Aug. 20, 1940. W. A. WAITE 2,212,412

FURNACE WALL CONSTRUCTION

Filed April 14, 1939 2 Sheets-Sheet 1

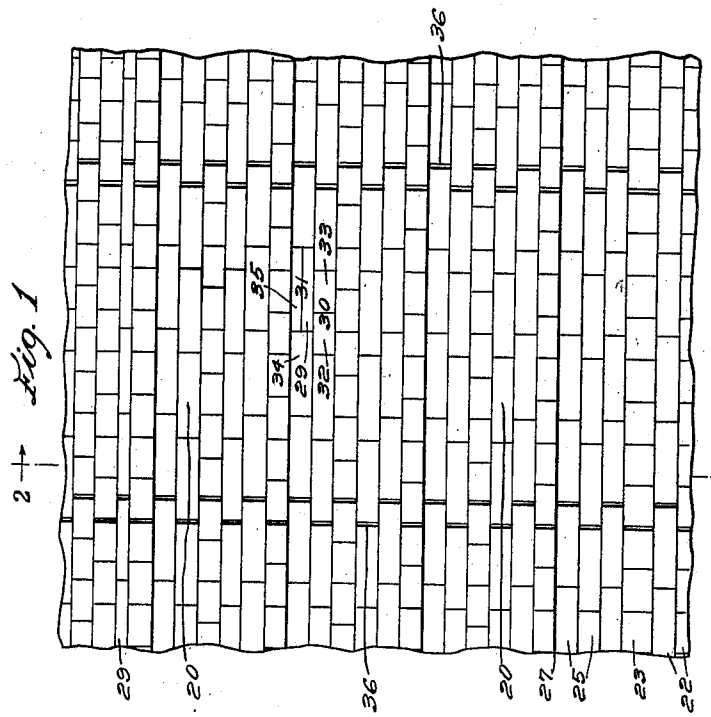


Fig. 1

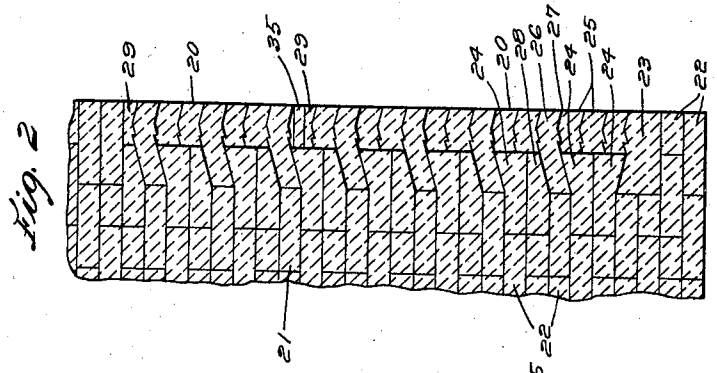


Fig. 2

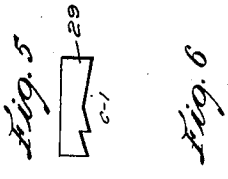


Fig. 5

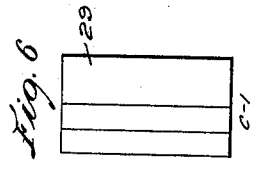


Fig. 6

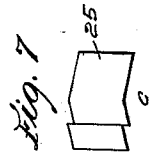


Fig. 7

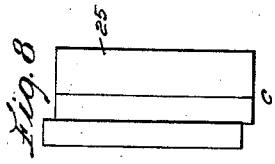


Fig. 8

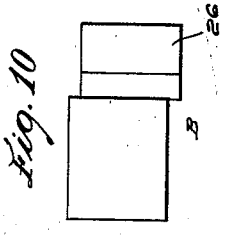


Fig. 10

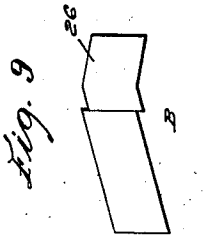


Fig. 9

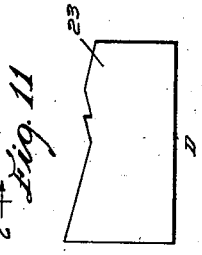


Fig. 11

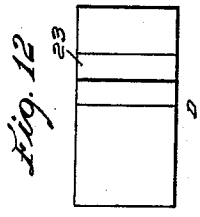


Fig. 12

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Aug. 20, 1940. W. A. WAITE 2,212,412

