Oct. 18, 1938. D. G. MERRILL 2,133,784

METHOD OF AND APPARATUS FOR ANNEALING GLASSWARE

Filed Sept. 22, 1936 2 Sheets-Sheet 1

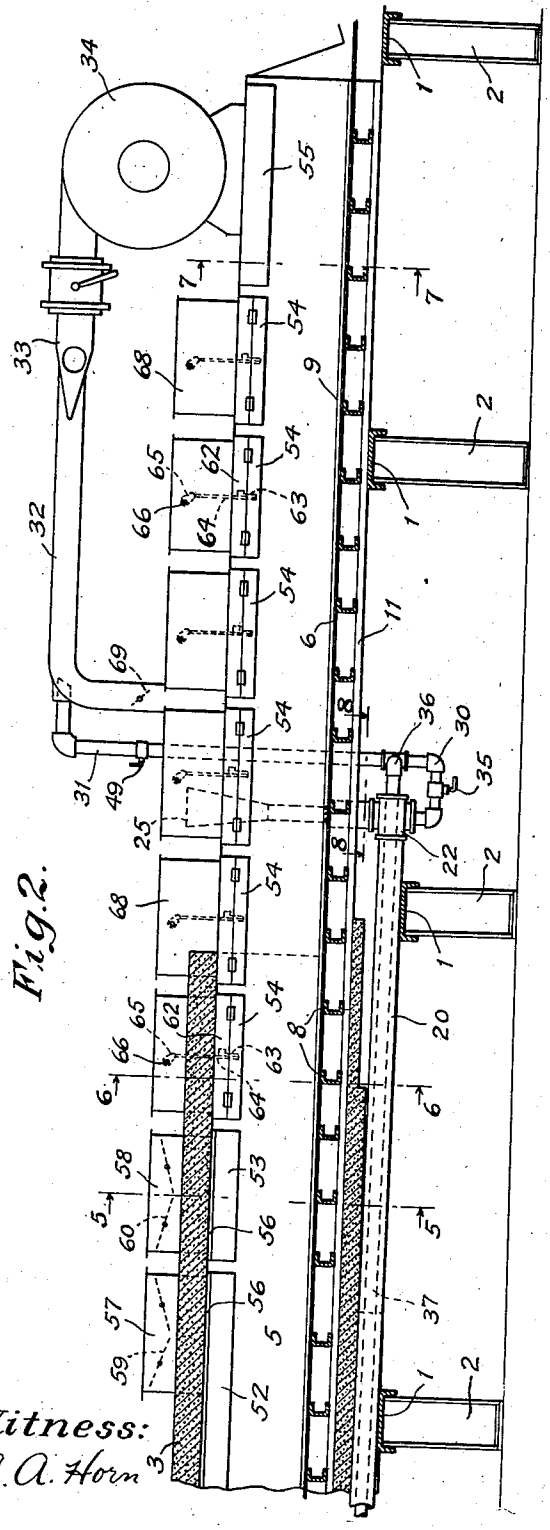

Fig. 2.

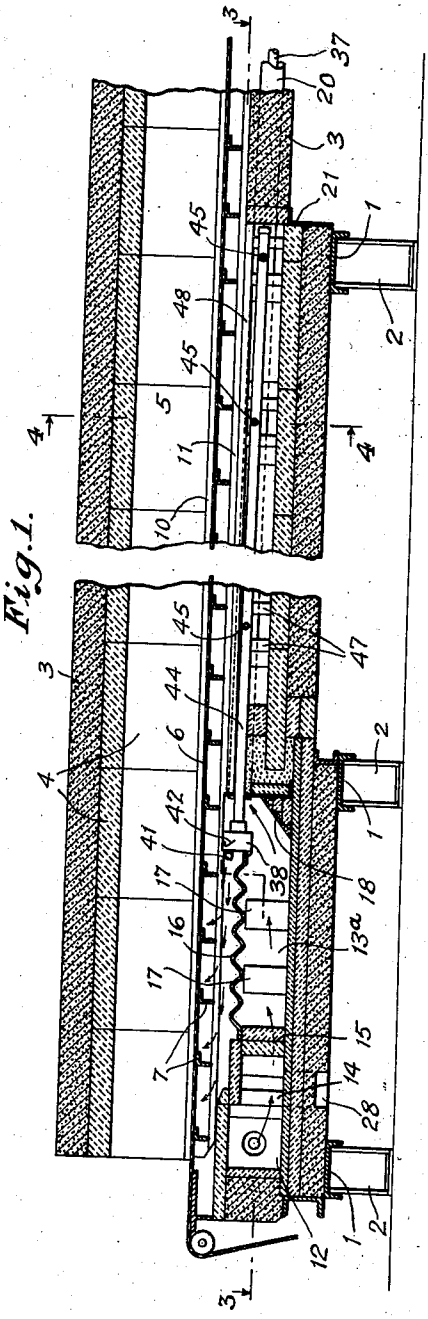

Fig. 1.

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Fig.3.

