July 24, 1951 L. S. LONGENECKER 2,561,933

COMPENSATED FURNACE CHAMBER ENCLOSURE STRUCTURE

Filed May 22, 1948 5 Sheets-Sheet 1

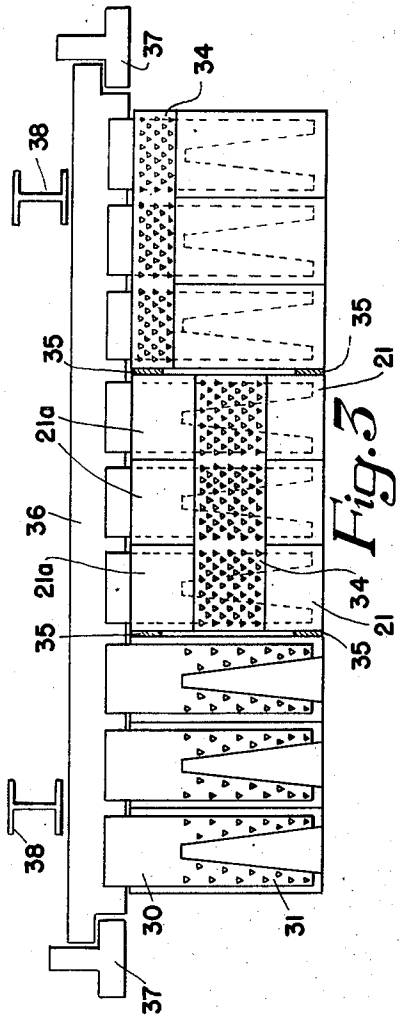


Fig. 3

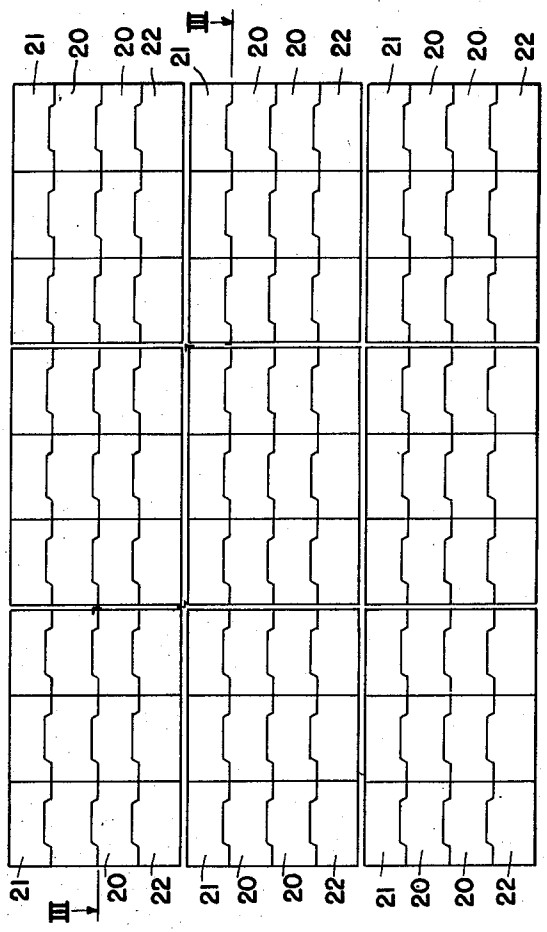


Fig. 1

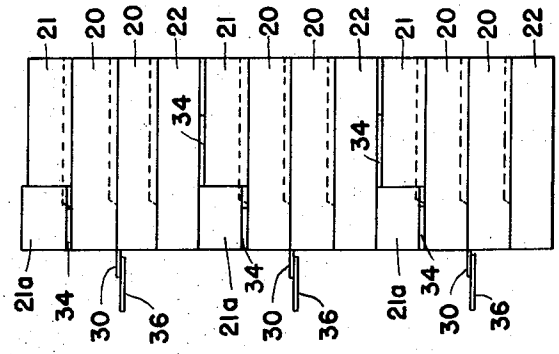


Fig. 2

INVENTOR

Levi S. Longenecker

BY Green, McCallister & Miller

HIS ATTORNEYS

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Filed May 22, 1948 5 Sheets-Sheet 2

