This invention relates to improvements in glassware lehrs and to annealing methods performed thereby, more particularly to such lehrs and methods as provide and make use of circulatory movement of the tunnel atmosphere in at least a portion of the lehr tunnel through which the ware is transported during the annealing thereof.

An object of the invention is to provide a lehr of the character described having improved facilities for producing and controlling circulatory movements of gaseous media in the lehr tunnel.

A further object of the invention is the provision in a lehr of the character described of a tunnel having a main longitudinal space or chamber through which the ware being annealed is transported and in which gaseous media is being circulated in directions generally transverse of the tunnel and a pair of longitudinal spaces or chambers at the sides of the main space in which gaseous media may move longitudinally of the tunnel toward the ware-entering end thereof and portions of such longitudinally moving gaseous media may be injected into the circulating gaseous media in the main space of the tunnel at intervals along the length of the latter.

Other objects and advantages of the invention will hereinafter be pointed out or will become apparent from the following description of a practical embodiment of the invention as shown in the accompanying drawings, in which.

Figure 1 is a longitudinal vertical section through a portion of the lehr, beginning at the front or ware-entering end of the lehr tunnel.

Fig. 2 is a longitudinal vertical section of another portion of the lehr which may comprise the remainder of the lehr tunnel.

Fig. 3 is a transverse vertical section through the lehr along the line 3—3 of Fig. 1.

Fig. 4 is a similar view taken along the line 4—4 of Fig. 2.

Fig. 5 is another transverse vertical section through the lehr along the line 5—5 of Fig. 2.

Fig. 6 is a portion of Fig. 5 on a larger scale, Fig. 7 is an enlarged fragmentary view, showing in horizontal section a portion of the lehr at approximately the place indicated by the section line 7—7 of Fig. 4.

Fig. 8 is a transverse vertical section in enlarged form through approximately half of the lehr at the place indicated by the line 8—8 of Fig. 1, and

Fig. 9 is a plan view of a fragmentary portion of the top of the lehr, showing operating mechanism for a pair of drift controlling vanes which are located within the lehr tunnel.

The lehr illustrated in the drawings comprises an elongate tunnel 10 which may comprise the portions shown in longitudinal vertical section in Figs. 1 and 2. This tunnel may be constructed in any suitable manner of suitable materials. As shown, it comprises an outer metallic shell or case 11, on legs 11a. Suitable insulation, such as indicated at 12, Figs. 1 and 2, may be provided within the metallic shell or case 11 at the places at which it is desired to insulate the walls of the tunnel. Within this insulation may be an inner metallic lining 13. Also, refractory mate-
rial, as at 14, Fig. 1, may be employed to line the tunnel at the place or places at which the temperature will be relatively high or service conditions such as to make the use of refractory material advantageous.

The sides of construction of the tunnel walls may vary according to particular service requirements or preference, and do not per se form part of the present invention.

An endless conveyer belt 15 of openwork structure, such as woven wire fabric, has an upper or ware-entering reach or portion 16a passing longitudinally through the tunnel, and an inactive or return reach or portion 16b supported beneath the tunnel, as is usual in modern glass-ware lehrs.

The upper reach of the conveyer belt is supported within the tunnel by a supporting frame structure which comprises longitudinal Z-bars 18 and spaced transverse members 17 which may vary somewhat in specific shape and structure in different portions of the lehr. This conveyer supporting frame structure may be supported at a substantial distance above the bottom or floor of the tunnel from the front or ware-entering end of the tunnel for the major part of the length thereof, as by suitable columns or pedestals indicated at 18, Figs. 1 and 2, and the top of a combustion chamber 19 which may constitute the lower front end portion of the tunnel, beneath the conveyer supporting frame, as best seen in Figs. 1, 3 and 8.

