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2,606,017

FURNACE ROOF AND WALL STRUCTURE

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2 SHEETS--SHEET 1

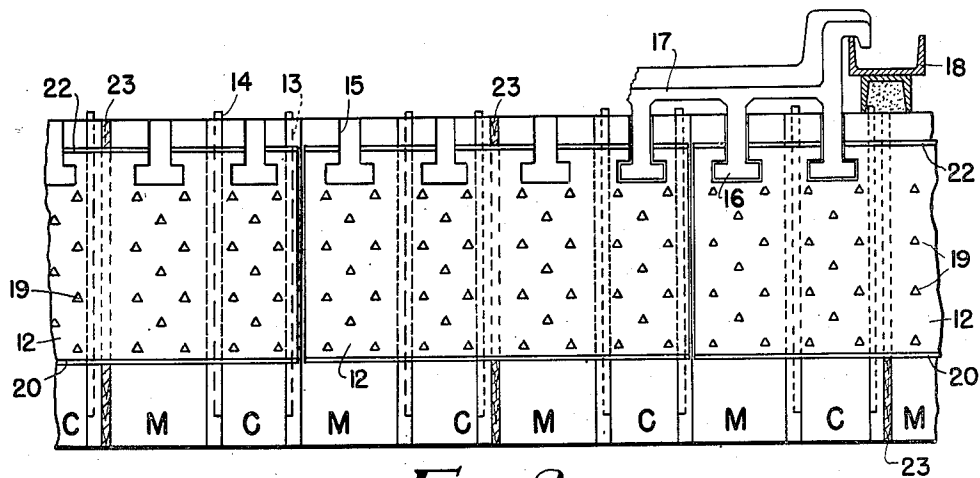


Fig. 2

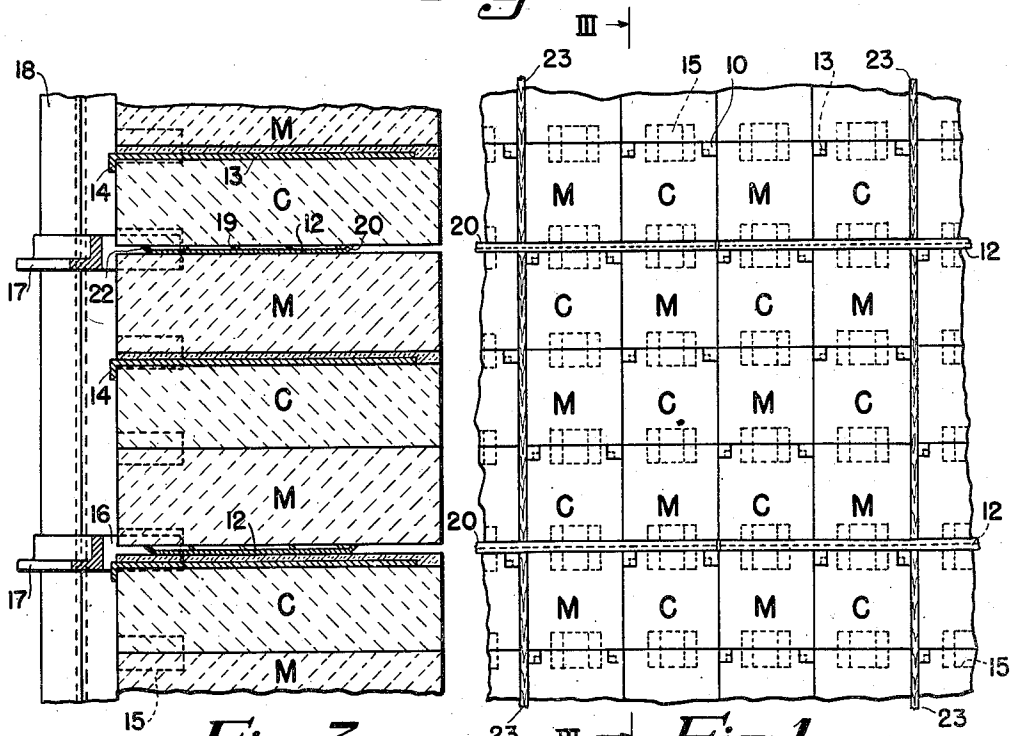


Fig. 3

Fig. 1

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2 SHEETS—SHEET 2

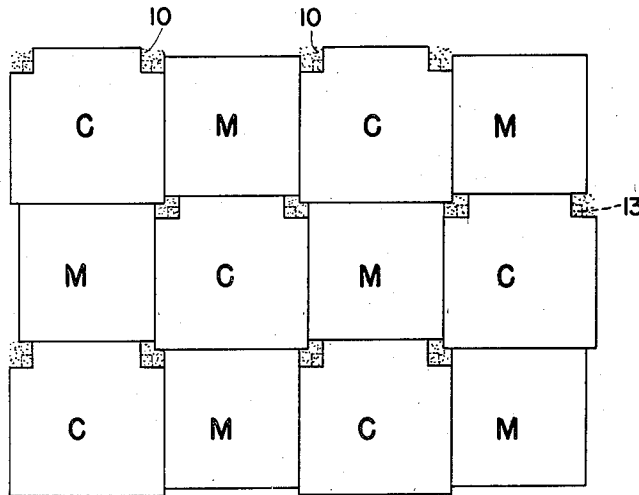


Fig. 4

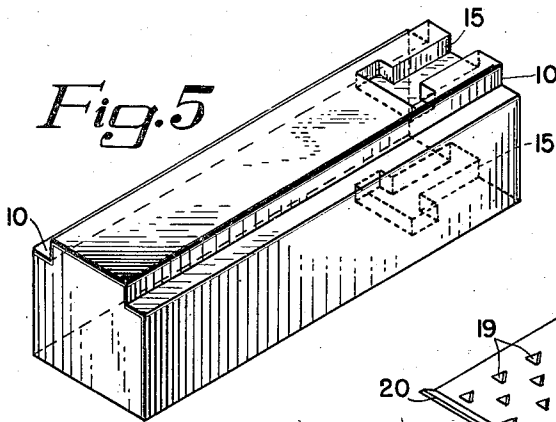


Fig. 5

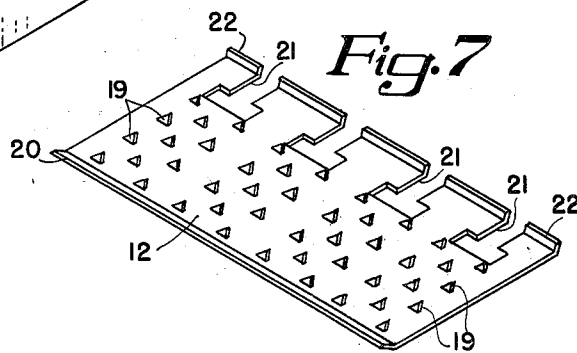


Fig. 7

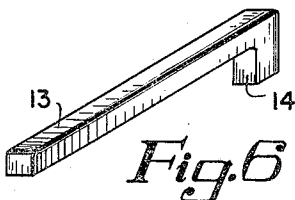


Fig. 6

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FURNACE ROOF AND WALL STRUCTURE

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9 Claims. (Cl. 266—43)

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This invention relates to furnace wall and roof structures and more particularly to such structures made from chemically bonded and/or burned basic refractories used in the make-up of open hearth furnace walls and roofs.

Such basic refractories usually comprise a mixture of magnesite and chrome ore and a typical length of such refractories in brick form is $13\frac{1}{2}$ inches; the same being somewhat modified when used in the make-up of suspended roof structures.

These basic refractories when used in open hearth furnace walls and roofs behave in a manner, the reason for which is not well understood, but which materially shortens their effective life. For example, a furnace chamber wall or roof when new loses layer after layer from the furnace chamber side thereof. These layers vary in thickness from $2\frac{1}{2}$ inches down to $\frac{3}{4}$ of an inch, depending somewhat upon the original thickness of the wall as well as on the furnace chamber temperatures and pressures. The loss or peeling off of these layers seems to follow some sort of a time cycle, since peeling does not occur immediately on heating up the furnace, but starts later on when the inside surface of the wall or roof, as the case may be, becomes saturated with vapors from the furnace atmosphere.