FURNACE WALL CONSTRUCTION

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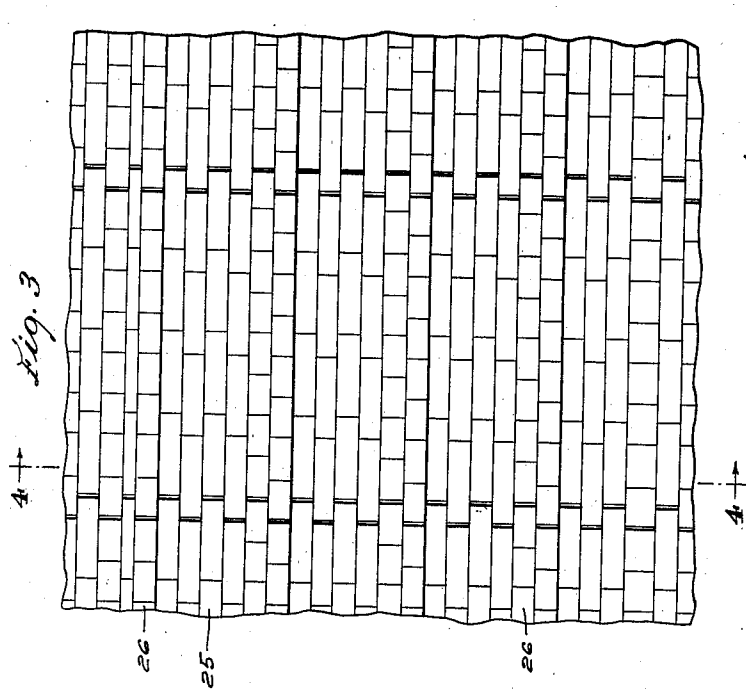