The cooler portion of the tunnel may have its floor or raised floor or offset floor as from the place indicated at 20, Fig. 2, to the exit end of the tunnel and the supporting frame structure for the upper reach of the conveyer may be supported directly on the raised floor or bottom of this portion of the lehr tunnel. The arrangement is such that space is provided beneath the supporting frame structure for the upper reach of the conveyer from the front or ware-entering end of the tunnel for a substantial, preferably, a major, part of the length of the tunnel for the circulation of gaseous media. In the heated portion of the lehr, heat may be applied to the gaseous media in this space from a suitable source of heat.

Such heat may be supplied by apparatus of any suitable type, such as electrical or combustion heating apparatus. Preferably, such heating apparatus should apply heat with decreasing effect from the front or ware-entering end portion of the tunnel longitudinally of the tunnel for the distance required. The particular heating apparatus shown is of the combustion type, and includes a burner or burners, such as that indicated at 21 in Fig. 1, for discharging a combustible fuel into the combustion chamber or firebox 19. The top of this firebox may be made in part of any usual type of refractory, indicated at 22, and in part of tile, indicated at 23, having relatively high heat conducting property. The top portion 23 of the firebox top may be corrugated transversely to afford increased strength and for efficient transmission of heat to the overhead tunnel space and also to provide transverse channels beneath the conveyer supporting frame for circulating heated gases in the media.

The firebox is closed at its rear, that is, at the end farthest from the ware-entering end of the tunnel, except for the open ends of heater pipes 24, Figs. 3 and 8. The heater pipes 24 extend in the lower corner portions of the tunnel from the firebox for a substantial, preferably the major, part of the length of the tunnel, where they communicate with stacks or outlet pipes 25 (see Figs. 2 and 4), which project above the top of the tunnel. These heater pipes conduct the heated products of combustion from the firebox rearwardly in the lower corner portion of the tunnel for the distance required to effect adequate heating of the circulating media which pass in contact therewith as hereinafter will be more fully explained.

Ejectors in the form of air nozzles 27 may receive air from the side walls or from pipe 28 and discharge jets of air upwardly in the upper portions of the stacks or outlet pipes 25 so as to augment the draft therein. One of these ejectors 27 is shown in Fig. 2.

The lehr tunnel may have false inner side walls 29 extending vertically from the outer flanges of the Z-bars at the sides of the conveyer supporting frame to the top of the tunnel. These false side walls may be made of metal and secured in place in any suitable way. The arrangement is such as to divide the tunnel above the plane of the ware support frame 18 into the longitudinally extending main space or annealing chamber 100 through which the ware is transported by the conveyer and a pair of longitudinally extending relatively narrow spaces or chambers 30 at the sides of this ware-receiving space or chamber.

The side spaces 30 communicate at their upper portions with the main middle section 100 by means of inwardly projecting nipples 31 which may be provided at closely spaced places along the length of such side spaces. Also, these side spaces 30 extend substantially the full length of the tunnel (see Figs. 1 and 2). These nipples 31, being relatively narrow or constricted at their inner ends, serve as Venturi ports when air under pressure is blown therethrough into the tunnel proper, as may be accomplished by lateral nozzles 32 on pressure air pipes 33 which extend longitudinally of the passages 30 in the upper portions thereof. These nozzles 32 on the pipes 33 are located in register with the corresponding nipples 31. The pipes 33 may be supplied with air under pressure from the blower pipe 28 through suitable connections, as indicated at 34, Figs. 1 and 2. These connections may be dampered so as to permit regulable control of the volume of air passing therethrough to the pipes 33. The pipe 28 may be connected with the air delivery side of a blower fan 35, which may be located on the rear end portion of the tunnel, as shown in Fig. 2.

The side spaces 30 are open at their bottoms at the plane of the conveyer supporting frame structure. Slightly above this plane, each false side wall 29 is provided with a series of long, comparatively narrow openings or ports 36. These openings or ports establish lateral communication between the lower portions of the spaces 30 and the main ware containing tunnel 30. Pivotable shutters or dampers 37 are provided in the lower portions of the side spaces 30 for controlling both the ports 36 and the portions of the side passages themselves above the level of the ports. Thus, when all the shutters 37 of a side space 30 are in their raised positions, substantially as shown for the shutter 37 in Fig. 6, all the ports 36 adjacent to such shutters are fully open and that side space 30 is closed at the level referred to by the series of shutters which then constitute a bottom wall for the portion of the space 30 above such shutters. In other words,
when the shutters are raised, each side space or chamber is in effect a longitudinal duct at one side of the main or ware-containing tunnel space 100 with which such duct then communicates only through the nipples 31.