After the first layer falls away, the new surface takes on a glaze or vapor coating which persists for a time or until the structure loses another layer in a similar manner. The time between peelings seems to increase and the thickness of the peeled layers appears to decrease as the wall becomes thinner. For instance, this peeling, if it can be called peeling, in a roof or wall $13\frac{1}{2}$ inches thick, disappears or ceases when the structure (wall or roof) arrives at a thickness of from 4–5 inches. From here on, while the structure becomes thinner with each successive heat, no more peeling occurs.

Such a wall or roof in an open hearth furnace, after it has reached the point at which it no longer peels, produces an average of about 60 heats per inch of wear. A $13\frac{1}{2}$ inch wall or roof therefore before it burns down to a thickness of $1\frac{1}{2}$ inches ought to have a useful thickness of 12 inches, and on the basis of 60 heats per inch of thickness, such a structure (wall or roof) should produce 720 heats. At the present time, however, due to this peeling phenomenon, such a wall only produces around 360 heats.

From a study of brick ends taken from the slag pocket of an open hearth furnace having chemically bonded basic refractories it is ap-

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parent that the pieces (peelings) of each of the layers are of fairly uniform thickness throughout their entire cross sectional area. In other words, the plane of the fracture face of such brick ends parallels that of the original inner or furnace chamber face of the brick.

These pieces (brick ends) have fairly square edges, and measurements of the same adjacent their fracture face show that the original thickness of 3 inches has increased to about $3\frac{1}{4}$ inches with a corresponding increase in the width as well. Apparently the whole inner brick end has swelled or grown due to the furnace vapors which penetrated its structure. This swelling or growth of $\frac{1}{4}$ inch per every 3 inches means a growth of 1 inch per foot. This vapor or liquid penetration should follow some sort of a gradient line. The amount of penetration should be greatest at the inner or furnace chamber face and should taper off to zero somewhere back within the brick. The swelling or growth of the brick, therefore, should be greatest at the inner or furnace chamber face and should taper off to zero somewhere back of such face.

I am convinced from my study of the broken brick ends taken from the slag pocket that the pieces making up each of the broken away or peeled off layers have grown or swelled at the rate of about one inch per foot. This swelling is localized and is confined to a zone which is relatively narrow with relation to the thickness of a $13\frac{1}{2}$ inch brick wall and since the remainder of the wall has not grown or swelled and is too heavy to be raised or lifted by any of the relatively narrow zones as such zones swell or grow, the swelled portions buckle for relief and tear themselves loose from the remainder of the wall.

I am of the belief that as the thickness of the wall, due to the peeling off of successive layers, approaches a thickness of from 4–5 inches, the weight of the unswelled portion has decreased to such a point that such portion can be raised by the swelled portions without tearing the swelled portions away from the unswelled portions. This seems to be borne out by the behavior of the outside face of the wall at or about the time the peeling off ceases. The courses in this portion appear to separate sufficiently to relieve any further tendency of the inner or furnace chamber face of the wall to peel.

The general opinion gathered from published papers and reports seems to be that this growth or swelling is caused by the action of the iron oxide in the furnace atmosphere on the chrome content of the basic brick.

Magnesite bricks on the other hand under continued heating at high temperatures shrink and continue to shrink until they apparently reach zero porosity. Iron oxide in the furnace atmosphere under furnace operating temperatures may retard or somewhat reduce the amount of shrinking but it will not cause any growth or swelling of magnesite bricks.

Chrome ore is apparently added to the magnesite for the purpose of making a more stable brick structure and reducing its burning shrinkage. Since a valuable brick structure is obtained by proper balancing of magnesite and chrome ore, we apparently are forced to accept its growth or swelling which occurs immediately adjacent the furnace chamber face when such structure is used in furnaces having iron oxide in the furnace chamber atmosphere, and one object of this invention is to produce a furnace wall or roof structure a portion at least of which is made up of chemically bonded or burned magnesite-chrome refractories in which the effects of such growth behavior are offset and rendered harmless.

Another object of this invention is to produce a chemically bonded or burned basic refractory wall or roof structure for open hearth furnace use in which the service life will be materially increased over what it has heretofore been.