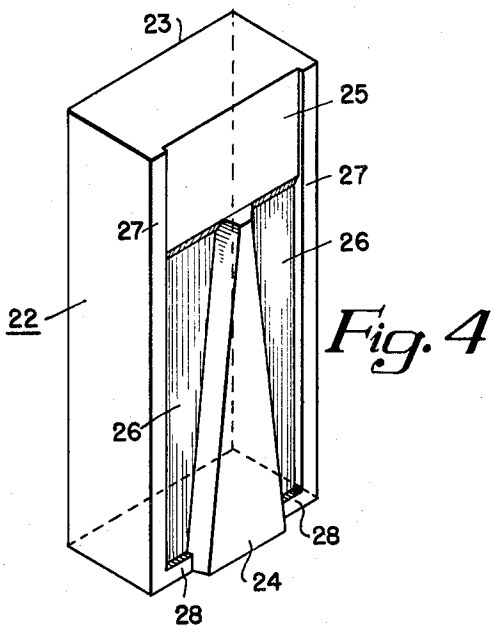


Fig. 4

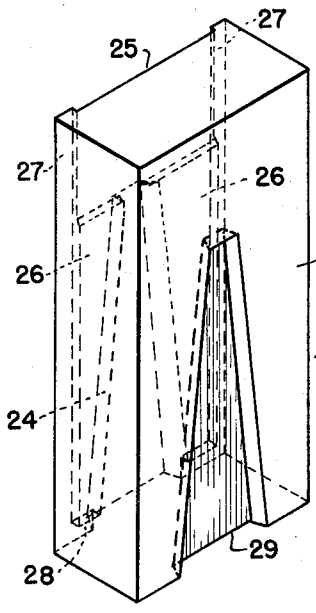


Fig. 5

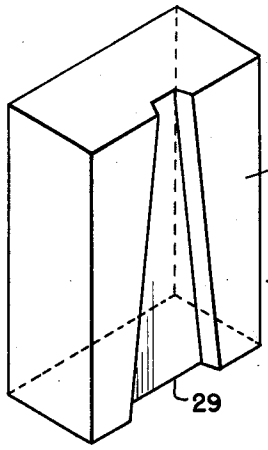


Fig. 6

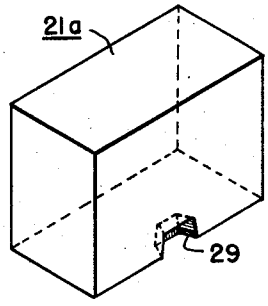


Fig. 7

INVENTOR
Levi S. Longenecker
BY Greene, McCallister & Miller
HIS ATTORNEYS

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COMPENSATED FURNACE CHAMBER ENCLOSURE STRUCTURE

Filed May 22, 1948 5 Sheets-Sheet 3

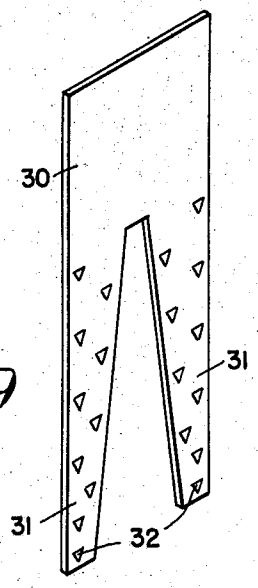


Fig. 9

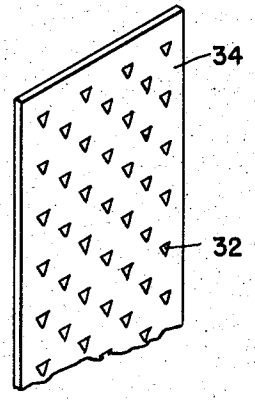


Fig. 10

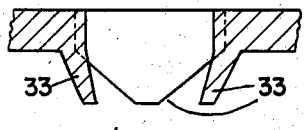


Fig. 11

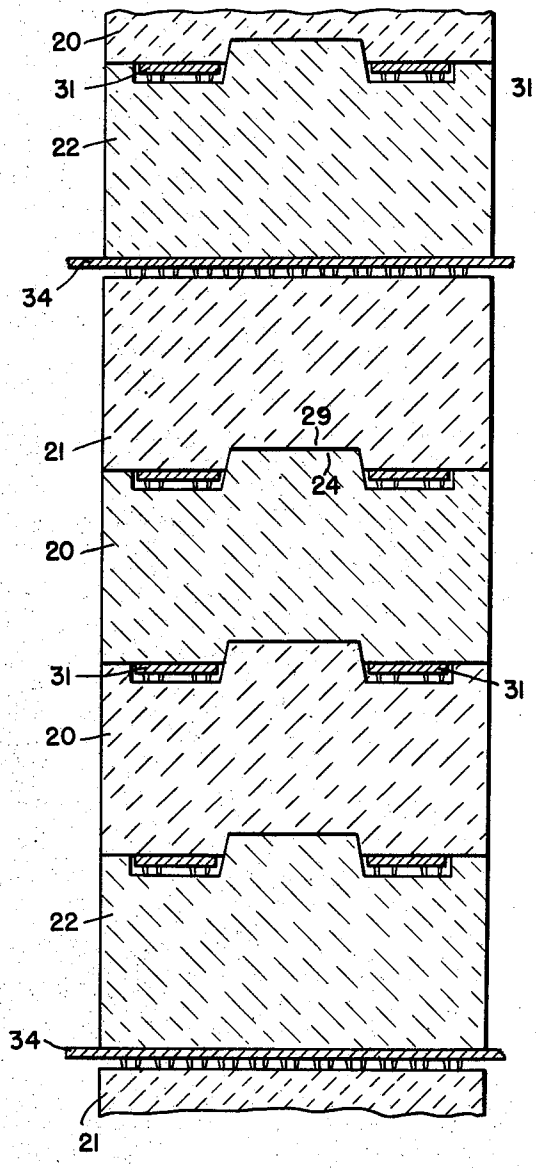


Fig. 8

INVENTOR
Levi S. Longenecker
BY Green, McCallister & Miller
HIS ATTORNEYS

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COMPENSATED FURNACE CHAMBER ENCLOSURE STRUCTURE

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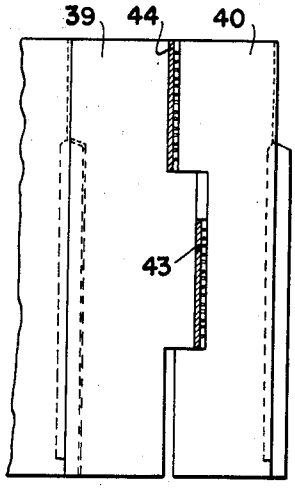