At this time, the portion of the tunnel at that side of the conveyor supporting frame and in the lower portion of the side space communicate with the main tunnel space 100 through the ports 35 and the closed shutters 37 may be inclined downwardly toward their outer side edges to facilitate deflection of rising gaseous media from the upper side of the direction of the space 100 into the transversely circulating gaseous media in the main, ware-containing space 100.

When, however, all the shutters 37 in a side space 30 are lowered, as for example to the position indicated by the dotted lines in Figs. 6 and 8, then all the ports 35 controlled by such shutters will be closed and the side passage 30 will communicate with the main tunnel space 100 through the nipples 31 near the top of such space 100 and beneath the open work conveyor supporting frame.

Each of these shutters 37 may be raised or lowered and maintained in adjusted position by a suitable operating mechanism which may comprise a crank 38 journaled in a bearing in the adjacent side wall of the lehr tunnel and connected with the shutter by linkage 39.

The side spaces 30 may be open at their ends, adjacent to the front and rear ends of the lehr tunnel. The upper portion of such space, i.e., the portion that forms a continuous longitudinal duct when all the shutters 37 therein are closed, may be divided transversely at will into a plurality of successive longitudinal zones by horizontally swingable pivoted dampers or division members 200. (See Fig. 7 which shows a plurality of these members 200 as viewed from above and Fig. 8 which includes a face view of one of them.) Each member 200 is pivotally supported at its outer side edge on a vertical shaft 201 (Fig. 8) which extends through the top of the lehr tunnel and is provided at its upper end with a laterally bent portion or handle 202 which may be manipulated to swing the member 200 from a fully closed position, shown in Fig. 8 and in full lines in Fig. 7, across the space 30 at right angles to the direction of length, to a fully open position at which the member 200 will be disposed flatwise against the outer side wall of the space 30 or to any intermediate position, such as the positions shown in dotted lines in Fig. 8. As shown in Fig. 8, each member 200 may be partially cut away or notched at 203 to clear the pipe 32 when the member is in any of its possible adjusted positions.

The lehr tunnel is provided with longitudinally extending deflectors 40 (Figs. 1, 2, 7 and 9) which are inclined downwardly and toward the longitudinal median line of the tunnel (Figs. 3, 4, and 8) for deflecting the jets or streams of air from the Venturi ports 31 downwardly toward the underlying conveyor and promoting desirable transverse circulations of gaseous media at opposite sides of the vertical plane passing longitudinally of the tunnel midway between the sides thereof.

The deflectors 40 extend in the lehr tunnel from the front to the rear thereof and are of a series of hollow deflectors 41 (Figs. 2, 5 and 6) in the cooling section of the lehr. Each deflector 41 comprises a hollow body having inclined side walls 43 provided with hinged sections 42 at their tops, which can be opened as indicated by the dotted line position of one of these sections in Fig. 6 to allow egress of more or less of the tunnel atmosphere. These hollow deflectors 41 communicate with stacks 44. The hinged sections 42 may be controlled by suitable operating mechanism 45. The rearward deflectors in the cooling section of the lehr, one of which is indicated at 40—a in Fig. 2, may be similar to the deflectors 40, hereinafore described. In general, the deflectors in the cooling section of the lehr are similar to those which are described in greater detail in the copending application of Donald G. Merrill, for Method and apparatus for annealing glassware, Serial No. 68,611 filed March 2, 1936, and do not per se form part of the present invention.