Another object is to produce a chemically bonded basic refractory wall or roof structure for open hearth furnaces in which the service life is doubled over what it has heretofore been.

Another object is to provide a method of making a furnace wall or roof structure from basic refractory blocks or bricks in which the peeling phenomenon above referred to does not occur.

A still further object is to produce a furnace wall or roof structure comprising at least some chemically bonded or burned basic refractories which increase their cross sectional dimensions immediately adjacent their furnace chamber end faces under the influence of open hearth furnace temperatures and atmospheres and in which such growth behavior is offset by the shrinking characteristics of other refractories included in such structures.

These and other objects, I attain by means of the structure described in the specification and illustrated in the drawings accompanying and forming part of this application.

In the drawings:

Figure 1 is a view in front elevation of a fragmentary portion of a furnace wall embodying this invention;

Fig. 2 is a top plan view of a larger section of such wall;

Fig. 3 is a sectional view taken on line III—III of Fig. 1;

Fig. 4 is an enlarged view in front elevation of three of the courses of bricks disclosed in Fig. 1 after the wall has reached furnace operating temperature under operating conditions;

Fig. 5 is an enlarged perspective view of one of the magnesite-chrome bricks used in the make-up of the wall of Figs. 1-3 inclusive;

Fig. 6 is an enlarged perspective view of a steel reinforcing bar which may be used in the make-up of the wall structure of this invention; and

Fig. 7 is an enlarged perspective view of one of the load carrying expansion compensating shim-like members which are preferably used in the wall structure of this invention.

A typical wall for open hearth furnaces embodying this invention comprises groups of

chemically bonded or burned bricks part of which swell immediately adjacent their furnace chamber end faces and part shrink a corresponding amount immediately adjacent their furnace chamber end faces under furnace operating conditions and temperatures. These two types of bricks are alternately arranged as in a checkerboard so that the swelling of one type is offset by the shrinking of the other type; the composition of the bricks being such that the amount of shrinking of one type will as nearly as possible offset the amount of swelling of the other type.

In the preferred form of wall of this invention, the bricks are preferably chemically bonded. The swelling bricks are magnesite-chrome bricks, while the shrinking bricks are preferably magnesite with very little, if any, chrome in their make-up. I have marked the magnesite bricks M and the magnesite-chrome bricks C.

While bricks of usual shape and dimensions $3 \times 4\frac{1}{2} \times 13\frac{1}{2}$ " can be used provided each of the C bricks along at least two of its longitudinally extending edge portions is modified or shaped so as to provide space for accommodating lengthening of the diagonals of the C bricks as is bound to occur under furnace operating temperatures and conditions, I prefer to use bricks that are generally square in cross section and are $4 \times 4 \times 13\frac{1}{2}$ ".

While each M brick may be and preferably is square in cross section, each C brick has at least two of its longitudinally extending edge portions so modified or shaped as to provide spaces for accommodating lengthening of the diagonals of the C bricks which occurs under furnace operating temperatures and conditions. This modifying or shaping preferably is accomplished by forming depressions 10, which as shown in Fig. 5, extend along the upper longitudinally extending edges of the C bricks (the swelling bricks). When these bricks are alternately arranged as in a checkerboard, these depressions provide the necessary space to accommodate the increase in length of their diagonals due to the localized swelling which occurs under furnace operating temperatures and conditions. When the wall is laid up, these recesses are preferably filled with a magnesia carbonate mortar which shrinks at a temperature below the brick swelling temperature.

In some cases, it may be desirable to provide ferrous metal reinforcing members for the bricks, and if desired, these can take the form of steel rods 13 having their outer ends 14 bent over as shown in Figure 6 so as to lie against the outer face of the C bricks. The sides of depressions 10 in bricks of the size here used are preferably $\frac{1}{2}$ inch wide when the reinforcing rods are used. The rods will be embedded in the magnesia carbonate mortar which shrinks at a temperature below the oxidizing temperature of the rods.

The groups of bricks making up a wall or roof structure may each comprise as many bricks as desired, but in the drawings I have limited each group to 12 bricks.