Fig. 14

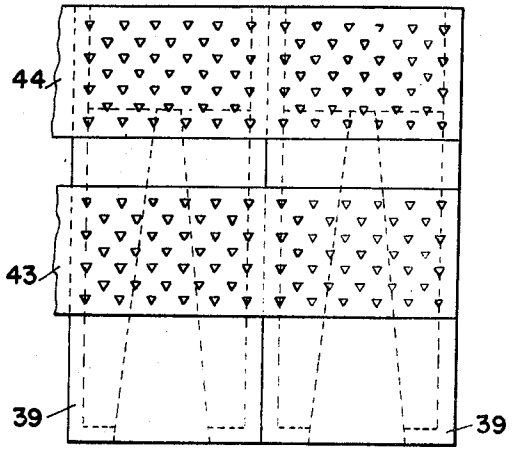


Fig. 15

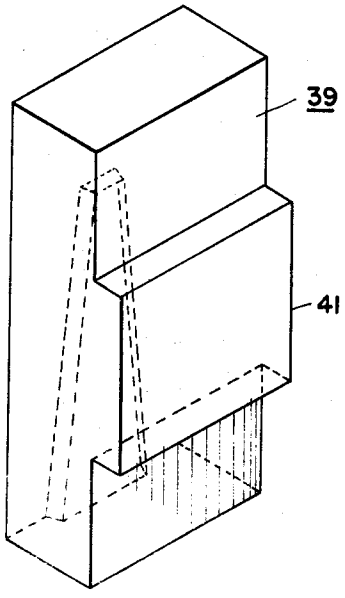


Fig. 12

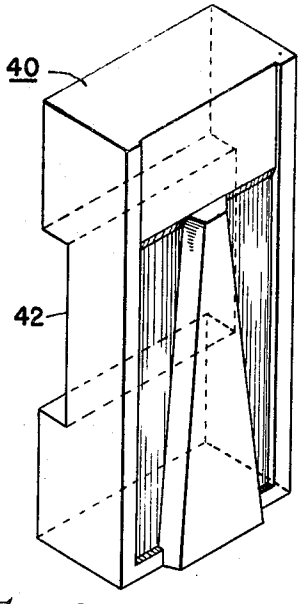


Fig. 13

INVENTOR
Levi S. Longenecker
BY Green, McCallister & Miller
HIS ATTORNEYS

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COMPENSATED FURNACE CHAMBER ENCLOSURE STRUCTURE

Filed May 22, 1948 5 Sheets-Sheet 5

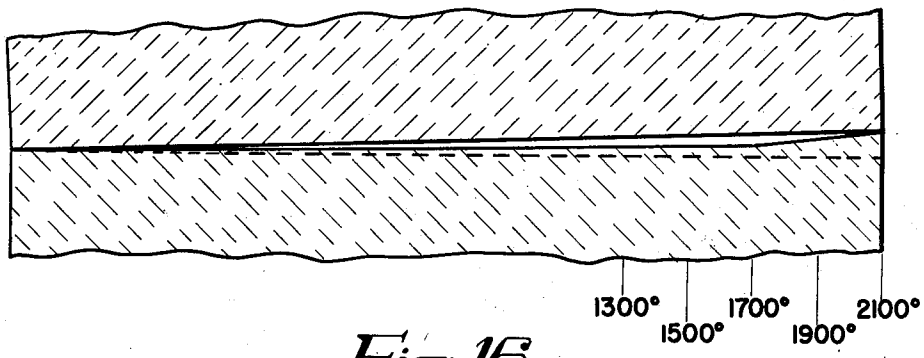


Fig. 16

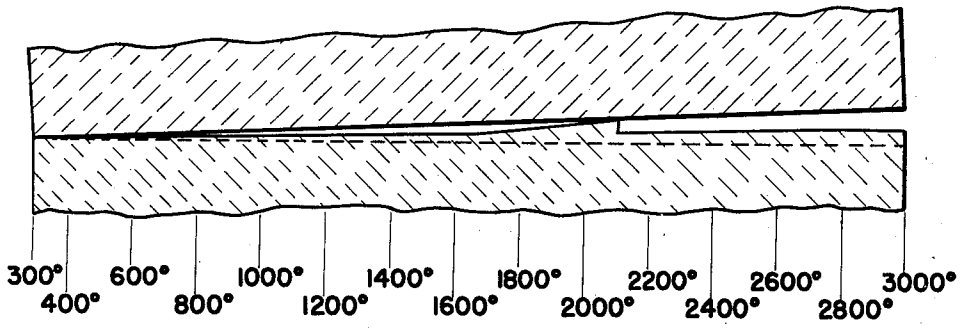


Fig. 17

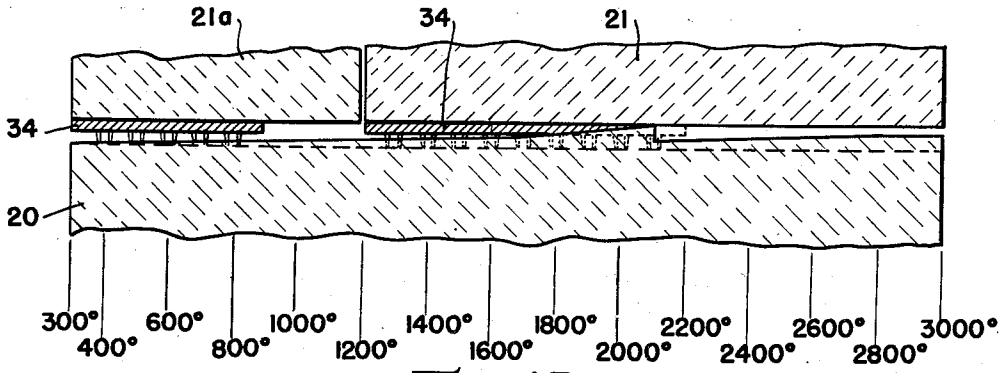


Fig. 18

INVENTOR

Levi S. Longenecker

BY Greey, McCallister & Miller

HIS ATTORNEYS

Patented July 24, 1951

2,561,933

UNITED STATES PATENT OFFICE

2,561,933

COMPENSATED FURNACE CHAMBER ENCLOSURE STRUCTURE

Levi S. Longenecker, Pittsburgh, Pa.

Application May 22, 1948, Serial No. 28,600

7 Claims. (Cl. 263—46)

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This invention relates to furnace wall and roof structures and more particularly to furnace wall and roof structures made of basic refractories.

Basic refractories are generally considered to be those composed of magnesite or chrome or mixtures of magnesite and chrome and are both burned and unburned. If unburned, they are chemically bonded. Basic refractories in the form of blocks or brick, whether burned or chemically bonded, expand from about $\frac{3}{16}$ to about ¼ of an inch per foot when heated to furnace operating temperatures. Unburned basic brick have a very sharp expansion rate from about 1700° F. to about 2100° F. Beyond 2100° F., when under load, they begin to shrink. Above 2800° F., basic brick whether burned or unburned, begin to soften so that their load carrying strength falls off.

If a furnace chamber wall constructed of such basic brick and having no expansion joints is so heated that its inside or furnace chamber face has a temperature of about 3000° F. and its outside face has a temperature of about 700° F.—a zone adjacent the furnace chamber face is expanded its full amount of ¼ of an inch per foot, while the zone adjacent the outside face is expanded but very little.

Such heating causes the bricks to become wedge-shape, with the thicker section thereof adjacent the inside face of the wall and with the thinner section adjacent the outside face. Under such conditions the wall, as will be expected, has a tendency to bow out, and will, unless it is restrained. Restraining is usually accomplished by sectionally tying the wall to the buckstays or furnace steelwork. If restrained so that it cannot bow, the expansion of the inner end portions of the bricks causes the wall to grow in height and of course, the inner end portions of the bricks or blocks carry the entire wall load. This growth in height spreads apart the outer ends of the bricks, and if the load on the inner end portions is too great, such portions become squashed out of shape, causing refractory failure.

