June 4, 1940. W. S. RENDALL 2,203,182

ANNEALING LEHR AND METHOD OF ANNEALING GLASSWARE

Filed Nov. 21, 1936 2 Sheets-Sheet 1

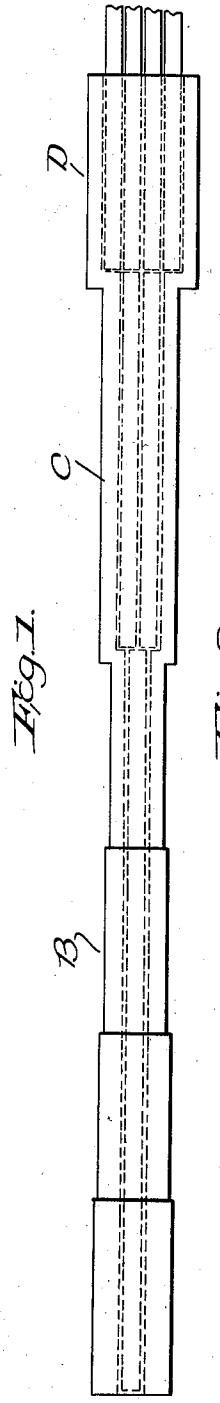


Fig. 1.

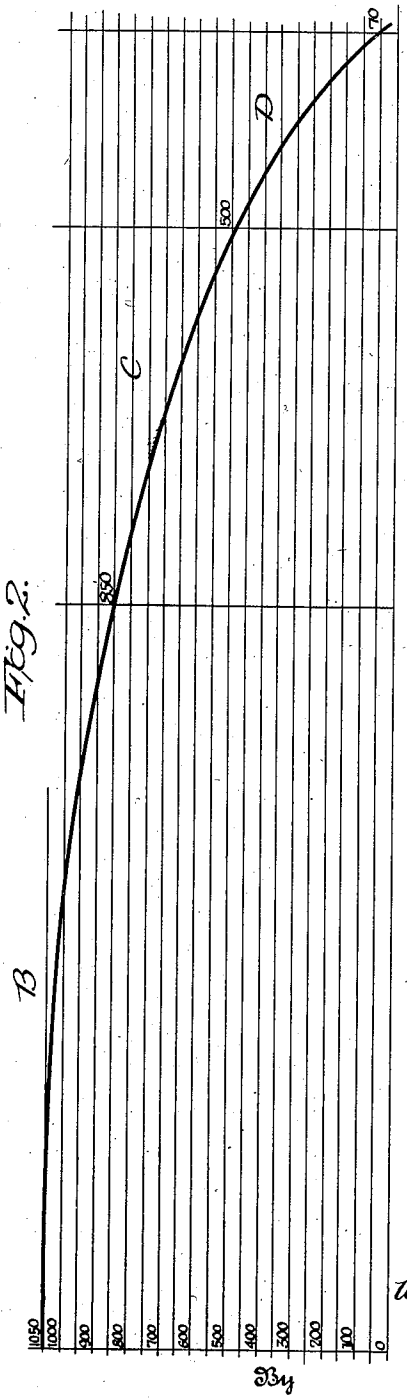


Fig. 2.

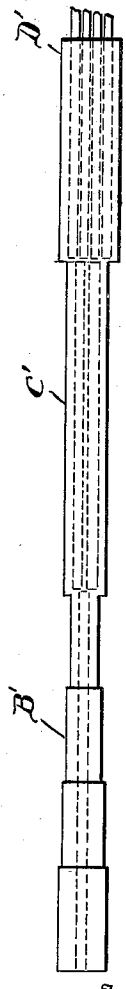


Fig. 3.