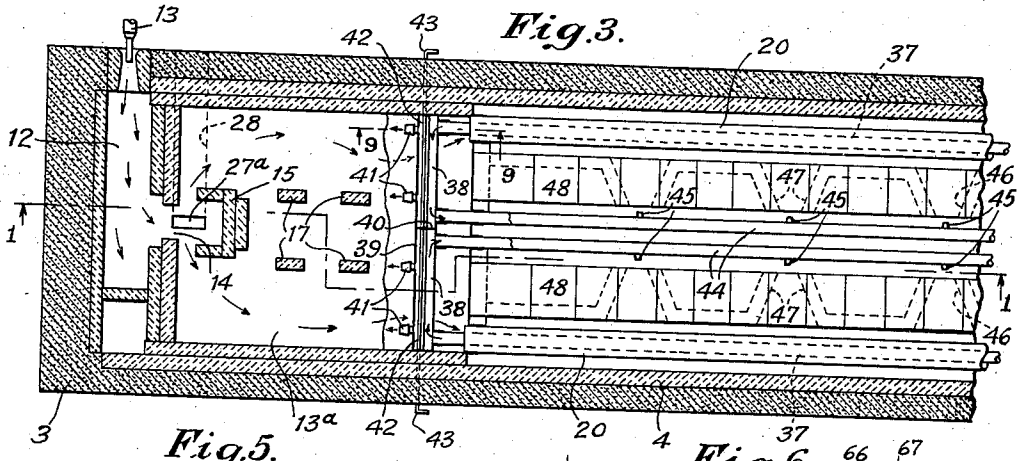


Fig.5.

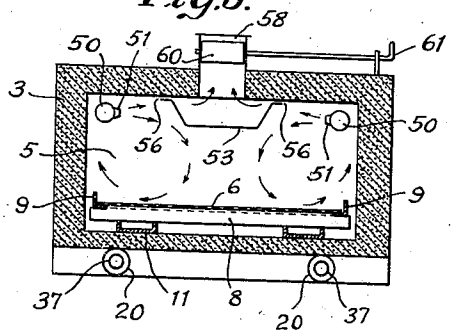


Fig.6.

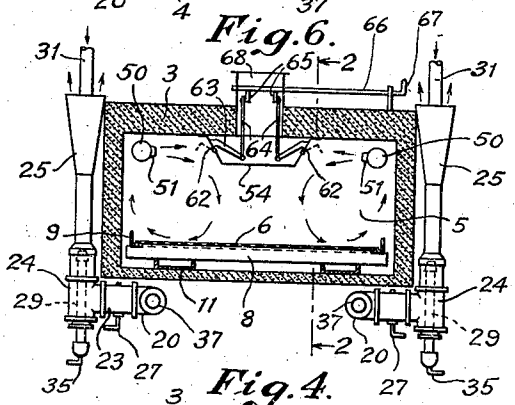


Fig.7.

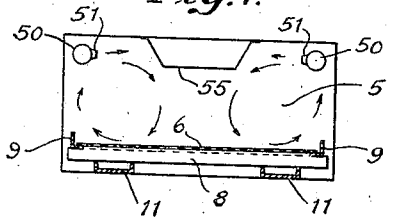


Fig.4.

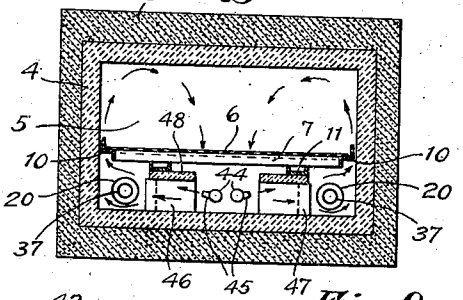


Fig.8.

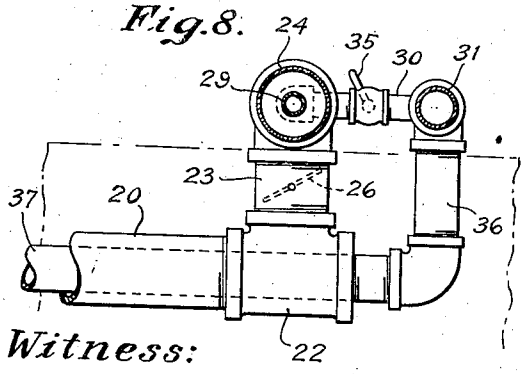
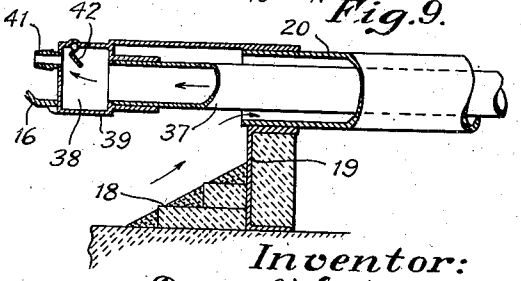


Fig.9.



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Patented Oct. 18, 1938 2,133,784

UNITED STATES PATENT OFFICE

2,133,784

METHOD OF AND APPARATUS FOR ANNEALING GLASSWARE

Donald G. Merrill, West Hartford, Conn., assignor to Hartford-Empire Company, Hartford, Conn., a corporation of Delaware

Application September 22, 1936, Serial No. 101,926

23 Claims. (Cl. 49—47)

This invention relates to a method of and an apparatus for annealing glassware and more particularly to a method of operating and the constructing of glassware annealing lehrs in which the temperature of the ware is controlled by products of combustion or other heated media which pass longitudinally of the tunnel in a manner to supply heat by radiation to the ware passing therethrough and at the same time in such fashion that a part of the heat of the media is transferred to air, which is thereafter injected into the tunnel in such manner as to create therein predetermined desired circulatory currents, the direct radiant and indirect heat supplied to the tunnel and the circulatory currents therein controlling the temperature gradient of the ware during its passage throughout the annealing portion at least of the tunnel.

