in the present day commercial glass melting furnaces.

It will be apparent that knuckle 39 can be placed at just the proper position to locate the shadow or cold spot so that it falls on the port floor instead of the surface of the glass directly in front of the port, as it does in the present day commercial type of furnace. These cold spots are not only idle surfaces, but are especially harmful in the boiling zone.

With the continuous ports of this invention, it is possible to locate the point of heaviest firing so that it will at all times completely blanket the boiling zone and particularly the foam line. These continuous ports also eliminate the cold spots on the glass bath which occur between the ports of the present day commercial furnaces of this type.

By utilizing knuckle 15 which extends along or adjacent the longitudinal center line of the zone in which my ports are used, that is, along the center line of the boiling zone or the center line of the degassing zone, as the case may be, or along the center line of both of these zones, I definitely establish a point of turbulence which completes the mixture of any unburned fuel and air. This final rapid mixing insures complete combustion of all of the fuel before it enters the port which at the time is serving as the outlet port and provides a uniform temperature across the furnace chamber from port to port. This is important because combustion which is completed in the outlet ports is not only wasteful of fuel and loss of temperature ahead of the port, but adds to the wear and tear on the refractories.

This turbulence-producing knuckle, instead of being continuous as in Fig. 2, may be formed, if desired, as disclosed in Fig. 6, that is, with alternating flat and knuckle sections. Such a construction will not only produce turbulence, but the knuckle sections will serve as guiding vanes to keep the flame from side slipping.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A glass melting furnace including a furnace chamber and a tank for molten glass located below said chamber, a suspended roof for said chamber which while flat in the main is provided adjacent its longitudinal center line with a suspended crenelated knuckle which serves not only to create turbulence but to prevent side slipping of the fuel traversing the heating chamber.

2. In a glass melting furnace including a furnace chamber and a tank for a molten glass bath located below said chamber, a suspended roof for said chamber, which while flat in the main is provided adjacent its longitudinal center line with a downwardly extending knuckle.

3. In a glass melting furnace including a furnace chamber and a tank for a molten glass bath located below said chamber, a suspended roof for said chamber, which while flat in the main is provided adjacent its longitudinal center line with a portion which is located closer to the glass bath than the flat portion thereof.

4. In a glass melting furnace including a furnace chamber and a tank for a molten glass bath located below said chamber, a suspended roof for said chamber, which while flat in the main, is provided adjacent its longitudinal center line with a suspended turbulence-creating knuckle.

5. In a glass melting furnace of the type having a heating chamber, a tank below said chamber for containing a bath of molten glass, an air

preheating regenerator on each side of said tank, and ports for alternately discharging into opposite sides of said chamber and above the molten bath level in said tank, a combustible mixture of fuel and preheated air, a structure for each such port comprising a floor extending from the uptake of the adjacent regenerator to the adjacent tank side and having cop-like high portions alternating with crenelle-like low portions throughout the length of the port, and a suspended knuckle-like roof section above said floor, in combination with means for discharging fuel into those portions of the preheated air stream traversing the crenelle-like low portions of the floor.

6. In a glass melting furnace of the type having a heating chamber, a tank below said chamber for containing a bath of molten glass, an air preheating regenerator on each side of said tank, and ports for alternately discharging into opposite sides of said chamber and above the molten bath level in said tank a combustible mixture of fuel and preheated air, a structure for each such port having a floor extending from the uptake of the adjacent regenerator to the adjacent tank side and comprising cop-like high portions and crenelle-like low portions alternating therewith throughout the length of the port, and a suspended knuckle-like roof section above said floor, in combination with means for discharging fuel through the sides of the cop-like high portions and into those portions of the preheated air stream traversing the crenelle-like low portions.

7. In a glass melting furnace of the type having a heating chamber, a tank below said chamber for containing a bath of molten glass, an air preheating regenerator on each side of said tank, and ports for alternately discharging into opposite sides of said chamber and above the molten bath level in said tank, a combustible mixture of fuel and preheated air, a structure for each such port having a floor extending from the uptake of the adjacent regenerator to the adjacent tank side and comprising cop-like high portions each having a top and spaced and ported side walls, and crenelle-like low portions alternating with said high portions throughout the length of the port, and a suspended knuckle-like roof section above said floor, in combination with means for discharging fuel through the ports of said high portions for mixing with those portions of the preheated air stream traversing said low portions.

8. In a glass melting furnace of the type having a heating chamber, a tank for molten glass beneath said chamber, air regenerators on opposite sides of said tank and relatively long ports on opposite sides of said chamber for discharging into said chamber air preheated in said regenerators, each such port having its upper wall formed as a suspended knuckle-like roof section and its lower wall or floor made up of low portions alternating with hollow high portions each having more or less triangularly shaped and spaced ported side walls and a top which slopes downwardly in opposite directions from its approximate center line, and means for discharging fuel through said side wall ports and into the preheated air traversing said low portions.

9. In a glass melting furnace of the type having a heating chamber, a tank beneath said chamber for molten glass, air regenerators on opposite sides of said tank having vertically extending uptakes, and relatively long side ports

for discharging into said chamber air preheated in said regenerators, a suspended roof for said heating chamber and which includes knuckle-like portions which form the roofs or tops of said ports, and a section which extends outwardly from each knuckle over the adjacent regenerator uptake and is provided with vanes for preventing side-slipping of the preheated air passing from said uptakes to said ports.

10. A relatively long port structure for discharging preheated air into the heating chamber of a glass melting furnace, comprising a knuckle-like roof or upper wall and a crenellated floor in which the cops and crenelles alternate throughout the length of the port whereby an air stream traversing said port is formed into alternating relatively shallow and relatively deep portions arranged side by side, in combination with means for discharging fuel into the relatively deep portions of the air stream.