Fig. 3

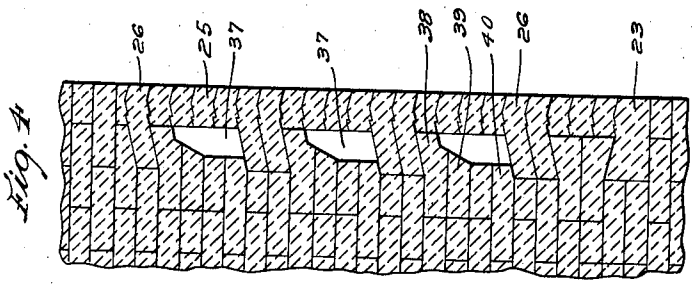


Fig. 4

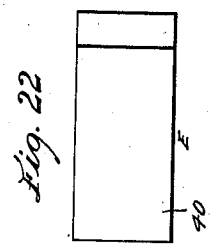


Fig. 22

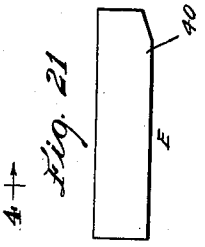


Fig. 21

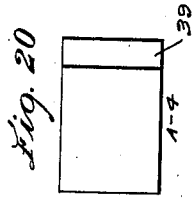


Fig. 20

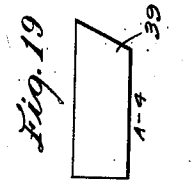


Fig. 19

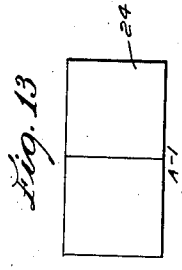


Fig. 13

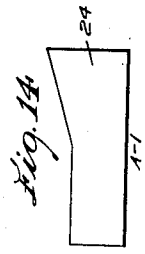


Fig. 14

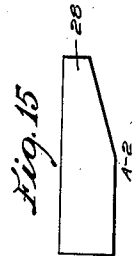


Fig. 15

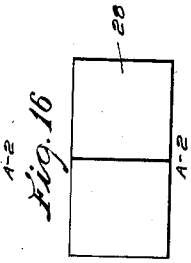


Fig. 16

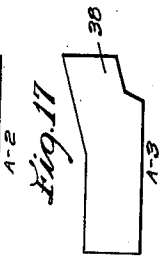


Fig. 17

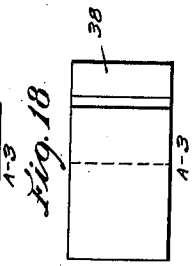


Fig. 18

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Patented Aug. 20, 1940 2,212,412

UNITED STATES PATENT OFFICE

2,212,412

FURNACE WALL CONSTRUCTION

William A. Waite, Providence, R. I.

Application April 14, 1939, Serial No. 267,785

10 Claims. (Cl. 72—102)

My present invention relates to furnace wall constructions, and has particular reference to a novel brick arrangement therefor.

It is the principal object of my invention to provide a furnace wall construction designed to overcome mechanical failure due to expansion and contraction strains on the inner lining of the wall, and in which the expansion joints are self-clearing of any soot, slag, or other foreign matter tending to work its way into the expansion joints.

It is another object of my invention to provide a wall construction which resists the tendency of inner lining brick courses to bend and buckle inwardly and to pull away from the cooler outer portion of the wall.

A further object of my invention is to utilize the weight of the inner lining to press the inner lining towards the outer portion.

Still another object is to progressively transfer the weight of the furnace wall from the inner lining to the cooler outer portion.

An additional object of my invention is to provide simple and effective provisions for uneven vertical expansion or contraction which normally occurs in a furnace wall, while at the same time rendering the expansion joints self-clearing.

A further object is to provide a wall construction comprising a plurality of self-supporting wall panels on the furnace surface, each of which may independently expand or contract and may be independently removed and replaced with minimum disturbance to the adjacent panels and the outer supporting wall.

With the above and other objects and advantageous features in view, my invention consists of a novel arrangement of parts more fully disclosed in the detailed description following, in conjunction with accompanying drawings, and more specifically defined in the appended claims.

In the drawings:

Fig. 1 is a front elevation of a section of furnace wall embodying my invention;

Fig. 2 is a vertical section taken along line 2—2 on Fig. 1;

Fig. 3 is a front elevation of a section of air-cooled furnace wall embodying my invention;

Fig. 4 is a vertical section taken along line 4—4 on Fig. 3;

Figs. 5 and 6 are respectively end and bottom plan views of the closer;

Figs. 7 and 8 are respectively end and bottom plan views of the stretcher;

Figs. 9 and 10 are respectively end and bottom plan views of the header;

Figs. 11 and 12 are respectively end and plan views of the starting header;

Figs. 13 and 14 are respectively plan and end views of another type of header;

Figs. 15 and 16 are respectively end and bottom plan views of another type of header;

Figs. 17 and 18 are respectively end and bottom plan views of still another type of header;

Figs. 19 and 20 are respectively end and bottom plan views of another type of header; and

Figs. 21 and 22 are respectively end and bottom plan views of another type of header.

The present invention constitutes an improvement on the application of William A. Waite, entitled Firebrick wall construction, filed July 18, 1938, Serial No. 219,719. The invention is designed to counteract one of the most difficult conditions in a construction of a furnace wall, i. e. the effect of violently fluctuating expansion and contraction strains in the hotter courses of brick on the inside lining of the wall, the firebrick being a poor conductor of heat and the temperature drop through the wall normally being very steep. Thus, sometimes eight hours or more are required after a cold furnace is put into operation to establish approximate heat equilibrium conditions through the wall; conversely, the hot exposed surface space cools off at a much faster rate than the interior of the wall when the furnace is shut down.