If the furnace temperatures are such that the inside face of the furnace wall reaches 3000° F., and the wall is soaked through until temperature equilibrium is obtained, the maximum expansion occurs about 4½" in from the furnace chamber face. This maximum expansion causes a hump to be formed at this position and such hump must carry the entire wall load, if the wall is bucked up from the outside by the usual lateral braces. The wall under such conditions may teeter on the hump, since there will be voids both inside

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and outside of such hump. Since the hump can be quite narrow, the load per square inch of refractories can be extremely heavy.

If the basic bricks are reinforced either by steel jackets or steel plates (as is now common) with the furnace chamber ends of such metal members exposed to the furnace chamber temperature, these will soften at about 2300° F. and such plates and the horizontal portions of such jackets may be squeezed out from between the bricks, offsetting the expansion of the bricks in an amount equal to the thickness of such jackets or reinforcing plates.

This squeezing out of the softened jacket or plate material however only occurs between the outer end of the softening zones of such plates or jackets and the furnace chamber face of the wall. From such softening zone to the outer or opposite face of the wall, these plates or jackets generally oxidize and swell or increase in thickness. Because of this swelling, the hump is exaggerated.

From this it will be seen that while a wall made of basic brick may be solid when built, it will not be solid after it has been heated to operating temperatures.

Before heat is applied to the inside face of the wall, the wall load is evenly distributed, but as soon as heat is applied to the inside face, the load shifts to a zone adjacent such inside face. When temperature equilibrium is established through the wall, with the temperature of the inside face about 2800° F., the inside ends of the bricks begin to soften and the load is shifted to the hump. This hump, as above pointed out, becomes more pronounced when spacer reinforcing plates or jackets are used, since the inner ends of such plates or jackets melt away and the remaining metal oxidizes and swells.

An object of this invention is to produce a basic refractory furnace wall which is provided with means for overcoming this difficulty.

Another object is to provide a method of making a refractory furnace wall which overcomes this difficulty.

Another object is to produce an improved basic refractory furnace wall and/or roof structure.

Another object is to provide a method of making an improved furnace wall or roof structure in which the refractories are formed of basic materials.

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

drawings accompanying and forming part of this application.

In the drawings:

Figure 1 is an elevational view looking toward the inner or furnace chamber face of a section of a side wall of a furnace chamber enclosure structure embodying this invention;

Fig. 2 is an end elevational view of such wall section;

Fig. 3 is a sectional view taken on line III—III of Fig. 1 looking in the direction of the arrows;

Fig. 4 is a perspective view of one type of full length block or brick used in the make-up of the wall section of Figs. 1, 2 and 3;

Fig. 5 is a perspective view of another type of full length block of such figures;

Fig. 6 is a perspective view of one of the shorter blocks utilized in the make-up of the wall of Figs. 1 to 3 inclusive;

Fig. 7 is a perspective view of a still shorter block; the blocks of Figs. 6 and 7 taken together equalling the length of a full size block and being utilized to offset the load carrying metal spacer members;

Fig. 8 is an enlarged sectional view of a portion of Fig. 2 and discloses four ferrous metal reinforcing members and two cuprous metal load carrying spacer members;

Fig. 9 is a perspective view of one of the ferrous metal reinforcing members such as may be used in a furnace enclosure structure embodying this invention;

Fig. 10 is a fragmentary perspective view of one of the load carrying spacer members;

Fig. 11 is an enlarged fragmentary view of a pronged portion of the spacer member of Fig. 10 or the reinforcing member of Fig. 9;

Fig. 12 is a perspective view of a modified form of block or brick which may be used in an anchored wall or suspended roof structure embodying this invention;

Fig. 13 is a perspective view of a companion brick or block to be used in connection with that of Fig. 12;

Fig. 14 is a side view in elevation of the blocks of Figs. 12 and 13 nested together with load carrying cuprous metal spacer members in place therebetween;

Fig. 15 is a face view of two blocks or bricks such as shown in Fig. 14. This view shows two such blocks in side by side abutting relation with the cuprous metal load carrying spacers occupying the positions shown in Fig. 14;

Figs. 16, 17 and 18 are diagrammatic views and comprise a combination of basic bricks, load carrying spacer members and hypothetical temperatures and are used for the purpose of describing the behavior of the basic bricks in an ordinary wall and in the wall embodying certain features of the invention of this application.