11. A relatively long port structure for discharging preheated air into the heating chamber of a glass melting furnace, comprising a knuckle-like roof or upper wall and a crenellated floor in which the cops and crenelles alternate throughout the length of the port; the construction and arrangement being such that an air stream traversing said port is formed as a continuous air blanket extending from end to end of the port with depending deep portions joined to and depending from said blanket; said relatively deep portions being spaced apart throughout the length of the port, in combination with means for discharging fuel into opposite sides of each of said deep portions of the fuel stream and below said blanket.

12. In a glass melting furnace heating chamber, a suspended roof which, while flat in the main is provided adjacent opposite sides and adjacent its longitudinal center line with suspended knuckles, and port floors below the side knuckles and which with said knuckles form ports for discharging fuel and air into the furnace chamber.

13. In a glass melting furnace of the type having a heating chamber, a tank for molten glass below said chamber, air preheating regenerators on opposite sides of said tank and relatively long ports on opposite sides of said chamber for discharging into said chamber air preheated in said regenerators; each of said ports having a floor made up of low and hollow high portions alternately arranged throughout its length and a knuckle above said floor forming the top of said port, which is substantially straight from end to end of the port and is spaced a distance above the tops of said high portions, in combination with means for discharging fuel through the side walls of said hollow high portions and into the spaces above said low portions.

14. The combination of a regenerator chamber having an offtake extending vertically above the same and of materially less horizontal area than that of the regenerator chamber, a suspended roof section over the regenerator chamber, a suspended roof section over the offtake and a sectionally supported vertical wall connecting said roof section:

15. In a glass melting furnace, a suspended roof provided at one side thereof with a knuckle, which, cooperating with a port floor therebeneath forms a port for discharging preheated air into the furnace, a regenerator chamber having an offtake which, extending vertically above the same, is of materially less horizontal area than

the horizontal area of said chamber and is adapted to supply preheated air to said port, a suspended low level roof section above the regenerator chamber, a suspended roof section above said offtake, and a sectionally supported vertical wall connecting the roof sections above said regenerator chamber and said offtake.

16. In a glass melting furnace, a suspended roof provided at opposite sides thereof, with knuckles, which, co-operating with port floors therebeneath form ports for discharging preheated air into the furnace, regenerator chambers on opposite sides of the furnace, and each having an offtake which, extending vertically above the same, is of materially less horizontal area than that of its regenerator chamber, for supplying preheated air to the port on its side of the furnace, a suspended low level roof section above each regenerator chamber, a suspended roof section above each offtake and having guide vanes for preventing side slipping of the preheated air, and sectionally supported vertical walls connecting the roof sections above the regenerator chambers and said offtakes.

17. In a glass melting furnace having a furnace chamber, a suspended roof for said chamber, and which on one side thereof has a knuckle, which, co-operating with a port floor therebeneath, forms a port for discharging preheated air into the furnace chamber, a regenerator chamber on one side of the furnace, and having an offtake, which extending vertically above said regenerator chamber, is divided into separate flues by vertically extending partitions, a suspended roof section above the regenerator chamber, a suspended roof section above said offtake and which has guiding vanes extending from said offtake to said port to prevent sideslipping of the preheated air, and a sectionally supported vertical wall connecting the roof sections above said offtake and said regenerator chamber.

18. In a glass melting furnace having a furnace chamber, a suspended roof for said chamber, and which on one side thereof has a knuckle, which, co-operating with a port floor therebeneath, forms a port for discharging preheated air into the furnace chamber, a regenerator chamber on one side of the furnace, and having an offtake which extending vertically above the same, is divided into separate flues, a suspended roof section above the regenerator chamber, a suspended roof section above said offtake and which has guiding vanes extending from said offtake to said port to prevent sideslipping of the preheated air, a sectionally supported vertical wall connecting the roof sections above said offtake and said regenerator chamber, and means extending through said vertical wall for independently controlling the effective area of said flues and therefore the delivery of preheated air to said port.

19. In a furnace of the type having a heating chamber with side ports, air regenerators on opposite sides of said chamber and each having a vertically extending uptake for discharging through said ports air preheated in said regenerators, a suspended roof for said heating chamber having a section which extends outwardly over each regenerator uptake and is provided with vanes for preventing sideslipping of the preheated air passing from said uptakes to one of said ports.

20. In a furnace of the type having a heating chamber, an air regenerator having a vertically extending uptake, a port for discharging into

said chamber air preheated in said regenerator, a suspended roof for said heating chamber and which includes a knuckle-like portion which forms the roof of said port, and a roof section which extends outwardly from said knuckle over the regenerator uptake and is provided with vanes for preventing sideslipping of the preheated air passing from said uptake to said port.

21. A glass melting furnace including a furnace heating chamber and a tank for molten glass located below said chamber, a roof for said chamber which, while flat in the main, is provided adjacent its longitudinal center line with a depending crenellated knuckle which serves not only to create turbulency, but prevents sideslip-

ping of the fuel traversing the heating chamber. 22. A glass melting furnace including a furnace chamber and tank for molten glass located below said chamber, a roof for said chamber which, while flat in the main, is provided adjacent its longitudinal center line with a downwardly extending knuckle.

23. A glass melting furnace including a furnace heating chamber, a tank for molten glass located below said chamber, a roof for said chamber which, while flat in the main, is provided adjacent its longitudinal center line with a turbulency-creating knuckle.

LEVI S. LONGENECKER.