Since many plants operate for a part only of each day, with additional week-end shutdowns, the expansion and contraction strains, particularly in the furnace lining courses, are very severe and result in failure of the furnace wall due to mechanical failure of the inside courses of brick.

The vertical and horizontal expansions which periodically occur in the hotter sections of the wall produce a marked tendency for the inside courses to bend or pull inwardly and so pull away from the cooler portions of the wall. The standard type of firebrick construction relies on the weight of the super-imposed wall to hold the inside courses to the rest of the wall, it being standard practice to use a strong bond of overlapping headers through the wall so as to progressively transmit the weight of the super-imposed wall to the inner lining. This type of construction causes the weight on the supporting headers to become progressively greater in the lower portion of the wall, where the highest temperature and the most violent fluctuations of temperature oc-

cur. The supporting headers normally project half their length in the hottest zone of the wall, and the projecting half is thus heated to a high temperature and is forced to expand upwardly before any material temperature and volume change has occurred in the cooler half, which is imbedded in the super-imposed cooler section of the wall immediately above. When the effects of the temperature strains have snapped sufficient supporting headers, the bond between the inner and outer courses becomes broken, and the inner lining splits away from the outer section of the wall.

Moreover, no suitable provision can be conveniently made with standard construction to relieve vertical expansion other than to leave the top of the wall clear. Another disadvantage with standard construction is that the refractory qualities of firebrick which are exposed to high temperature decrease with increase of the super-imposed load, wherefore the exposed brick in the lower part of the furnace wall is subjected to the most unfavorable conditions, because it is subjected to the maximum load, to the highest temperature, and to the greatest temperature range.

The application hereinbefore referred to was designed to overcome the aforesaid disadvantages. However, in the use of a rhomboidal, inclined brick structure, liquid slag or other extraneous matter may enter between the bricks of the inner wall sections and interfere with proper functioning of the expansion joints during the expansion and contraction. By using the novel bricks of the present invention, the wall not only provides for the defects of standard brick construction heretofore outlined, but is also self-clearing and tends to resist or entirely eliminate the infiltration of foreign matter between the bricks of the inner lining.

To effectually improve and meet the conditions heretofore outlined, I have provided a wall construction which assures longer service and lower cost for repairs than it is possible to obtain with the use of standard brick, the construction being applicable to either solid or air-cooled furnace walls of any desired thickness. To this end, I provide special brick which have the same overall dimensions as standard firebrick, and occupy the same space in the wall, so that they may be laid up in the wall with standard brick by usual bricklaying methods.

Referring to the drawings, and particularly to Figs. 1 and 2, the furnace wall construction includes a plurality of separate panel sections 20, which are formed of special brick, standard brick forming the outer wall portion 21. Each of the panels may independently expand both vertically and horizontally, the special brick being so arranged as to bond each panel to the outer portion of the wall so as to be indepenently supported thereby.

Standard brick, as illustrated at 22, are used to lay up the outer portion of the wall; and the inner lining starts with a brick of the D type (Figs. 11 and 12), designated 23 in Fig. 2. An A—1 header, designated 24, as in Fig. 14, is then turned upside down with the inclined portion overlapping the starting header 23. Another A—1 header is placed over the upside down A—1 header in an upright position as shown in Fig. 2. The inner lining of the wall comprises a group of C stretchers designated 25, see Figs. 7 and 8, which are supported on the inner end of the starting header 23. Both edges of the C stretcher and the upper edge of the starting header are provided with projections which will form interlocking bonds between the various bricks as shown in Fig. 2.