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ANNEALING LEHR AND METHOD OF ANNEALING GLASSWARE

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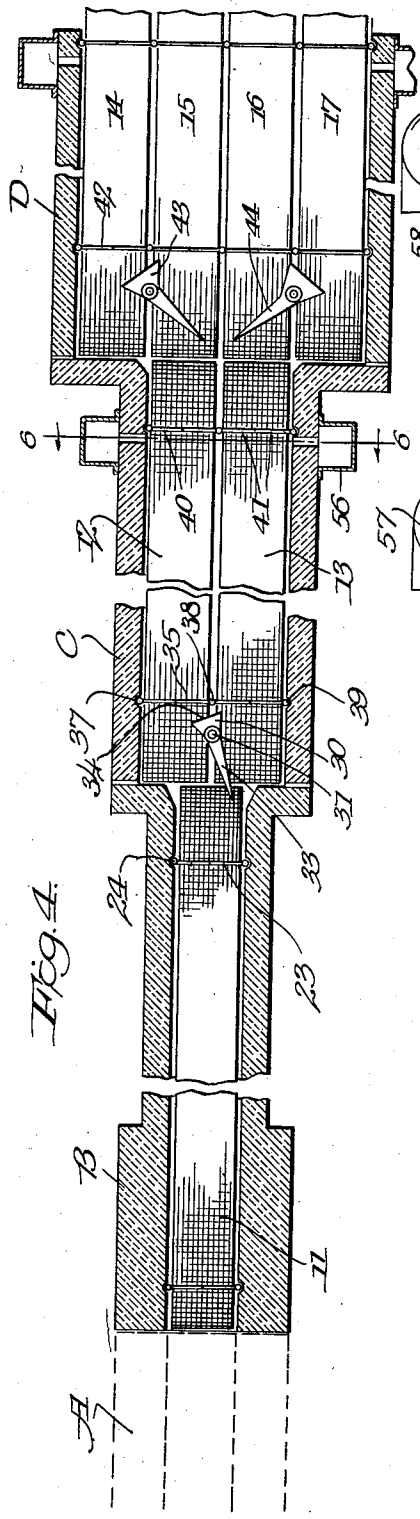


Fig. 4.

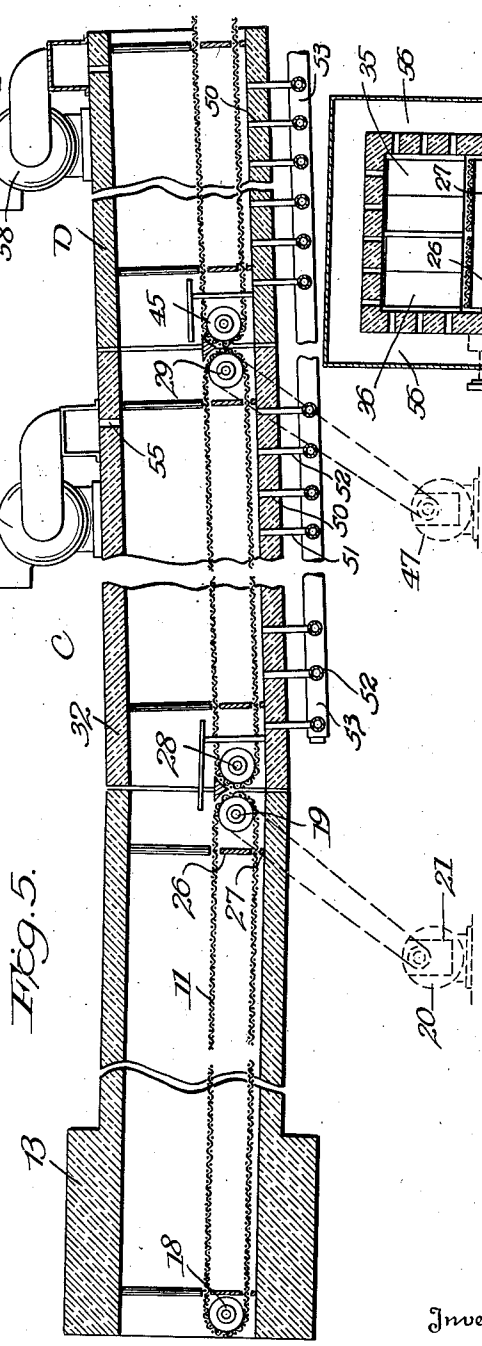


Fig. 5.