The invention also provides pivoted vanes, designated 46, Figs. 4, 7, 8 and 9, for aiding in controlling drift of the circulating gaseous media in the main or ware-containing space 100 of the tunnel. The vanes 46 are supported in the upper part of the main tunnel space 100 and by the deflectors 40 and the false side walls 29 and are adjustable around vertical axes to various angular positions with respect to the longitudinal axis of the lehr tunnel. Thus, the vanes 46 may be suspended by shafts 45 which are journaled in suitable bearings in the top structure of the tunnel and may be rocked about their axes to swing the vanes 46 to the angularly adjusted positions desired. Usually, the vanes will be turned so as to aid forward drift or movement of the transversely circulating gaseous media in the tunnel although other angularly adjusted positions of such vanes are possible. The shafts 47 of each pair of transversely aligned vanes 46 may be connected for simultaneous adjustment, as by linkage 48, connecting arms 49 on the upper ends of the shafts 47, and an operating handle 50 which may be attached to one of the arms 49 or to the linkage 48. The handle 50 may be provided with notches 51 engageable with a keeper 52 to maintain the connected vanes in adjusted positions, or any other suitable means may be employed for this purpose.

From the foregoing description of a practical embodiment of the invention, the operation and advantages thereof will be readily understood.

The heating apparatus may be controlled to supply the required amount of heat to the firebox and to the heater pipes 24 for any particular annealing operation. Primary streams of air will flow under pressure longitudinally of the lehr tunnel in the pipes 33 from which air will be discharged into the ware-containing space of the tunnel in the form of jets through the Venturi ports 31. These jets, either alone or in conjunction with the convection currents, produce generally transverse circulatory movements of the tunnel atmosphere throughout substantially the entire length of the tunnel. The vanes 46 preferably are set to aid forward drift of the circulating tunnel atmosphere in the main or ware-containing space 100 in the tunnel.

The vertically swingable shutters 31 and the horizontally swingable dampers or division members 200 in the side passages 30 may be adjusted, in view of the convection circulations caused by the heating of the gaseous media in the lower portion of the tunnel and the pressure and induced actions of the jets of air from the rearward deflectors 41 in the upper corner portions of the tunnel, to produce the desired movements of the tunnel at-
mosphere and temperature distributing and controlling functions required for particular requirements and conditions at different times. In general, raising of all the shutters 27 and opening of all the members 200 would convert the upper portions of the side passages 30 into longitudinal ducts in which secondary streams of air or gaseous media of increasing temperature would be conducted inwardly of the tunnel in the side portions thereof and would be tapped off at intervals into the transversely circulating gaseous media in the main space of the tunnel through the Venturi ports 31. In the meantime, the circulating gaseous media in such main space would be augmented and influenced somewhat, particularly in the heated portion of the lehr, by the gaseous media passing through the ports 35 into such main tunnel space. The forward movement of the secondary streams of air or gaseous media may be interrupted or retarded at the place or places desired by swinging one or more of the members 200 to fully closed or intermediate positions. Opening, i. e., lowering, of a shutter or shutters 31 permits gaseous media to pass upwardly from the lower portion of the tunnel in the portion or portions of a side space or side spaces 30 controlled by such shutter or shutters and thus tends locally to interrupt or retard longitudinal movement of the secondary air in such portion to portions and also to vary the character and effect of the circulatory movements of tunnel atmosphere. The shutters 31 may be adjusted between raised and lowered positions to the same or different extents at different places longitudinally of the lehr tunnel and these and the other control members hereinbefore pointed out may be employed in various ways and combinations to produce substantially different results as required to meet various service requirements and conditions at different times.

The invention is not to be limited beyond the terms of the appended claims when such claims are construed as broadly as the prior art will permit.

I claim:

1. A lehr comprising a tunnel, means for transporting glassware to be annealed through an annealing chamber which extends longitudinally of said tunnel, a second chamber extending longitudinally of the tunnel adjacent to said annealing chamber, said second chamber having a plurality of ports spaced along the length thereof and communicating with the upper portion of said annealing chamber, and an air conduit extending longitudinally of the lehr tunnel and having spaced nozzles discharging jets of air through said ports into said annealing chamber in such manner as to have inductive action on gasses in said second chamber.