My present invention comprises a continuation in part of my prior and copending application, Serial No. 66,611, filed March 2, 1936, for Method of and apparatus for annealing glassware.

Among the objects of the present invention are to provide a lehr of the general type disclosed in my said copending application, but in which products of combustion, which may be passed in heat transferring relation with the ware in the lehr, are maintained out of direct contact with such ware. Thus, for example, any desired fuel, including oil, may be employed in the generation of the products of combustion without injuriously affecting the ware being annealed. This is further facilitated by the provision according to the present invention of but one burner as contrasted with a plurality of relatively small burners employed in the device of my said copending application.

A further object of the invention is to provide a method and an apparatus for annealing glassware as above generally set forth in which a maximum part of the heat of the fuel used is employed in an advantageous fashion in annealing the ware by utilizing this heat both directly by radiation to supply heat to the tunnel through muffled passages, and indirectly to heat air which is later circulated in the tunnel by utilizing certain at least of the passages as heat interchangers. It is a further object to so locate certain at least of the muffle passages as to supply heat to the portions of the tunnel where it is principally required, namely, adjacent to the sides at the lower portion of the tunnel, so as to offset heat losses through the sidewalls and to maintain substantially uniform temperatures transversely of the tunnel.

A further object of the present invention is to provide in a lehr of the character hereinabove set forth for the control of temperatures laterally of the lehr at various portions thereof, either to accommodate non-uniform lateral loading of the lehr and consequent desired non-uniform lateral heating and/or cooling thereof or to provide for the establishment and maintenance of uniform conditions laterally of the lehr where the normal tendency would render these conditions non-uniform.

Other and more detailed objects of the present invention will become apparent from the following specification and appended claims, when taken in connection with the accompanying drawings, in which:

Figure 1 is a view substantially in longitudinal vertical section on the line 1—1 of Fig. 3 and with a part at the center broken out, showing the hotter or annealing portion of a lehr embodying my invention;

Fig. 2 is a view similar to Fig. 1 of the cooling portion of the lehr taken substantially on the line 2—2 of Fig. 6;

Fig. 3 is a view of the hotter portion of the lehr in horizontal section taken substantially on the line 3—3 of Fig. 1;

Fig. 4 is a view in transverse vertical section taken substantially on the line 4—4 of Fig. 1;

Fig. 5 is a view in transverse vertical section taken substantially on the line 5—5 of Fig. 2;

Fig. 6 is a view in transverse vertical section taken substantially on the line 6—6 of Fig. 2;

Fig. 7 is a view in transverse vertical section taken substantially on the line 7—7 of Fig. 2;

Fig. 8 is a fragmentary view of certain of the piping associated with the lehr in horizontal section taken substantially on the line 8—8 of Fig. 2; and

Fig. 9 is a fragmentary detail view partly in vertical section on the line 9—9 of Fig. 3.

The lehr which I have chosen to illustrate in the accompanying drawings is constructed with or upon a rigid structural frame work including longitudinally extending channel members (not shown), which are connected at intervals along the lehr by transverse channels 1, these channels being supported upon suitable legs 2, which in turn may rest upon the floor of the plant in which the lehr is installed or upon any other suitable support. If desired, suitable rollers or castors (not shown) may be employed in association with each of the legs or supports. I have, however, not illustrated any such means as they are now

in common use in the art and per se involve no invention on my part.

The hotter portions of the lehr tunnel are built upon a structural frame work including the channels 1 and within a casing, usually of sheet metal, and comprise insulating material 3 and relatively rigid heat resistant blocks 4, which form the sides and top of the tunnel, special provisions being made as hereinafter more fully described for forming the bottom of the tunnel 5 in the hotter portion thereof. The cooler portion of the tunnel 5 shown at the right in Fig. 2 is preferably uninsulated and is constructed of suitable metallic structural members and sheets. Ware is conveyed through the tunnel upon an endless belt 6, which is preferably of open work metallic material. Specifically I prefer to use a belt of helical wound wire such as is now in common use in annealing lehrs. The belt 6 may be drawn through the tunnel by suitable belt driving mechanism (not shown), but which may, for example, be constructed as disclosed in the patent to Mulholland, No. 1,560,481, granted Nov. 3, 1925. As the driving means for the belt 6 form per se no part of the present invention, I have not illustrated them in the accompanying drawings.

The belt 6 is supported in its passage through the lehr upon a plurality of spaced structural members comprising angles 7 in the hotter portion of the lehr, as seen in Fig. 1, and channels 8 in the cooler portion thereof, as seen in Fig. 2. These angles and channels are suitably secured to longitudinally extending structural members as more particularly described in my copending application above referred to and including, for example, angles 9 (Fig. 5) or Z-shaped members 10 (Fig. 4). The belt supporting structure is preferably formed in a plurality of independently removable sections as disclosed in my said copending application. This structure is supported upon and may be suitably secured to longitudinally extending channels 11. The belt supporting means thus provides adequate support both laterally and longitudinally for the belt 6, while permitting free flow of tunnel atmosphere therethrough and about all sides of the ware being transported through the tunnel.