The swelling or growth of the C bricks is localized being limited to a relatively narrow zone adjacent the inside or furnace chamber face of the wall or roof and develops during a constantly held temperature in the presence of iron oxide in the furnace atmosphere such as encountered under open hearth furnace operating temperatures and conditions.

The thermal expansion to which basic refrac-

ories are subject is an entirely different phenomenon from this localized swelling or growth due to the effect of iron oxide on the chrome of the C bricks, and has no relation whatever thereto.

Thermal expansion affects the entire brick thickness and causes the bricks to become wedge-shaped; the thicker section thereof being adjacent the inner or furnace chamber face of the wall and the thinner section being adjacent the outside face. Under these conditions due to thermal expansion, the wall bows outwardly unless restrained or compensated for. I prevent this outwardly bowing by tying certain of the bricks in each bundle to the buckstays or steel-work of the furnace structure. In this connection, each of the bricks, both C and M, at their outer ends, is provided in both its top and bottom sides with T-shaped slots 15 for receiving the T-shaped ends 16 of wall tying members 17 which, in the case of vertical walls, can be secured to the furnace buckstays 18.

In the case of furnace roofs embodying this invention, these tying members can be supported by overhead beams and used as suspension means for the bricks in forming a suspended roof structure. The T-shaped ends of these tying members fit into two adjacent bricks so that the bricks are suspended from opposite sides, that is, each brick is supported by two T-shaped supports of the tying members.

In the case of vertical walls, I preferably only tie the top and bottom rows of bricks in each bundle or group to the buckstays or steel structure of the furnace.

If the bricks are chemically bonded and are used in an open hearth furnace, the furnace operating temperatures will be such that the inside face of the furnace wall or roof as the case may be, reaches 3000° F. when the wall is soaked through and temperature equilibrium is obtained. The maximum expansion will occur about 4½ inches in from the furnace chamber face. At the point of this maximum expansion a hump is formed and such hump must carry the entire wall load, since the wall is bucked up from the outside by tying members 17. In order to prevent the wall under such conditions from teetering on such hump (there being voids in the wall both inside and outside of such hump) I preferably employ load carrying expansion compensating shim-like members such as disclosed in an application filed by me on May 22, 1948, and serially numbered 28,600, now Patent No. 2,561,933.

One such member which is numbered 12 is disclosed in Figure 7, its design, however differs somewhat from that disclosed in my said application. It is preferably produced from copper strip of 14 or 16 gauge and is provided with prongs 19 as in said application. It is preferably of such length as to embrace four of the bricks and of such width as to extend from a point adjacent the outer face of the wall to the high point of the hump which, as pointed out, is about 4½ inches from the inside or furnace chamber face of the furnace wall as disclosed in Figure 3.

The forward or inner edges of these load carrying expansion compensating members 12 are bent up as shown at 20 preferably about ¼ inch. The rear portion of each of these members has T-shaped slots 21 punched therein to accommodate the T-shaped tie members 17.

The edge portions 22 between such slots are also bent up ¼ inch as shown in Figure 7.

Prongs 19 are formed by punching and this punching is performed by a pointed punch which forms a hole and forces the displaced metal outwardly to provide the prong-like protuberances around such holes. These protuberances or prongs project about ⅛ inch beyond the pronged face of the member, so that their height plus the thickness of the metal strip will equal the height of the bent up inner and outer edges of the members.

In laying up a wall, these copper expansion compensating members are preferably placed so that each of the same extends from the center of one bundle or group to the center of the next adjacent bundle or group. The bent up ends serve as seals for the spaces or gaps between the bricks above and below the same, caused by prongs 19.

In laying up the wall, vertical wood strips 23 are used to space apart the groups or bundles of bricks for the purpose of providing room for the bundles to grow transversely. These strips are removed after the wall is completed, since they might not burn away rapidly enough to accommodate such expansion.

Instead of using wood strips as spacers for the vertical joints between the groups, I may make use of spacers made from copper strip material such as used for the horizontal load carrying shim-like members of Figure 7, but without the notches 21. In other words, the strip will have two continuous lips like lip 20, which act as seals; the effective thickness of the strip being determined by the length of the prongs and the height of the lips 20. These strips can be wide, or two narrow strips can be used, one adjacent the furnace chamber face of the wall and one adjacent the outside face of the wall.