2. A lehr comprising a tunnel having an annealing chamber extending longitudinally thereof and also having a relatively narrow chamber containing gaseous media extending longitudinally of the tunnel at one side of the annealing chamber and communicating with the upper portion of the annealing chamber through spaced ports located at intervals along the length of the annealing chamber, means for transporting glassware through the annealing chamber, and a conduit located in said side chamber for conducting air longitudinally of the tunnel in the direction opposite the direction of movement of glassware through the annealing chamber and having spaced nozzles for directing jets of air through spaced ports into said annealing chamber.

3. A lehr comprising a tunnel having an annealing chamber extending longitudinally thereof and also having a relatively narrow chamber containing gaseous media extending longitudinally of the tunnel at one side of the annealing chamber and communicating with the upper portion of the annealing chamber through spaced ports located at intervals along the length of the annealing chamber, a conduit located in said side chamber for conducting air longitudinally of the tunnel in the direction opposite the direction of movement of glassware through the annealing chamber and having spaced nozzles for directing jets of air through spaced ports into said annealing chamber, and means for applying heat to gaseous media in the lower portion of said tunnel in a zone extending from the front end of said tunnel for part of the length thereof.

4. A lehr comprising a tunnel having an annealing chamber extending longitudinally thereof and also having a relatively narrow chamber containing gaseous media extending longitudinally of the tunnel at one side of the annealing chamber and communicating with the upper portion of the annealing chamber through spaced ports located at intervals along the length of the annealing chamber, means for transporting glassware through the annealing chamber, a conduit located in said side chamber for conducting air longitudinally of the tunnel in the direction opposite the direction of movement of glassware through the annealing chamber and having spaced nozzles for directing jets of air through said spaced ports into said annealing chamber to set up therein generally transverse circulation of gaseous media, and means for applying heat to gaseous media in the lower portion of said tunnel in a zone extending from the front end of said tunnel for part of the length thereof.

5. A lehr comprising a tunnel having an annealing chamber extending longitudinally thereof and having at the side of said annealing chamber a relatively narrow chamber containing gaseous media and communicating with the upper portion of said annealing chamber through ports located at intervals along the length of said annealing chamber, said side chamber having open communication at its bottom with the lower portion of the annealing chamber, means for heating gaseous media in the lower portion of said side chamber in a zone extending longitudinally of the tunnel from the front end thereof for a substantial part of the length thereof, means controlling in zones longitudinally of said side chamber upward movement of gaseous media in said side chamber, and a conduit located in the upper portion of said side chamber for conducting air under pressure longitudinally thereof and for discharging jets of air through said ports into the upper portion of said annealing chamber.

6. A lehr comprising a tunnel having an annealing chamber extending longitudinally thereof and also having a relatively narrow chamber containing gaseous media and communicating with the upper portion of said annealing chamber through ports located at intervals along the length of said annealing chamber, said side chamber having open communication at its bottom with the lower portion of the annealing chamber, means for heating gaseous media in the lower portion of said side chamber, and a conduit located in the upper portion of said side chamber for conducting air under pressure longitudinally thereof and for discharging jets of air through said ports into the upper portion of said annealing chamber.
said side chamber in a zone extending longitudinally along the tunnel from the front thereof for a substantially greater length thereof, and forming a substantially greater length thereof, and a longitudinal series of shutters located in said side chamber intermediate the height thereof for regulating the communication between upper and lower portions of said side chamber in zones longitudinally thereof.

10. A lehr comprising a tunnel having an annealing chamber extending longitudinally thereof and a relatively narrow chamber at one side of the annealing chamber and communicating with the upper portion of the latter at intervals along the length thereof through spaced ports, said side chamber communicating at its bottom with the lower portion of the annealing chamber, an open-work conveyor for conveying glassware through the annealing chamber, an open-work supporting frame for supporting said conveyor in a plane above the annealing chamber for at least the major portion of the length of the latter beginning at the front of said annealing chamber, means for applying heat to the gaseous media in the lower portions of said annealing chamber and said side chamber in the front end portion of the tunnel and to the gaseous media in said side chamber for a further part of the length of the tunnel, said conveyor and its duct extending in the upper portion of said side chamber for conducting air under pressure longitudinally thereof in the direction opposite the direction in which said conveyor transports glassware through the annealing chamber, said conveyor having spaced nozzles for discharging jets of air through said spaced ports into the upper portion of the annealing chamber, and means for controlling upward and longitudinal movements of gaseous media in said side chamber at places spaced along the length thereof.