Fig. 6.

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ANNEALING LEHR AND METHOD OF ANNEALING GLASSWARE

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Application November 21, 1936, Serial No. 112,147

7 Claims. (Cl. 49—47)

This invention relates to a new and improved method of and apparatus for annealing glassware. It is an object of the invention to provide a lehr wherein a more accurate temperature control of the glassware may be effected, to expedite the annealing operation, and to improve the quality of the annealed ware.

It is a further object of the invention to decrease the longitudinal space ordinarily occupied by an annealing lehr, without decreasing the volume of ware which can be annealed.

Annealing lehrs of conventional design comprise a long annealing tunnel through which the glassware is conveyed at a slow, constant rate of speed on a constantly moving woven wire belt or the like. According to the usual practice, attempts are made to control the temperature within the tunnel by the provision of heating and cooling means and appropriate insulated walls to provide three different temperature zones. These are first, a heating zone adjacent the entrance end adapted to raise and/or maintain the temperature of the ware at the upper annealing point; second, an annealing zone where the temperature of the ware is decreased slowly to the lower annealing point, and third, a cooling zone where the heat from the ware is more rapidly extracted.

The upper annealing point is that temperature at which no stresses of harmful magnitude are present in the glassware, and the lower annealing point is the temperature where no new stresses can be introduced upon further cooling, because of the permanent arrangement of the molecular structure which has been effected. It is well established that glass containers of orthodox composition and average wall thickness have an upper annealing point of about 1050° F. and a lower annealing point of about 850° F.

Past experience has taught an operating practice in the annealing art, expressed for convenience in terms of not permitting the glass to lose temperature from the upper to the lower annealing points at a rate in excess of 10° F. per minute, and of not permitting the glass, after having reached the lower annealing point, to lose temperature at a rate substantially in excess of 40° per minute.

In conventional lehrs, accurate zonal control of temperature in the annealing range and in the cooling range is difficult, if not impossible, because the annealing tunnel is in the form of a continuous passage, and drafts, air currents and drift, which are always present in more or less degree, tend to destroy the control that might be effected by graduated insulation, controllable heating means and controllable cooling means. In a continuous open tunnel which is hot at one end and cool at the other, currents are bound to be set up, and cool air flows to the hot zones and vice versa, with the result that the temperature curve is disturbed and improper annealing operations are often performed.

It is a primary object of the present invention to introduce more positive temperature control by zones, by having each zone separated from the others. It is a further object to accomplish a varying speed of travel through the different zones in the lehr, corresponding to the permissible rates of cooling. Moreover, it is a further important object of the invention to provide means for selectively spacing the articles on the conveying means in the several zones, to vary the rate of heat extraction.

Preferably the lehr of the present invention is divided into four zones as follows:

Zone A_____heating zone
Zone B_____annealing zone
Zone C_____first fast cooling zone
Zone D_____second fast cooling zone

Any appropriate means may be used to raise the temperature in zone A so that the ware will be at the upper annealing point when it enters zone B. In reality the invention is not particularly concerned with the heating zone, since any appropriate means may be provided to raise the ware to the upper annealing point. Moreover, in some cases, the ware will be at this or a higher temperature when it is discharged from the forming machine, and if it is then deposited quickly into the lehr, a heating zone is unnecessary.

The invention contemplates the provision of separately driven belts or other conveying means in the last three zones. Two parallel belts will be used in zone C, or the width of the belt in zone C will be twice the width of the belt in zone B, and, likewise, in zone D the conveying means is twice as wide as in zone C and four times as wide as in zone B. Means are provided for forming and distributing each line of bottles in zone B into two lines of bottles in zone C, and for forming these two lines into four lines in zone D. If the belts in all of these zones are driven at the same speed, then the longitudinal spacing of the bottles on the belt or belts in zone C will be twice as great as in zone B, and the bottles in zone D spaced longitudinally four times the spacing in zone B. If this long spaced apart relationship between the ware is not desired, the speeds of movement of the conveying means in zones C and D can be reduced to a point not less than a speed which would result in a crowding or touching of the ware. By properly relating the speed of movement of the belts, any desired spacing can be effected. Moreover, the overall length of the lehr can be shortened by decreasing the speeds of movement of the belt in the subsequent sections. For instance, the speed of travel of the belt or belts in zone C can be one half the speed

of the belt in zone B, and the speed in zone D may again be cut in half. By the provision of positive and controllable cooling means in zones C and D, a high flexibility of annealing is accomplished, when considered in combination with the selective spacing of the ware on the belts.