Means are provided for supplying heat to the lehr in a manner which is in effect muffled. This permits of the use of any desired types of fuel including those which will produce combustion products of the type which it is desired to keep out of contact with the ware being annealed, for example, certain types of fuel oils. It also permits the use of more efficient combustion methods, as all the fuel may be burned at one place. For this purpose there is provided adjacent to the forward end of the lehr a combustion chamber 12 (Figs. 1 and 3) to which fuel or a mixture of fuel and air is supplied through a burner diagrammatically illustrated at 13, the burning fuel and the products of combustion flowing in the direction of the arrows in Figs. 1 and 3. The combustion chamber 12 debouches into a muffle chamber 13a substantially coextensive in width with the tunnel, through a passage 14, there being a baffle 15 in the chamber 13a opposite the passage 14. The combustion chamber 12 and the chamber 13a may be formed of blocks of suitable refractory material, this construction also being used for a part of the roof of the chamber 13a. The remainder of the roof of the chamber 13a (as shown) may comprise a corrugated member 16, which may be of thin ceramic or metallic material and which is supported at intervals upon pillars 17 intermediate the sides of the lehr. The right hand end of the chamber 13a as shown in the drawings is formed of an inclined refractory wall generally indicated at 18 and a vertical wall formed in part of refractory material and in part of a structural metal member shown at 19 (see Fig. 9).

The products of combustion pass from the chamber 13a through two longitudinally extending passages 20 formed as relatively large diameter pipes, these passages or pipes being located as shown adjacent to the floor or bottom of the tunnel, vertically below the path of the ware and adjacent to the side walls of the lehr. As will be obvious from the drawings, the pipes 20 are in direct heat radiating relation with the ware passing through the tunnel up to the jog 21 in the tunnel bottom, which is located substantially at the end of the annealing zone proper of the lehr, that is, the point along the lehr where it is contemplated that the ware will be cooled at least down to its "low annealing temperature".

The "low annealing temperature" of glassware is that temperature below which permanent strains cannot be introduced or reintroduced into the ware, due to the fact that glass below this temperature is so rigid that no further molecular rearrangement can take place therein. Below this temperature temporary strains may be introduced into the ware, but these will disappear upon the ware being finally cooled. However, any permanent strains which have not been removed at the time the ware has reached this "low annealing temperature" will be present in the finished articles to the same extent that they are present in the ware when it passes through this "low annealing temperature".

The passages or pipes 20 pass through a part of the insulation 3 surrounding the tunnel beyond the jog 21 for a certain distance, after which they emerge to the outside as best shown in Fig. 2 and terminate in pipe fittings best shown at 22, Fig. 8. The products of combustion thence pass laterally through nipples 23 to vertically extending T-members 24, Fig. 6, which lead to exhaust passages 25, one at each side of the lehr as shown. In each nipple 23 there may be arranged suitable flow controlling means, here shown as a butterfly damper 26, controlled by a handle 27. Thus the total amount of the products of combustion may be controlled by suitable adjustment of the control means (not shown) associated with the burner 13, while the relative amounts of the products of combustion passing down the opposite sides of the lehr may be controlled by the adjustment of dampers 26 to afford a lateral control of the heat supplied to the lehr.

Associated with the fire box 12 or more particularly with the chamber 13a, there is an inlet 27a for air from the outer atmosphere to provide a desired amount of secondary air and/or to provide for the dilution of the products of combustion to bring them to a desired temperature. The inlet 27a communicates with a laterally extending passage indicated in dotted lines in Fig. 3 at 28 and also shown in Fig. 1. This passage opens to the side of the lehr and may be controlled by a suitable damper (not shown). If desired there may be located in the passage 27a a means (not shown) by which incoming air may be directed more or less to one side or the other selectively. Such a means is disclosed in the

patent to Wm. T. Honiss, No. 1,849,037, granted March 8, 1932.

For insuring a positive draft through the passages just described, there is preferably provided some suitable draft inducing means. In the present instance this means comprises ejector nozzles 29 associated with the members 24 and 25 on each side of the lehr and supplied with air through passages 30 and 31 from air supply passages 32 and 33 (Fig. 2) leading from a suitable fan 34 and controlled by dampers associated with handles 35 (Figs. 2 and 8) to afford independent control for the two sides of the lehr. The fan 34 may be driven from any suitable prime mover, which in the usual case comprises an electric motor (not shown).

Means are preferably provided for preheating air which is thereafter to be introduced into the tunnel in a manner more specifically hereinafter to be described. The air preheating not only serves to impart heat to the air by heat interchange, but also serves to control the temperature gradient of the hot products of combustion which pass along the lehr as aforesaid. For this purpose a branch pipe 36 (Figs. 2 and 8) leading from each of the air supply pipes 31 communicates with a concentric pipe 37 in and extending longitudinally of each of the passages or pipes 20. The pipes 37 communicate at their ends nearer the ware-entering end of the lehr with respective side chambers 38 (Figs. 3 and 9) formed as portions of a divided header 39, the division being shown at 40 (Fig. 3). Associated with each of the chambers 38 are a plurality of nozzles 41 (Figs. 1, 3 and 9). Flow of air through the nozzles 41 is controlled independently for each side of the lehr by the provision of dampers 42, each of which is controlled by a handle 43.