To start the next panel a B header, designated 26 in Figs. 9 and 10, is placed above the A—1 header with the inner end extending over the uppermost C stretcher but spaced therefrom to form an expansion joint 27. The outer end of the B header 26 is retained in the wall by the superimposed A—2 header designated 28 in Figs. 15 and 16. Superimposed on the A—2 header is another A—1 header; the inner end of the B header being super-imposed by a group of C stretchers. It can thus be seen that one half of the A header is laid up with the standard brick wall and the other half extends outwardly from the outer portion of the wall at an upwardly inclined angle so that the downward thrust thereon is inwardly towards the wall surface. This construction is illustrated in Fig. 2 and is more fully described in the application heretofore referred to. There are many possible combinations in which three or more bricks can be laid up together, an illustrative combination being shown in Fig. 2; the essential features of the construction residing in the use of upwardly inclined joints instead of horizontal joints on the header between the inside portions of the brick on the furnace face, and a downwardly inclined joint on the inner lining of the furnace face between the C stretchers and the B headers which causes any slag or other extraneous material tending to work its way between the headers and stretchers to move upwardly against the force of gravity. The joint on the furnace face of the wall may be changed at any point from horizontal to inclined and back to horizontal by the use of a C—1 closer, designated 29 in Figs. 5 and 6.

In replacing or repairing any of the panels, a slight difficulty may be encountered when the top course of each panel is reached, in placing the bent brick into place because of the narrowness of the space. This is overcome by the use of the C—1 closer 29. The entire panel is laid up as illustrated in Fig. 2 with the exception of the last two stretchers, see Fig. 1, 30 and 31. A C stretcher is then cut in half and one half, designated 32, is dropped into the opening and slid to the left under the over-hanging C stretcher. The other half 33 is then merely dropped into place. The horizontal tongue on the stretcher to the left of the upper opening 31, designated 34, having been previously cut off, a closer 29 is slid into place above the half stretcher 33. A standard brick is then split in two to form a half brick, designated 35, and is then slid over the closer. This permits the brick wall or section thereof to be finished without interference from the depending portions of the next section above. The above described construction locks the inner lining firmly to the rest of the wall by its own weight, and at the same time relieves the inner lining from the progressively increased weight of the super-imposed wall. This release is obtained by an overlapping A and an overlapping B header so that the weight of the super-imposed inner lining or stretchers is progressively transmitted through the inclined portion of the B header beneath, to the cooler outer part or section of the wall. Each course of headers, irrespective of its position in the wall, thus supports the super-imposed load of the relatively small number of courses of stretchers.

The possibility of fly ash, soot or fluid slag

seeping into the open expansion joint on the furnace face is reduced to a minimum by providing a downward slant of about 9½ degrees from the horizontal, the joints being thus practically self-clearing. This construction has the further advantage of providing an additional lock to hold the top course of stretchers in any panel firmly to the rest of the wall; as shown in Fig. 2, these top stretchers cannot fail or tip inwardly without pulling the B header above up the inclined plane against the super-imposed weight of the panel above.

The exposed furnace face of the wall is thus divided into separate horizontal panels, separated by expansion joints, each self supporting and each consisting of B headers with a small number of super-imposed courses of C stretchers. Although any desired angle of incline may be used, the preferred angle is approximately 15 degrees, more specifically 15 degrees 31 minutes, so as to provide bricks in which the rise is in the ratio of the thickness of a standard firebrick to its length.

The projecting portions of the A and B headers are thus cantilevers which each support a load uniformly distributed over its length, the maximum force acting vertically downward being exerted at the point of support and diminishing to zero at the furnace face of the wall. The load on each brick in the inner lining thus progressively falls and is negligible at the hottest section nearest the face. Moreover, the weight on each successive brick is progressively reduced so that the top stretchers in any section on the exposed face support no load at all.

The above described construction has great advantages when compared with standard firebrick construction, as the load on the exposed face of the brick at the lower, hotter half is very much less, due to the small number of bricks in each panel. The inclined arrangement of the joints of the inner lining provides a self-clearing action which prevents fly ash or fluid slag seeping between the joints of the brick on the furnace face.