Preferably, the cooling sections of the lehr are provided with positive and controllable cooling means for extracting the heat from the ware at the desired rate, and this means may take the form of a circulation of controlled volumes of cooling air through the cooling zones. Moreover, cooling air may be recirculated from the second cooling zone back to and through the first cooling zone, as pointed out below.

Although in the specific embodiment of the invention described below, the sections of the lehr are shown arranged in longitudinal alignment, the invention is not limited to such an arrangement, as one section can well be placed above another to discharge downwardly into the next section positioned therebelow.

In a specific example, the lehr is provided with four zones as mentioned above. The bottles travel in a single file through zones A and B and, at the end of zone B, they are transferred into two rows onto a wider belt or a pair of belts running side by side in zone C. The bottles then travel in two rows at a reduced speed, for instance, one half the speed of travel in the zones A and B, unless a greater longitudinal spacing is desired in zone C, in which case the speed is more than one-half speed. At the end of zone C, the two rows of bottles are formed into four rows and they are transferred to zone D and placed upon a wider belt or four parallel belts, and the speed of travel is likewise again reduced. Of course, the invention is not limited to this particular number of rows, as it is entirely feasible to convey the bottles through zones A and B in any number of rows, for instance eight, then distribute these into sixteen rows in zone C, and 32 rows in zone D.

In order to secure accurate zonal temperature control, the invention contemplates providing self-opening and closing shutters or doors between the zones. The shutters are preferably arranged in pairs to provide a lock-out between adjacent zones. For instance, the shutter at the end of zone C would be opened and closed again before the shutter at the entrance end of zone D is opened by the passage of a bottle. Since one door of a pair is always closed, the flow of air between adjacent zones is prevented.

As a result of the provision of means to prevent the circulation of air within the lehr tunnel from zone to zone, it is possible to change the inclination of the lehr tunnel from that generally thought desirable by the art. Certain prior art lehrs are built on an incline extending downwardly from the hot entrance and to the cool discharge end so as to build up a hotter temperature in the heating zone and to force the heat dissipated from the ware to travel in a direction opposed to the travel of the ware.

According to the present invention, it is preferred to have zones A and B disposed on a substantially horizontal plane, and to have zones C and D slope upwardly. As a result of this construction, the infiltration of drift, and the creation of uncontrolled drafts is prevented. The cooling medium forced into the cooling sections flows in the sections under positive control, and is not affected by such drift or drafts.

In the accompanying drawings:

Figure 1 is a diagrammatic plan of a lehr in accordance with the invention;

Figure 2 is an annealing graph;

Figure 3 is a diagrammatic plan view similar to Figure 1, but showing a modification;

Figure 4 is a horizontal longitudinal sectional view through a lehr;

Figure 5 is a vertical, longitudinal sectional view of the lehr of Figure 4.

Figure 6 is a vertical, transverse, sectional view taken on line 6—6 of Figure 4.

In the accompanying drawings, the heating section of the lehr has been omitted because the invention is concerned primarily with the annealing and cooling zones, and any appropriate means may be used for raising the temperature of the ware to, and maintaining it at, the upper annealing point.

With glassware of standard composition and usual wall thickness, the ware leaves the heating zone at about 1050° F., as indicated at the left of Figure 2. The heat should not be extracted rapidly from the ware during the critical annealing period in the annealing zone B and, by the use of appropriate insulation, the rate of heat extraction is kept down to about 9° F. per minute. The ware enters the first fast cooling zone C at about 850° F., and its heat may be extracted more rapidly, for instance, at about 18° F. per minute. At about 500° F., the ware enters the final fast cooling zone D, and it may there be cooled much faster, for instance, at about 36° F. per minute.