The remainder of the preheated air is conducted from the chambers 38 into longitudinally extending pipes 44, one of which is associated with each of these chambers. The pipes 44 are provided at spaced intervals therealong with nozzles 45. The pipes 44 extend longitudinally of the lehr and substantially up to the jog 21 in the bottom thereof and adjacent to the center of the tunnel beneath the path of the ware therethrough (Figs. 3 and 4). The nozzles 45 are arranged to direct jets of air laterally, and as shown in Fig. 4, slightly upwardly in respect to the horizontal, the air in the tunnel 5 being circulated thereby through passages 46 formed by diverging vertical walls 47 and horizontal walls 48 which may be formed of tiles, as shown. The circulation of air induced by the jets from nozzles 45 is laterally from the center toward the sides of the tunnel and around the pipes 20, which conduct the hot products of combustion as aforesaid, so that the circulating air is further heated at this point. The circulating heated air then flows upwardly along the sides of the tunnel to oppose the normal tendency for loss of heat through the sides, thence toward the center above the path of the ware, and thence downwardly through the path of the ware to be recirculated by the inductive action of the jets from the nozzles 45. This circulation is shown by the arrows in Fig. 4.

At the forward zone of the lehr, i. e., above the muffle chamber 13a and the fire box 12, the air from the nozzles 41 moves forwardly beneath the path of the ware, some of this air passing out through the entrance end of the tunnel and serving at this end to oppose any tendency of the relatively cool atmospheric air to flow into the tunnel where it might interfere with the maintenance of a desired temperature gradient. Another part of this air returns rearwardly of the tunnel and is recirculated by the inductive action from the jets from the nozzles 41 and in an orbital path generally longitudinal of the tunnel. Thus, there is in the present lehr a circulation in the hotter portions of the tunnel substantially similar to that disclosed in my said copending application, with this difference that the medium being circulated in the present instance is air and does not contain any products of combustion, whereas in my copending application the products of combustion were themselves circulated and recirculated in the tunnel.

Also, there will not only be a lateral control of the air supplied to the tunnel toward the entering end thereof through the nozzles 41, but also there is provided according to my invention a lateral control of the circulations transversely of the tunnel caused by the inductive action of the nozzles 45. There may be for this purpose valves 49 provided in the pipes 31 or 36;

The lehr also has associated therewith a cooling means, which is substantially the same as the cooling means shown and described in my aforesaid copending application, this cooling means being associated with the portions of the tunnel beyond the portion shown in Fig. 1, most of which is illustrated in Fig. 2, and in transverse section in Figs. 5, 6 and 7 which show the details of the structure of Fig. 2. In order to render the present description complete, this cooling means will be briefly described.

Cooling is generally effected by the provision of means by which cooling air is circulated in directions generally transverse of the tunnel and in substantially orbital paths, which may be considered as starting adjacent to the upper side corners of the tunnel, thence toward the center above the path of the ware, where the air is deflected downwardly through the path of the ware, thence again toward the sides of the tunnel and thence upwardly to be recirculated by the inductive action of the jets by which cooling air is continuously introduced into the tunnel. In association with this induction and circulating means, there are means provided at intervals longitudinally of the tunnel for drawing off controllable amounts of air from the circulation as aforesaid, these means being located above the path of the ware and substantially centrally of the tunnel.

More specifically, there is provided along each of the upper side corner portions of the tunnel a longitudinally extending pipe 50 (Figs. 5, 6 and 7). With these pipes there are associated a plurality of jet nozzles 51, part of which are directed at 90° to the axis of the associated pipes and transversely of the tunnel, so as to direct air toward the center thereof, while some of which may be directed also generally transversely of the tunnel, but slightly toward the entering end thereof, so as to assist in inducing an inflow of atmospheric air at the cooler or exit end of the tunnel.

Associated with the roof of the tunnel and in alignment with the paths of the jets from the nozzles 51 are a plurality of deflector members 52, 53, 54 and 55. The deflector members 52 and 53 are stationary in position and have no movable parts, these deflector members having their inclined lateral side portions spaced a predetermined distance from the roof of the tunnel, as best shown in Figs. 2 and 5, to provide openings

56 into the interior of the deflector members from which the air may be withdrawn through outlet ports 57 and 58 associated with deflectors 52 and 53 respectively. These outlet ports are respectively controlled by mating damper members 59 and 60, which may be controlled by suitable manual operating means as indicated at 61, Fig. 5. The deflector 52 has a longitudinal extent greater than that of the outlet port 57 associated therewith and in practice extends several feet along the lehr toward the entrance end thereof. The deflector member 53 is of substantially the same longitudinal extent as the port 58 associated therewith. It will be understood that the amount of air withdrawn through the ports 57 and 58 may be controlled by the dampers 59 and 60, so as to control the temperature gradient or the cooling in the portions of the lehr with which deflector members 52 and 53 are associated.

Deflector members 54 have upper portions 62 of their side walls pivotally connected to the lower stationary portions thereof and arranged to be adjusted in respect thereto to control the width of the opening between these hinged portions and the roof of the tunnel and thereby to control the amount of air deflected from the circulation in the tunnel. For this purpose the hinged portions 62 have associated therewith rigid arms 63, which are connected by links 64 to cranks 65 secured to transversely extending rock shafts 66, these rock shafts being provided with handles 67 at suitable points accessible from the side of the lehr. As shown, there are six similar deflector members 54, each of which has associated therewith an outlet port 68, flow through which is controlled by the hinged deflector portions 62 just described.

The deflector member 55 is not provided with any outlet means, but is merely a stationary deflector member constructed of sheet metal or any other suitable material as best shown in Figs. 2 and 7.