It will, of course, be understood that this wall and roof construction is applicable to sprung roofs as well as suspended roofs and may be utilized in forming the lining of rotary kilns as well as the hearths of furnaces.

What I claim is:

1. A furnace side wall or roof structure comprising two types of generally rectangular refractory members of substantially the same size alternately arranged as in a checkerboard, the members of one type being subject to localized swelling immediately adjacent their furnace chamber faces under furnace operating temperatures and conditions and those of the other type being subject to localized shrinking a corresponding amount immediately adjacent their furnace chamber faces under the same furnace operating temperatures and conditions each refractory member of the swelling type having at least two of its longitudinally extending edge portions so shaped as to provide spaces for accommodating lengthening of the diagonals of the refractory members of such type due to localized swelling under furnace operating temperatures and conditions.

2. A furnace side wall or roof structure comprising two types of generally rectangular refractory members of substantially the same size, the members of one type being subject to localized swelling immediately adjacent their furnace chamber faces under furnace operating temperatures and conditions and the members of the other type being subject to localized shrinking a corresponding amount immediate-

ly adjacent their furnace chamber faces under the same furnace operating temperatures and conditions, the members of such two types being alternately arranged as in a checkerboard, but with at least two of the longitudinally extending corner portions of each refractory member of the swelling type being so shaped that space is provided to accommodate the increasing length of their diagonals occurring under such furnace operating temperatures and conditions.

3. A furnace side wall or roof structure comprising two types of generally rectangular members of substantially the same size, those of one type being subject to localized swelling immediately adjacent their furnace chamber faces under furnace operating temperatures and conditions and those of the other type being subject to localized shrinking a corresponding amount immediately adjacent their furnace chamber faces under the same furnace operating temperatures and operating conditions, the members of such two types being alternately arranged as in a checkerboard but with the two upper longitudinally extending corner portions of the refractory members of the swelling type being so shaped that spaces are provided to accommodate increase in the length of their diagonals occurring under furnace temperature and operating conditions.

4. A structure as defined in claim 1, in which the refractory members of the swelling type are chemically bonded and contain chrome.

5. A structure as defined in claim 1, in which the refractory members of both types are chemically bonded and those of the swelling type contain both magnesite and chrome.

6. A structure as defined in claim 1, in which the spaces for accommodating lengthening of the diagonals of the refractory members of the swelling type are formed by providing grooves which extend lengthwise of and include at least two of its longitudinally extending corner edges.

7. A structure as defined in claim 1, in which the grooves forming the spaces for accommodating lengthening of the diagonals of the refractory members of the swelling type extend along the upper longitudinal edge portions of such refractory members.

8. A furnace side wall or roof structure comprising two types of chemically bonded generally rectangular refractory members of substantially the same size, those of one type being subject to localized swelling immediately adjacent their furnace chamber faces under furnace operating temperatures and conditions and those

of the other type being subject to localized shrinking a corresponding amount immediately adjacent their furnace chamber faces under the same furnace operating temperatures and conditions, the members of such two types being alternately arranged as in a checkerboard; two of the longitudinally extending edge portions of each refractory member of the swelling type being so shaped as to provide spaces for accommodating lengthening of the diagonals of two adjacent refractory members of the same type under such furnace operating temperatures and conditions.

9. A furnace side wall or roof structure comprising two types of chemically bonded generally rectangular refractory members of substantially the same size alternately arranged as in a checkerboard, the members of one type comprising magnesite and sufficient chrome ore to cause localized swelling immediately adjacent their furnace chamber faces under furnace operating temperatures and conditions and those of the other type containing magnesite and little if any chrome ore so that localized shrinking in corresponding amount will occur immediately adjacent their furnace chamber faces under the same furnace operating temperatures and conditions; each refractory member of the swelling type having at least two of its longitudinally extending edge portions so shaped as to provide spaces for accommodating lengthening of the diagonals of the refractory members of such type due to localized swelling under furnace operating temperatures and conditions.

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