Since the ware must lose 200° of temperature in zone B, the annealing chamber must be of a length, and the speed of movement of the conveying means therein must be such as to consume about 22 minutes for the passage of an article through that zone. Likewise, the length and speed of movement of the belt or belts in zone C must be such that it takes about 20 minutes for the ware to pass therethrough, so that it can lose 350° of temperature at a rate of 18° per minute. The ware need only remain in zone D for about 12 minutes, in order to lose 430° at a rate of 36° per minute.

The division line between zones C and D in the accompanying drawings is purely arbitrary, as in many cases the fast cooling may commence when the ware is above a 500° temperature, and in other cases it may be desired to begin this final fast cooling when the ware is at a lower temperature. For purposes of illustration, however, and in order to indicate the principles of the present invention, the arbitrary figure of 500° has been selected.

If the rates of heat extraction indicated above are used, the ware should take 54 minutes to pass from the entrance end of section B to the discharge end of section D. If the speed of movement of the ware through the lehr were constant, and the lehr were of a length equal to 100 units of distance, the section B would be 41 units, section C 37 units and section D 22 units. This relation of the lengths of the sections is indicated at B', C', D' in Figure 3. Referring to Figure 1, considerable economy of floor space can be effected, however, by increasing the number of belts in the sections C and D and reducing their speed of travel. As indicated in Figure 1, section C may have twice as many belts as section B, and if these belts are driven at one half the speed of the belt or belts in section B, the length of section C may be reduced from 37 units to

19½ units. Likewise, if the number of belts in section D are twice the number in section C, and if the speed of travel of the belts is again cut in half, the length of section D may be cut down from 22 units to 5½ units.

In Figure 3 the number of belts is multiplied in the same manner as in Figure 1, but the sections are of such a length that all of the belts may be driven at the same rate of speed and still maintain the ware in the various sections for the proper length of time. With the belts arranged in this manner and driven at this speed, the spacing of the articles longitudinally of the belts in section B' will be twice as great as in section A', and in section C', the spacing will again be doubled. This wide spacing of the bottles in the fast cooling zones is of material advantage in securing a rapid and uniform extraction of heat from the ware. The invention contemplates designing a lehr in any desired manner between the limits indicated respectively by Figures 1 and 3. In other words, if a constant spacing of bottles is desired, the design of Figure 1 may be followed, wherein the speed of movement of each belt is one half the speed of movement of the preceding belt. On the other hand, if an increased spacing is desired in sections C and D, the belts in those sections may be driven at more than half speeds, up to the same or greater speeds than the belts in the preceding sections, and in such case, the lengths of the sections should be increased to make sure that the ware remains in each section for the proper length of time.

In the annealing zone B, the problem is to prevent the rapid extraction of heat from the ware and to this end, the annealing section is provided with relatively heavy insulation, which may be graduated in thickness as indicated in Figures 4 and 5. The lehr is provided with means for conveying the articles to be annealed through the several sections, and this means may conveniently take the form of wire mesh belts **11**, **12**, **13**, etc. The belt **11** in the annealing chamber B may be mounted upon rolls **18**, **19**, the latter of which may be driven by any appropriate means, such as an electric motor **20** and a speed controller **21**. The belt **11** may, if desired, extend forwardly beyond the section B into the adjacent heating section A, if such a section is used, as in conventional practice. The annealing section is provided, adjacent its discharge end **22**, with means for preventing circulation of air into and from the adjacent fast cooling section C. Preferably, this means includes a pair of doors **23** pivoted on vertical posts **24** at the sides of the belt **11**. The doors are normally held in the closed position indicated in Figure 5. They may be opened, however, by contact with a bottle or other article on the conveyor **11** to permit the passage of the article into the next chamber. The space below and between the two runs of the belt is preferably closed by fixed baffle plates or the like, as indicated at **26**, **27**, in Figure 5.