By the use and proper adjustment of the cooling means provided and specifically by the control of dampers 69 in the vertical portions of pipes 32, which conduct air to the longitudinally extending pipes 50, I am enabled independently laterally to control the degree of cooling effected by the cooling means in the cooling portion of the tunnel. Furthermore, due to the fact that some of the nozzles 51, particularly those adjacent to the exit end of the lehr, are inclined somewhat forwardly, air will be induced into the exit end of the tunnel and caused to flow counter-currently in respect to the ware, so as to provide the desired type of cooling. Also, due to the fact that the coolest air in the circulation is caused to flow toward the center and thence downwardly through the ware at the regions spaced from the side walls thereof, the ware nearer the center of the belt may be maintained at the same temperature as the ware at the sides, which tends normally to cool more quickly.

Thus, I have provided a lateral control of the cooling, which in conjunction with the lateral control provided for the heating means and circulating means in the hotter portions of the lehr, affords a lateral control substantially throughout the length of the lehr. Thus, for example, if one side of the lehr is loaded with ware of a different average weight than that loaded on the other side, the annealing conditions may be so adjusted in respect to the weights of the ware on the two sides of the belt that all the ware may be properly and uniformly annealed. On the other hand, if the normal conditions transversely of the lehr would tend to be dissimilar, while the loading of the ware on the belt is substantially uniform from side to side, I am enabled to obtain uniform temperature conditions transversely of the lehr. Such a condition may arise, for example, when the lehr is positioned adjacent to a hot body on one side, as a glass melting tank, while the other side is closed to a relatively cold region, as for example the side wall of the factory. Under these circumstances the normal rate of heat dissipation through the hotter wall is less than that through the colder wall and it is desirable that the heating and cooling of the lehr be so adjusted as to compensate for this difference. This may be effected by the use of apparatus constructed in accordance with the present invention.

In the hotter portion of the lehr the region or zone above the fire box 12 and the muffle chamber 13a may be considered as a "soaking zone", i. e., a zone where it is desired that the ware be brought to and maintained at a given temperature for the release of permanent strains. The next relatively long zone of the lehr may be considered as that from the end of the muffle chamber 13a substantially to the jog 21. During its passage through this zone, the ware is allowed to cool through its critical temperature range, that is, down to the "low annealing temperature" as defined above. This may be termed the "annealing" zone of the lehr. The remainder of the lehr is primarily devoted to the cooling of the ware down to the desired handling temperature. Here the temperature gradient is controlled as to cool the ware at a rate usually somewhat faster than that in the annealing zone in order that the device operate efficiently, while at the same time keeping the rate of cooling within the permissive limits, such that the ware is at no time subjected to such heavy temporary strains as might cause rupture of the ware being annealed. This cooling of the ware may be advantageously effected by the proper control of the transverse circulation of cooling air as just described, sufficient air being withdrawn from the tunnel at the various zones through the ports 57, 58 and 68, so that a desired cooling gradient is provided.

While I have shown for the purpose of illustrating my present invention but one embodiment thereof, I contemplate that many changes may be made therein and equivalents substituted for individual parts or features herein specifically described. I do not wish to be limited, therefore, except by the scope of the appended claims, which should be construed as broadly as the state of the prior art permits.

I claim:

1. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing a relatively highly heated fluid medium longitudinally of a portion of the tunnel in heat-transferring relation with the ware passing therethrough but out of contact with the ware, preheating air by heat derived from said fluid medium, and thereafter introducing and recirculating such air in and generally transversely of the tunnel through the path of the ware and in contact therewith to control the temperature gradient of the ware passing through the tunnel.

2. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing a relatively highly heated

fluid medium longitudinally through a portion of the tunnel in heat-transferring relation with the ware passing therethrough but out of contact with the ware, and recirculating air in the tunnel by introducing air thereinto in a longitudinally extending median zone of the tunnel below the path of the ware and in directions such that the air is introduced into the tunnel in such zone toward the lateral side walls and caused to flow thence up the side walls, toward the center of the tunnel above the path of the ware, and thence downwardly through the path of the ware and spaced from the sides of the tunnel to be recirculated by the air being introduced into the tunnel, and during the circulation of the air as aforesaid, heating the air by heat derived from the highly heated fluid medium flowing longitudinally of the tunnel for thereby controlling the temperature gradient in the ware.

3. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, generating products of combustion and passing such products in muffled passages longitudinally of a portion of the tunnel in heat-radiating relation with the ware passing therethrough, preheating air by heat derived from the products of combustion, and thereafter introducing such preheated air into the tunnel below and centrally of the path of the ware and in the direction of the sides of the tunnel to cause recirculation of heated air in the tunnel in paths passing from the point of introduction of the air to the sides of the tunnel, thence up the sides, thence toward the center of the tunnel above the path of the ware and thence downwardly spaced from the sides of the tunnel and through the path of the ware to the zone of introduction of the air, the air during its circulation as aforesaid impinging upon and absorbing heat from the muffled passages through which the products of combustion are being conducted as aforesaid.

4. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing products of combustion longitudinally of the tunnel below the path of the ware and adjacent to the sides of the tunnel to supply heat primarily to the tunnel adjacent the sides thereof, while preventing contact between the products of combustion and the ware passing through the tunnel, recirculating air in the tunnel by introducing air thereinto below the path of the ware and toward the opposite sides of the tunnel to absorb heat from the products of combustion passing along the sides of the tunnel, thence to flow up the sides and toward the center of the tunnel above the path of the ware, thence downward through the path of the ware in a longitudinal median zone spaced from the sides of the tunnel to be recirculated, and thereby controlling the temperature gradient in the ware throughout a portion at least of its path through the tunnel.