11. A lehr comprising a tunnel having a pair of longitudinally extending relatively narrow side chambers containing gaseous media and an interposed longitudinally extending main or annealing chamber, said side chambers communicating with the upper portion of said annealing chamber at intervals along the length thereof through spaced ports, an open-work conveyor for transporting glassware through the annealing chamber as a plane spaced above the floor thereof for at least a substantial part of its length beginning at the front end, said side chambers communicating at their bottoms with the lower portion of said annealing chamber below the plane of said open-work conveyor and having other ports spaced longitudinally thereof establishing communication between said side chambers and the annealing chamber at a level slightly above that of said open-work conveyor, and vertically swingable shutters adapted when raised to constitute longitudinally extending partitions between upper and lower portions of successive zones longitudinally of each of said side chambers and adapted when lowered to close the second named ports between said side chambers and said annealing chamber.

12. The method of annealing articles of glassware which comprises passing such articles through a lehr tunnel, applying heat to gaseous media at the bottom of said tunnel to cause generally transverse circulating convection currents therein to envelop the articles in moving gaseous media during their passage through the tunnel, discharging jets of air into the circulating currents of gaseous media to aid the circulatory movements thereof, and supplying gaseous media to said circulating currents by the inductive action of said jets of air.

13. The method of annealing articles of glass-
ware which comprises passing such articles through an annealing chamber, heating the gaseous media in a portion of said chamber to cause generally transverse convection circulations of gaseous media in successive portions of said annealing chamber, passing a stream of air under pressure adjacent to the annealing chamber in the direction opposite the direction of movement of the articles of glassware through said chamber and discharging jets of such air transversely into the annealing chamber at intervals along the length thereof, and causing a secondary supply of gaseous media to envelop the stream of air in such manner that portions thereof will be injected into the annealing chamber by the inductive action of said jets of air.

14. The method of annealing glassware which comprises passing articles of glassware through an annealing chamber extending longitudinally of a lehr, causing generally transverse circulating movements of gaseous media in successive zones of said chamber by introducing jets of air horizontally into the upper portion of the annealing chamber directed toward the longitudinal median line thereof and applying heat to gaseous media at the bottom of the annealing chamber, and augmenting the circulating gaseous media in said annealing chamber by introducing gaseous media thereinto in addition to said jets of air at intervals along the length of the annealing chamber.

15. The method of annealing articles of glassware which comprises passing the articles to be annealed through an annealing chamber extending longitudinally of the lehr, producing convection currents circulating in generally transverse closed paths through the annealing chamber to envelop the articles being annealed in moving gaseous media during the passage of such articles through a zone extending from the front of the annealing chamber for a substantial part of the length thereof, introducing jets of air into the upper part of annealing chamber at intervals along the length thereof to vary the circulating currents, and further varying such circulating currents by injecting thereinto at intervals along the length of the annealing chamber streams of gaseous media obtained from an adjacent supply by the inductive action of said jets of air.

16. The method of annealing articles of glassware which comprises causing the articles to advance along a pathway in an annealing chamber located between a pair of adjacent longitudinally extending bodies of gaseous media, causing circulating convection currents of gaseous media in said annealing chamber to envelop the advancing articles in a zone extending from the intake end of the annealing chamber for part of the length thereof, and injecting gaseous media from said longitudinally extending bodies of gaseous material into said annealing chamber together with jets of air under pressure by causing such jets of air to pass transversely through portions of said longitudinally extending bodies of gaseous media into said annealing chamber toward the longitudinal median portion of the latter.

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