In the chamber C, the belts **12**, **13** are trained about rolls **28**, **29**, and an usher device **30** is pivoted on a post **31** extending downwardly between the belts. The usher comprises a forwardly extending guiding end **33** and a fish-tail rear end **34** so that alternate bottles will be guided to the two belts.

The entrance end of the section C is provided with pairs of doors **35**, **36**, constructed in substantially the same manner as the doors **23**, and pivoted on posts **37**, **38**, **39**. These doors are so spaced from the doors **23** that they will be in closed position when the doors **23** are in the opened position, and vice versa. Thus, the doors **35**, **36** on the one hand and the doors **23** on the other constitute a lock-out means for preventing the circulation of air between sections B and C.

The discharge end of section C is also provided with pivoted doors **40**, **41**, constructed in like manner. Likewise, section D is provided with doors **42** at one end and with a curtain or similar doors at its discharge end. Ushers **43**, **44** are provided to transfer the two lines of articles coming from section C and to distribute them into four lines in section D, on the four belts **14**, **15**, **16** and **17**. These belts are trained about a roll **45**, and a similar roll spaced exteriorly of the lehr proper.

The belts **12**, **13** in section C are driven by any appropriate means, such as an electric motor and speed controller **47** at a desired rate with respect to the speed of movement of the belt **11**. In similar manner, the belts **14**—**17** in chamber B are driven at a properly related speed to the speed of movement of the other belts.

Positive and controllable cooling means are provided for sections C and D. The floor of the lehr may be provided with a plurality of apertures **50** (Figs. 5 and 6) to each of which is connected a branch pipe **51** leading from a transverse header **52** connected to a longitudinally extending conduit **53** carrying cooling air under pressure. Appropriate valves **54** (Fig. 6) are provided in front of each header **51** to control the amount and location of the admission of cooling air to the lehr. Also, the ceiling and side walls of sections C and D are provided with apertures **55** leading to an exhaust manifold **56** connecting with exhaust fans **57**, **58**. The invention contemplates connecting the exhaust fan **58** with the apertures in the floor of section C to effect a recirculation of the air from section D back to section C.

By properly controlling the relative speeds of the belts in the several sections, any desired longitudinal spacing of the articles to be annealed may be effected. For instance, if the spacing of the articles on the belt **11** is x, and if the belts **12**, **13** are driven at the same speed as the belt **11**, the articles will be spaced $2x$ in section C, and $4x$ in section D if the belts therein are also driven at the same speed. On the other hand, if the belts in section C are driven at half the speed of the belt in section B, the spacing x will be maintained. Obviously, if the speed of the belts in section D is again cut in half, the same spacing of the ware will be maintained. It will be apparent therefore that, by properly regulating the relative speeds, any desired spacing can be effected. This controllable spacing is of material advantage in the annealing operation because of its effect on the extraction of heat from the ware.

By properly relating the speeds of movement of the belts and the resulting spacing of the bottles with the amounts of cooling air, an extremely accurate annealing operation can be performed and the invention contemplates various adjustments and changes in these factors.

The two fast cooling sections C, D preferably slope upwardly toward their discharge end as indicated in Figure 5. Such a slope prevents setting up any random air currents between the sections and particularly into the annealing section B.

The present invention is not limited to the details of construction shown in the accompanying drawings and described above, but must be con-

strued to include all devices coming within the scope of the appended claims or their equivalents.

I claim:

1. A glassware annealing lehr comprising a plurality of zones, means for conveying glassware longitudinally through said zones in a single line in a forwardly disposed zone and in a double line in the next succeeding zone, pairs of doors spaced longitudinally of the lehr at adjacent ends of adjacent zones and providing lock spaces for isolating the zones from each other, and usher devices disposed in the spaces between said pairs of doors for distributing said single line of articles in the forwardly disposed zone into a double line of articles in the succeeding zone.