I have found that I can overcome the difficulties occasioned by the expansion differential between the furnace chamber face and the outside face of a wall formed of basic refractories, as well as those occasioned by the hump that occurs when the temperature equilibrium through such wall is reached. I do this by including in a furnace chamber wall, shim-like, metal, load sustaining spacer members which are so placed as to sustain load on opposite sides of the center of mass of the wall, and to provide spaces within which the bricks of such wall can grow under furnace heating up or operating temperatures; such spacer members being capable of softening and then melting away when the hump is completely formed and is in condition to take its share of the load.

In making the vertical wall section of a furnace chamber enclosure structure disclosed in Figs. 1, 2 and 3, which embodies the invention of this application in its preferred form, I preferably use chemically bonded basic brick having standard dimensions of 3" x 6" x 13½". Instead of bricks of standard form, however, I preferably use bricks of the type disclosed in an application filed by me on February 14, 1944 and Serially Numbered 522,259, now Patent No. 2,476,423.

These bricks are reinforced by means of ferrous metal reinforcing members which are located within pockets formed in the bricks and which are of such size with relation to the reinforcing members that such members can oxidize and swell without exaggerating the hump, as is the case where standard reinforcing plates or jacketed or plated bricks are used.

Referring to Figs. 1 to 3 inclusive, the wall section there disclosed comprises rows of interlocked basic brick **20**, **21**, **22**, and **21***a*. These are arranged in groups each of which is preferably four bricks high and three rows wide. Each group, therefore, includes three bottom bricks **22**, six intermediate bricks **20**, three two-third length top bricks **21** and three one-third length top bricks **21***a*; the combined lengths of bricks **21** and **21***a* being but 13½" and instead of being special bricks, these can be broken from one brick.

Bricks **22** (Fig. 4) have one wide face **23** which is smooth while the opposite wide face is provided with a triangular tongue **24**. Aside from the tongue **24**, such wide face is also provided with a shallow groove **25** extending from the apex of tongue **24** to the adjacent end of the brick, and identical sub grooves **26** located on opposite sides of tongue **24** and which terminate short of the furnace chamber end of the brick, as shown in Fig. 4. The forming of sub grooves **26** which terminate short of the furnace chamber end of the brick leaves side flanges **27—27** and end flanges **28—28** which form refractory barriers between the sub grooves and the furnace chamber.

Bricks **20** (Fig. 5) have one wide face provided with a tongue **24**, a groove **25**, sub grooves **26** and flanges **27** and **28**. The opposite wide face is provided with a groove **29** of a size such as to co-operate with a tongue **24**.

Each of bricks **21** and **21***a* has one wide side plain and smooth and the opposite wide side provided with a groove **29**.

When the tongue of a **20** or **22** brick engages the groove of an adjacent brick, a pocket is formed between the engaging bricks. The base or furnace chamber end of each triangular tongue **24** (whether in a wall, roof or floor brick) is located in the inner or furnace chamber face of the wall as disclosed in Fig. 1. Since the thickness of tongue **24** equals the depth of groove **29** plus the height of flanges **27** and **28**, sub grooves **26** and groove **25** are closed to the furnace chamber but open to the outside atmosphere.

The ferrous metal reinforcing members (sheet iron, sheet steel or heat resisting chrome alloy steel) disclosed in Figs. 9, 3 and 8, and having a thickness of about $\frac{1}{8}$", comprise a solid body portion **30** and leg portions **31**.

Each leg portion **31** has holes **32** punched

therein from one side. This punching operation is performed, in this case, by a pointed punch which, in forming the hole, forces the displaced metal outwardly to provide prong-like protuberances **33** around the hole. These protuberances or prongs project about ⅛" more or less beyond the pronged face.

These reinforcing members are placed within grooves **25** and sub grooves **26** with the ends of the prongs in contact with the bottom of sub grooves **26**; the face of body portion **30** lying in contact with the bottom of groove **25**. There is slight clearance between the body portion **30** and the walls of the pocket **25**. This clearance allows atmospheric air to enter sub grooves or pockets **26** to facilitate oxidation of the legs of the reinforcing members.

The volumetric capacity of these sub grooves or pockets with relation to the volume of metal in legs **31** of the reinforcing members when oxidized, is such that such legs when oxidized may fill, but will not overfill such sub grooves or pockets. My reinforcing members, therefore, will not increase the size of the hump nor will there be any tendency for them to force the bricks apart as they oxidize.

Load carrying expansion compensating spacer members

For each foot of wall height, I include in the make-up of each row of bricks my load carrying expansion compensating members **34**. These spacer members are preferably formed from copper strip of 14 or 16 gauge, and, like the brick reinforcing members are provided with prongs or protuberances similar to prongs **33**, produced by the same method as used in connection with the formation of the prongs in the brick reinforcing members. A portion of one such spacer member is shown in Fig. 10.