The inclination of the outer end of the B headers and C stretchers causes a gravity load on the inner lining which presses the inner lining towards the outer wall position, whereby a breaking of headers does not result in a separation of the inner lining, and instead causes the inner lining to settle on the panel below and to hug the outer wall portions with a force resulting from its weight. The relief of the super-imposed weight on the hot lining and the locking of the inner lining firmly to the rest of the wall permits more effective provision for expansion than is possible with standard brick construction, longitudinal expansion being preferably provided for by open vertical joints which are staggered or broken across the wall, and located at intervals as required, as illustrated at **36** in Fig. 1. Vertical expansion is provided for by leaving an open, horizontal joint, **27**, beneath spaced courses of B headers as described, as indicated in Figs. 1 and 2, the described arrangement in effect dividing the entire inner face of the wall into comparatively small rectangular panels which are self-supported, self-clearing, and free to move both vertically and horizontally as they expand and contract, independently of the adjacent panels.

The provision of separate panels facilitates the making of necessary replacements, as any panel, including all of the supporting B headers, can be removed and replaced with a minimum of disturbance to the rest of the wall. The replacements require a minimum of new material as compared with those necessary to replace a bonded, standard firebrick wall, which uses more headers than stretcher courses on the furnace face. Instead of replacing all of the headers, as is necessary when the face of a standard furnace wall is replaced, the novel construction only requires a replacement of a large number of stretchers and a relatively small number of headers, thus lowering the cost of repairs.

The above described construction may also be applied to air-cooled walls which have lanes or channels behind the hot face through which air is passed to cool the refractory. The thickness of the exposed wall in this type of construction must be reduced to a relatively thin section in order to effectively lower the temperature in the heated portion. This requires special steel supports for standard type walls, as a relatively thin section is too weak to carry the super-imposed weight; moreover, the supporting steel work and the hangers holding the inner lining must be protected from high temperature, thus requiring thick refractory shapes to protect the hangers. Since the novel construction heretofore described divides the inner lining into self-supporting sections which do not carry substantial weight, the novel construction may be readily adapted to air-cooled walls, the exposed face being thin enough to effectively reduce the temperature on the hot face without requiring special supporting steel work and vulnerable metal hangers. At the same time, the infiltration of fly ash and fluid slag and the accumulation of these materials in the expansion joints and the clogging thereof is eliminated and buckling of the thin wall structure of the inner lining because of uneven expansion is also eliminated.

Referring to Fig. 3, the inner lining is made up of B headers **26** supporting the super-imposed C stretchers **25**. To provide air passages or channels **37**, the outstretched B header is supported directly below it by an A—3 header, designated **38** in Figs. 17 and 18 which in turn is supported by an A—4 header, designated **39** in Figs. 19 and 20 which is supported by a standard brick. The standard brick may be laid in any number of courses depending upon the size of the particular section, the lowest brick comprising an E header designated **40** in Figs. 21 and 22, the inner edge of the E header resting on the outer edge of the supporting B header. As can readily be seen in Fig. 4, the angular shape of the inner edge of the supporting A header for the B header provides an unobstructed opening for the passage of the cooling air. The resulting inner lining its therefore merely a single thickness of C stretchers which are thin enough to effectively reduce the temperature in the hot part of the wall and B headers thick enough to mechanically carry the reduced weight supported by each header. It is preferable to use double B headers, as described in Fig. 4, to additionally support the inner lining, the headers and stretchers being formed with the usual interlocking notch arrangement.

While the brick used in the solid and air-cooled wall is the same, the notch arrangement becomes more important in the air-cooled wall where the stretchers are spaced from the outer wall surface. These notches are approximately ⅜ of an inch for the vertical and ½ inch for the horizontal and are designed to prevent leakage from the horizontal air flue or lane into the furnace and be-

sides interlocking the stretchers on the exposed face, the joints between each header and stretcher being locked together by the notches.