5. The method of annealing glassware as defined in claim 2, further characterized by the step of introducing air into the tunnel below the path of the ware and above a portion of the tunnel along which the highly heated fluid medium is flowing longitudinally of the tunnel, the air being directed into the tunnel toward the entrance end thereof and tending to prevent inflow of atmospheric air into the entrance end of the tunnel.

6. The method of annealing glassware, which comprises passing the ware through an elongate tunnel, passing a relatively highly heated fluid medium longitudinally of a portion of the tunnel in heat-transferring relation with the ware passing therethrough but out of contact with the ware, preheating air by heat derived from said fluid medium, and thereafter introducing such air into the tunnel while causing the recirculation of a part of such air in and generally transversely of the tunnel through the path of the ware and in contact therewith, and causing a flow of another part of such air into the tunnel below the path of the ware and toward the entrance end of the tunnel to oppose inflow of atmospheric air into the entrance end of the tunnel.

7. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing a relatively highly heated fluid medium longitudinally of the tunnel adjacent to the lateral sides thereof and in heat-radiating relation with the ware passing therethrough but out of contact with such ware, introducing air into the tunnel below the path of the ware and toward the sides thereof to cause recirculation of air toward the sides and about the paths of the highly heated fluid medium, thence up the sides, toward the center of the tunnel above the path of the ware, and thence downwardly through the path of the ware to be recirculated, passing other air into the tunnel below the path of the ware in a zone nearer the entrance end of the tunnel than the zone in which the air is transversely circulated as aforesaid and in a direction toward the entrance end of the tunnel to oppose inflow of atmospheric air into the entrance end of the tunnel and independently controlling the temperature gradient in the tunnel on opposite sides of the median line thereof.

8. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing a relatively highly heated fluid medium longitudinally of the tunnel in paths below the level of the path of the ware therethrough and adjacent to the sides of the tunnel while maintaining such medium out of contact with the ware passing through the tunnel, preheating air by causing it to flow longitudinally of the tunnel in heat-interchanging relation to the paths of the fluid medium as aforesaid and counter-current thereto, and thereafter introducing such preheated air into the tunnel in such manner that it will flow in paths enveloping the ware passing therethrough.

9. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing highly heated gases adjacent to and below the path of the ware in heat-transferring relation therewith during a portion at least of the ware path through the tunnel, the path of the gases adjacent to an initial zone for the ware adjacent to the entrance end of the tunnel being substantially coextensive laterally with the tunnel and thereafter in a next zone during which the ware is passing through its annealing range, adjacent to the sides only of the tunnel, and creating substantially transverse recirculations of heated air in the tunnel in the annealing zone for the ware and in paths passing through the path of the ware and past the paths of the highly heated gases as aforesaid to provide a desired temperature gradient for the ware.

10. The method of annealing glassware, which comprises passing the ware through an elongate lehr tunnel, passing a relatively highly heated fluid medium longitudinally of the portion of the

tunnel in heat-transferring relation with the ware passing therethrough but out of contact with the ware, introducing air into the tunnel in directions transverse to and below the path of the ware and directed at the lateral sides of the tunnel to cause a recirculation in the tunnel toward the sides, thence up the sides and toward the center of the tunnel above the path of the ware and thence downward through the path of the ware in a longitudinally median zone spaced from the sides of the tunnel, and setting up in the tunnel a super-atmospheric pressure by the continuous introduction of air as aforesaid, which tends to prevent inflow of relatively cold atmospheric air at the entrance end of the tunnel.

11. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, muffle means for passing relatively highly heated gases longitudinally of the tunnel and in heat-transferring relation with the ware passing therethrough, heat-interchanging means including air passages within the gas passages of the last-named means for preheating air, and means for directing the air thus preheated into the tunnel to envelope the glassware passing therethrough.

12. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, muffle means for passing relatively highly heated gases longitudinally of the tunnel and in heat-transferring relation with the ware passing therethrough, heat-interchanging means associated with said muffle means for preheating air, and means for directing air thus preheated into the tunnel below the path of the ware and toward the entrance end of the tunnel in such manner as to oppose any tendency of atmospheric air to flow into the entrance end of the tunnel.

13. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, muffle means for passing relatively highly heated gases longitudinally of the tunnel and in heat-transferring relation with the ware passing therethrough, heat interchanging means associated with said muffle means for preheating air, and means for directing such preheated air into the tunnel from below the path of the ware and toward the sides thereof to cause a recirculation of air toward the sides below the path of the ware, thence up the sides and toward the center of the tunnel above the path of the ware and thence downwardly through the path of the ware to be recirculated by the air being introduced into the tunnel.

14. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, muffle means for passing relatively highly heated gases longitudinally of the tunnel and in heat-transferring relation with the ware passing therethrough, heat-interchanging means associated with said muffle means for preheating air, means for directing a portion of the air so preheated into the tunnel from below the path of the ware and directed toward the entrance end of the tunnel, means for adjustably controlling the amount of air so introduced into the tunnel, and means for directing another independently controllable amount of air into the tunnel in such manner as to cause a recirculation thereof in paths generally transverse of said tunnel in a zone spaced further from the entrance end of the tunnel than that into which the first-named portion of the preheated air is introduced.

15. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, muffle means for passing relatively highly heated gases longitudinally of the tunnel and in heat-transferring relation with the ware passing therethrough, heat-interchanging means associated with said muffle means for preheating air, means for introducing a portion of the air so preheated into the tunnel in a first zone starting at the entrance end thereof and below the path of the ware in a direction toward the entrance end of the tunnel, means for introducing another portion of the air so preheated into the tunnel in a succeeding zone from the entrance end thereof and in directions generally transverse of the tunnel, and means for independently controlling the flow of all the air introduced into the tunnel as aforesaid on opposite sides of the longitudinal median line of the tunnel.

16. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, means associated with some at least of the conducting means for the products of combustion for preheating air prior to the introduction of such air into the tunnel, and means for thereafter introducing air so preheated into the tunnel in such manner as to cause it to flow through the path of the ware.

17. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, means associated with some at least of the conducting means for the products of combustion for preheating air prior to the introduction of such air into the tunnel, and means for introducing a part at least of the air so preheated into the tunnel above the muffle means in the soaking zone and below the path of the ware in a direction toward the entrance end of the tunnel and thereby setting up a gaseous current in the tunnel tending to oppose the inflow of atmospheric air into the entrance end of the lehr tunnel.

18. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the

ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, means associated with some at least of the conducting means for the products of combustion for preheating air prior to the introduction of such air into the tunnel, and means for introducing air thus preheated into the tunnel in the annealing zone thereof below the path of the ware and toward the lateral sides of the tunnel to absorb heat from said passages and thence to flow up the sides of the tunnel, toward the center thereof above the path of the ware, and thence downwardly through the path of the ware to be recirculated by the air being introduced into the tunnel as aforesaid.

19. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, air pipes within said passages, means for causing a counter-current flow of air through said pipes to provide for the preheating of the air in the heat interchanger so formed, and means for introducing the air so preheated into the tunnel and below the path of the ware in such manner that a portion of the air is introduced in a direction toward the entrance end of the tunnel above said muffle and another portion is introduced into the annealing zone of the tunnel in directions toward the latter sides of the tunnel to cause the circulation of air substantially transverse of the tunnel.

20. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, air pipes extending within said passages, means to cause a flow of air through said pipes to effect a counter-current preheating of the air, and means to introduce the air so preheated into the tunnel in the annealing zone thereof below the path of the ware and toward the lateral sides thereof to envelope the outsides of said passages and thereby to augment the heating of the air, thence up the lateral sides and toward the center of the tunnel above the path of the ware and thence downwardly through the path of the ware to be recirculated by the air being introduced as aforesaid.

21. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, air pipes extending within said passages, means to cause a flow of air through said pipes to effect a counter-current preheating of the air, means to introduce at least a part of the air so preheated into the tunnel between said muffle and the path of the ware and in a direction toward the entrance end of the tunnel, and means for independently controlling the temperature gradient in the tunnel on opposite sides of a longitudinal median line thereof.

22. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for supplying products of combustion to said muffle and said passages, air pipes extending within said passages, means to cause a flow of air through said pipes to effect a counter-current preheating of the air, means for introducing air so preheated into the tunnel below the path of the ware and toward the lateral sides thereof to envelope said passages and thereby to augment the heating of the air circulated in the tunnel and thence to flow up the sides and toward the center of the tunnel, thence downwardly through the path of the ware to be recirculated by the air being introduced, and means for controlling the temperature gradient laterally of the tunnel including means for independently controlling the air directed toward each side thereof and means for independently controlling the amounts of heated gases passing along the passages on the two sides of the lehr.

23. Apparatus for annealing glassware, comprising an elongate tunnel, means for conveying glassware therethrough, said tunnel including a first soaking zone starting at the entrance end

in passing through which the temperature of the ware is brought to and maintained at a desired point, a second annealing zone in passing through which the ware is caused to drop in temperature throughout its annealing range, and a cooling zone in which the ware is cooled to a desired point, a muffle substantially coextensive in width with the tunnel associated with the soaking zone thereof and below the path of the ware, passages extending from the muffle below the level of the path of the ware and adjacent to the lateral sides of the tunnel, means for causing a flow of products of combustion through said muffle and said passages, air pipes substantially concentric within said passages to form therewith heat interchangers, means for supplying air to and through said pipes in a direction counter-current to the flow of the products of combustion, means for introducing some of the air so preheated into the tunnel in said soaking zone between said muffle and the path of the ware and in a direction toward the entrance end of the tunnel, means for introducing another portion of the air so preheated into the tunnel below the path of the ware and toward the lateral sides thereof to envelope said passages and thereby to abstract heat therefrom, and thence to flow up the sides of the tunnel and toward the center thereof above the path of the ware, thence downwardly through the path of the ware to be recirculated by the inductive action of the air being introduced, means for independently controlling the amount of air supplied to the air pipes on opposite sides of the lehr, means for independently controlling the amount of products of combustion passing through said passages, means for independently controlling the amounts of air introduced into the tunnel toward the entrance end on opposite sides of the center of the tunnel, and means in the cooling portion of the tunnel for abstracting heat from the ware to bring it down to a desired temperature.

DONALD G. MERRILL.

CERTIFICATE OF CORRECTION.

Patent No. 2,133,784. October 18, 1938.

DONALD G. MERRILL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 10, for the word "closed" read closer; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of December, A. D. 1938.

(Seal)

Henry Van Arsdale
Acting Commissioner of Patents.