These spacer members preferably have a length equal to the width of three bricks and a width of from 2 to 3 inches. The effective overall thickness of each spacer member is approximately from $\frac{3}{16}$ to ¼". This includes the strip thickness and the length of the prongs. Their load carrying capacity depends upon the number and spacing of the prongs and therefore the number of punched holes.

While these spacer members could extend throughout the length of the bricks, nothing would be gained and if so used, they would produce through-openings in or passages through the wall which of course would be objectionable. They would also waste copper. In order to prevent these passages or through-openings, the spacer members are made in two parts, as disclosed in Figs. 2 and 3 and one such part is used in conjunction with bricks **21** and the other with bricks **21***a*. In other words, the two parts of each spacer (in reality there are two spacers) are offset, one part being used on top of brick **21** and the other part below brick **21***a*. This offsetting by the spacer members blocks off by refractory material the passages or openings formed in the furnace chamber enclosure structure by such spacer members.

The spacer shims having a length substantially equal to the width of three bricks lock the three rows of bricks in each bundle together. These spacers, located as they are on opposite sides of the center of mass of the wall form a stable support means and insure against any teetering that might occur if they were close together, were narrow and were located near the center of mass of the structure.

In laying up the wall, wood strips **35** are used to space the bundles or groups of bricks apart for the purpose of providing room for the bricks to grow transversely. These strips are removed after the wall is completed, since they probably would not burn away rapidly enough to accommodate the expansion.

All vertical walls embodying this invention should be laterally braced. Since the wall is solidly loaded, these braces may not be needed in bringing the wall up to operating temperature and probably will not be needed throughout a continuous operating period. Lateral braces, however, are necessary for the vertical walls of a furnace chamber, if the furnace is to be cooled down after the inner spacer members have been melted away. When this happens, the whole downward load will be supported by the outer spacer members, and with the center of mass located inwardly of the outer spacer members, the lateral braces or ties are necessary to prevent the wall from tipping inward.

As shown in Figs. 2 and 3, the body portions **30** of the brick reinforcing members are secured, as by welding, to lateral braces **36**. These braces are located between buckstays **37**, and by such buckstays and I-beams **38** of the steelwork of the furnace, are held in place but allowed to move vertically as the wall expands and contracts.

In structure where it is not convenient or practical to utilize short bricks for the purpose of offsetting the load carrying spacer members—structures such as suspended roofs, sprung arches, linings for rotary kilns, furnace door linings, etc., offsetting can be obtained by using special bricks.

In Figs. 12–15 inclusive, I have illustrated one type of such bricks to take the place of bricks **22**, **21** and **21***a*. Brick **39** can be used in place of bricks **21** and **21***a* and brick **40** can be used in place of brick **22**. Brick **39**, instead of having one flat face opposite its grooved face is provided with a central projection **41** which is adapted to fit within a central depression **42** in brick **40**. By utilizing bricks such as these, the inner spacer member which in Figs. 14 and 15 is numbered **43**, is offset from the outer spacer member which is numbered **44**. Engagement of projection **41** with slot **42** prevents a through-opening in the structure.

If these bricks are to be used in suspended roofs, furnace doors, rotary kiln linings and certain types of side walls, the bricks will be provided with slots at their outer ends for the reception of hanger members as disclosed in Patents 1,913,168 granted to me June 6, 1933, and 2,387,594 granted October 23, 1945.

When a wall of this invention is installed, the wall load is caried by the spacer members and of course those portions of the refractories in vertical alignment with the same. As the wall is heated, the inner brick ends can expand into the $\frac{3}{16}$" spaces between the inner spacer members and the furnace chamber face of the wall. Then, as the temperature increases throughout the wall, the prongs of the spacer members sag as the bricks expand.

When the inner spacer members reach 1981° F., the melting point of copper, they melt away and the load is assumed by the fully expanded bricks (the humps). As the wall wears thin, the humps move out to the outer spacer members

which behave in the same manner as the inner members, that is, melt away and allow the fully expanded wall to assume the remaining wall load.

The wall of this invention is thus solid when installed and is solid throughout the heating up and operating period from beginning to end of the service campaign of the refractories.

Fig. 16 is a fragmentary section of two adjacent conventional basic bricks of the size herein referred to, that is, bricks in a wall 13½" thick. This view shows the expansion of such bricks when the furnace chamber face of the wall reaches 2100° F. This view shows the sharp wedge caused by rapid expansion from 1700° F. to 2100° F. At a fast rate of heating, the outside face of the wall is still probably cold, therefore to have balanced loading, the upper brick would take a sloped position as shown in this view. If the buckstays and lateral braces prevent this outward tilting, then the wall rises upwardly and produces voids between the outer ends of the bricks causing the inside ends of the bricks to be pinched by the total wall load.