When building up from standard brick construction, the same method used in the solid wall construction is used in the air-cooled construction. A starting header, a pair of A—I headers and a series of C stretchers are first used before the first B header or pair of B headers, as illustrated in Fig. 4, are placed in position to begin the air-cooled construction. When the upper end of the wall is reached and it is necessary to change back to standard construction, the usual C—I closer is used.

As in the solid wall construction, in order to repair a particular section without disturbing the section above it, it is necessary to use the method heretofore described. The upper portion of the section is laid with two bricks left out and the split stretcher, closer and half of the standard brick are used to complete the section.

Any tendency for the top of the air-cooled panels to curl or tip inwardly is prevented by engagement of the vertical notch in the top stretcher with the notch in the header brick above, together with the inner angle of the face. The arrangement of the exposed face, that is with the horizontal and vertical expansion joints forming rectangular panels, is the same as for the solid walls shown in Figs. 1 and 2. The use of the special headers 38 and 39 to support the header 26 throws the weight of the super-imposed panel from the header 26 over to the outer wall. As in the construction shown in Fig. 2, the downwardly inclined inner angle on the furnace face provides an effective self-clearing joint which reduces the infiltration of slag or ash to a minimum.

The above described construction is particularly suitable for air cooling, as the B header which carries the stretcher load and the brick in the exposed inner lining are effectively air cooled, except the top stretcher; this stretcher, however, carries no super-imposed load.

While I have described a specific constructional embodiment of my invention, it is obvious that any change in size and shape of the firebrick and in their arrangement may be made to suit the requirements for different furnace installations without departing from the spirit and the scope of the invention as defined in the appended claims.

I claim:

1. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said headers the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section.

2. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said headers, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, the inner lining comprising horizontal sections formed of sets of stretchers mounted on vertically spaced header courses, the sections having horizontal, self-clearing expansion joints therebetween.

3. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said headers, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, the inner lining being divided into panels having vertical expansion joints therebetween.

4. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said second headers spaced from said outer section, whereby air passageways are provided between said lining and said outer section, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section.

5. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said second headers spaced from said outer section, whereby air passageways are provided between said lining and said outer section, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, the inner lining comprising horizontal sections formed of sets of stretchers mounted on vertically spaced header courses, the sections having horizontal, self-clearing expansion joints therebetween.

6. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said second headers spaced from said outer section, whereby air passageways are provided between said lining and said outer section, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, the inner lining being divided into panels having vertical expansion joints therebetween.

7. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said second headers spaced from said outer section, whereby air passageways are provided between said lining and said outer section, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, said second headers and said stretchers having cooperating locking shoulders.

8. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhom-

boidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said second headers spaced from said outer section, whereby air passageways are provided between said lining and said outer section, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, the inner lining comprising horizontal sections formed of sets of stretchers mounted on vertically spaced header courses, the sections having horizontal, self-clearing expansion joints therebetween, said second headers and said stretchers having cooperating locking shoulders.

9. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining having a plurality of headers bonded to said outer section, said headers having rhomboidal portions extending from said outer section, rhomboidal headers on said first headers and projecting therefrom, and rhomboidal stretchers on said second headers spaced from said outer section, whereby air passageways are provided between said lining and said outer section, the inner ends of said rhomboidal headers and stretchers sloping downwardly with respect to said outer section, the inner lining being divided into panels having vertical expansion joints therebetween.

10. In a furnace wall construction, an outer section of standard brick, and an inner lining, said inner lining comprising a plurality of headers bonded to said outer section and having portions upwardly inclined with respect thereto, a plurality of inclined headers each mounted on the inclined portion of one of said first-named headers and having the inner ends thereof locked to the outer section, and inclined stretchers mounted on said headers, the inner ends of said inclined headers and stretchers sloping downwardly with respect to said outer section.

WILLIAM A. WAITE.