2. The method of annealing glassware comprising providing three substantially isolated areas of predetermined longitudinal dimension but of progressively increased transverse dimension, controlling the temperature of each area independently of the others, conveying the ware in a line through the first area at a predetermined rate of speed to expose the ware to the effect of the temperature in that area for a predetermined length of time, and thereby reducing the temperature of the ware from the upper annealing point to the lower annealing point, forming the ware into two rows and conveying the same through the second area at a reduced speed as compared to its movement in the first area and thereby subjecting the ware to the effect of the temperature in the second area for a longer period of time per unit of travel to effect a cooling of the ware, forming said two lines of ware into four lines and conveying them through the third area at a further reduced rate of speed to expose the ware to the effect of the temperature in the third area for a still longer period of time, per unit of travel, to effect a final cooling of the ware.

3. The method of annealing glassware comprising providing at least three isolated areas of predetermined longitudinal and transverse dimensions, controlling the temperature of each area independently of the others, conveying the ware through the first area at a predetermined rate of speed to expose the ware to the effect of the temperature in that area for a predetermined length of time, and thereby reducing the temperature of the ware from the upper annealing point to the lower annealing point, continuously transferring the ware from the first area to the next while preventing the flow of air between the areas, and conveying the ware through the second area at a reduced speed as compared to its movement in the first area and thereby subjecting the ware to the effect of the temperature in the second area for a longer period of time, per linear unit of travel, to effect a cooling of the ware, continuously transferring the ware from the second area to the third area while preventing the flow of air between the areas, and conveying the ware through the third area at a further reduced rate of speed to expose the ware to the effect of the temperature in that area for a still longer period of time, per linear unit of travel, to effect a final cooling of the ware.

4. The method of annealing glassware comprising providing at least three isolated areas of predetermined longitudinal dimension and of progressively increased transverse dimension, controlling the temperature of each area independently of the others, conveying the ware in a line through the first area at a predetermined rate of speed to expose the ware to the effect of the temperature in that area for a predetermined length of time, thereby reducing the temperature of the ware from the upper annealing point to the lower annealing point, continuously forming the ware into two rows and transferring the same to the second area while preventing the flow of air between the areas, and conveying the ware through the second area at a predetermined rate of speed, thereby subjecting the ware to the effect of the temperature in the second area while in laterally spaced relation to effect a cooling of the ware, forming said two lines of ware into four lines and transferring the same to the third area while preventing the flow of air between the areas, and conveying the ware in said four lines through the third area to expose the ware to the effect of the temperature in that area to effect a final cooling of the ware.

5. An annealing lehr comprising a plurality of sections arranged end to end, a continuously moving belt coextensive in length with each section for conveying ware therethrough, the adjacent ends of successive belts being closely spaced in ware transferring relation, and means for isolating each section from the next, said means comprising doors extending across the sections and positioned near each end of each section and spaced longitudinally inwardly of the sections from the ends of the belt therein, thereby providing lock-out chambers between adjacent ends of adjacent sections, said chambers containing the adjacent ends of the belts for the two adjacent sections, whereby the ware is transferred from one belt to the next while in the lock-out chamber.

6. An annealing lehr comprising a plurality of sections arranged end to end, a belt coextensive in length with each section for conveying ware therethrough, the adjacent ends of successive belts being closely spaced in ware transferring relation, means for moving the successive belts continuously at progressively decreaing rates of speed longitudinally of the lehr, means for isolating each section from the next, said means comprising doors extending across the sections and positioned near each end of each section and spaced longitudinally inwardly of the sections from the ends of the belt therein, thereby providing lockout chambers between adjacent ends of adjacent sections, said chambers containing adjacent ends of the belts for the two adjacent sections, and means in said chambers for transferring the incoming ware into a plurality of rows on the outgoing belt leading to the next successive section, whereby the ware is transferred from one belt to the next and rearranged on the latter while in the lock-out chamber.

7. A glassware annealing lehr comprising a plurality of zones, independent belt means for conveying glassware longitudinally into and through each zone, pairs of doors spaced longitudinally of the lehr at adjacent ends of adjacent zones and providing lock spaces for isolating the zones from each other, the ends of adjacent belt means being disposed in the lock spaces between said pairs of doors, and means in said lock spaces for transferring articles of glassware from one belt means to another and for distributing the articles on the receiving belt means.

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