Fig. 17 shows the expansion lines and loading when the inside face of the wall reaches 3000° F. and the wall is soaked through to temperature equilibrium. Here the point of maximum expansion is located about 4½" in from the furnace chamber face. In other words, the sharp wedge forming the hump has moved in so that it is located between 1700° F. and 2100° F.

This is the hump which must carry the load. The wall, if it can bow, will take the position shown in the upper brick. If bucked up from the outside, the wall will teeter on the hump with voids between both the inner and outer ends of the bricks.

Fig. 18 shows the expansion lines and loading at temperature equilibrium with the inside face at 3000° F. Here, an inner spacing member is assumed to be located 4" back from the inside face so that it will carry the load as the temperature of Figure 16 works into Figure 18. Here it can be noted how the inner spacing member has formed into a reverse wedge to compensate for the wedge-shaped expansion of the brick.

As the wall burns away, the inner spacer member finally melts away and disappears and the wall is then carried on the outer spacer member and the brick hump.

Forming prongs on the spacer members is not only for the purpose of saving metal, but to produce a member which will compress on a line as nearly parallel to the expansion line of the bricks as is possible. The prongs weaken as they soften and disappear when the spacer members melt.

I have selected copper as the preferred metal for the spacer members, since its melting point occurs just ahead of the maximum expansion of the brick. Brass can be used, if a lower softening and melting point is desired. Low carbon steel can also be used, but its softening and melting points are rather high for the purpose. Copper has been found to be the preferred metal.

These spacer members can be used with any refractories where the material from which they are made when melted does not form a harmful flux with the refractory material. Neither copper, brass nor ferrous metals will when melted harm basic refractories in any way.

What I claim is:

1. A furnace chamber enclosure structure comprising rows of refractory blocks, each such row comprising groups of full length blocks arranged in abutting relation, each such group being separated from adjacent groups by two load sustaining cuprous metal spacer members separated from one another so as to embrace opposite sides of a plane which includes the center of mass of the structure and parallels its inner and outer faces; one such spacer member being in contact with the end face of one such group, the other being in contact with the adjacent end face of the adjacent group; such spacer members being separated by refractory block material and being designed to sustain the structure load and to decrease in height and then melt away under certain furnace operating temperatures to accommodate the increase in thickness of the refractories due to such temperatures.

2. A furnace chamber enclosure structure comprising groups of basic refractory blocks, some of the blocks in each such group being arranged in abutting relation, others being spaced apart by two metal spacer members one located adjacent the outside face of each such group and the other adjacent the point of greatest expansion in the thickness of such blocks when temperature equilibrium within the structure is attained, each such spacer member comprising a sheet-like body having protuberances extending from at least one side face thereof to increase its effective thickness, the construction and arrangement being such that the spacer members located adjacent such point of greatest expansion soften and then melt away at the temperature at which such greatest expansion occurs.

3. A structure as defined in claim 2, in which the spacer members are made from cuprous metal strips, are plate-like in the main and have prongs projecting from at least one face thereof.

4. A structure as defined in claim 2, in which the spacer members contain iron, are plate-like in the main and have prongs projecting from at least one face thereof.

5. A structure as defined in claim 1, in which the spacer members are plate-like in the main and have tapered prongs extending outwardly from at least one side thereof.

6. A furnace chamber enclosure structure comprising groups of chemically bonded basic refractory blocks, some of the blocks in each such group being arranged in abutting relation others being spaced apart by two cuprous metal spacer members, one located adjacent the outside face of each such group and the other adjacent the point of greatest expansion in thickness of such blocks when temperature equilibrium within the structure is attained, each such spacer member comprising a sheet-like body having protuberances extending from at least one wide face thereof to increase its effective thickness; the construction and arrangement being such that the spacer members located adjacent such points of greatest expansion, soften and then melt away at the temperatures at which such greatest expansion occurs.

7. A furnace chamber enclosure structure comprising rows of refractory blocks each such row comprising groups of full length blocks arranged in abutting relation, each such group being separated from adjacent groups by two load sustaining metal spacer members located on opposite sides of a plane which includes the center of mass of the structure and parallels its inner and outer faces; one such spacer member being in contact with the end face of one such group, the other being in contact with the adjacent end face of the adjacent group; such spacer members be-

ing separated by refractory block material and being designed to sustain the structure load and to decrease in height and then melt away under certain furnace operating temperatures to accommodate the increase in thickness of the refractories due to such temperatures.

LEVI S. LONGENECKER.

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