FURNACE ROOF CONSTRUCTION

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This invention relates to furnace construction, and pertains particularly to the construction of the refractory roofs of furnaces which are subjected to high temperatures and other influences of a destructive or disintegrating nature. The invention finds particular utility in metallurgical furnaces, such as furnaces of the reverberatory or open hearth types.

Refractories of basic or non-acidic character are desirable in furnaces used in certain kinds of metallurgical practice, such as in copper smelting and steel manufacture, and it has been more or less common heretofore to use basic or non-acidic refractories in linings for the walls and hearths of such furnaces. Efforts have been made also to construct the furnace roofs of such refractories. One of the principal difficulties in the way of the construction of furnace roofs, particularly extensive furnace roofs, of basic refractory material such as magnesite brick or tiles, or neutral material such as chrome brick or tiles, is the structural weakness or lack of cohesion which furnace refractories of those kinds exhibit, particularly through certain ranges of temperature.

A general object of the present invention is the provision of a construction which is particularly adapted to use of refractory tiles of low structural strength, and which may be employed effectively over furnaces of extensive span or area, to constitute a furnace roof capable of withstanding trying usage at high or variable temperatures over a protracted period of time.

A particular object is the provision of a furnace roof construction adapted to be made up for the most part of refractory tiles which ordinarily are prone to structural failure under the temperature variations encountered in furnace operation, such as refractories of basic or neutral character, for example magnesite or chrome brick, and which is particularly qualified to obviate spalling and certain other destructive or disintegrating effects, and maintain the integrity of the refractories in the structure.

Another object is the provision of such a construction which may be installed with facility and which is susceptible of being repaired readily, even while the furnace is in operation.

Other and further objects will be pointed out or indicated hereinafter, or will be apparent to one skilled in the art upon an understanding of the invention or its employment in use.

In the accompanying drawings forming a part of this specification I show, and hereinafter describe, certain constructions and features representative of embodiments and uses of the invention. It is to be understood, however, that these are presented merely for purpose of example or illustration, as the invention may be embodied and availed of in numerous other forms of construction. Hence the particular illustrative structures herein disclosed are not to be construed in any fashion calculated to limit the appended claims short of the true and most comprehensive scope of the invention in the art.

In said drawings,

Fig. 1 is a sectional elevational view of an upper portion of a furnace, serving to illustrate a form of furnace roof or arch and its supporting means, such as may be employed in a furnace of the reverberatory or open hearth type;

Fig. 2 is a perspective view of a furnace roof refractory and associated bonding plates, serving to illustrate some of the features of the present invention;

Fig. 3 is a detail in the nature of a part elevational and part sectional elevational view of a furnace roof portion which serves to illustrate features of the present invention;

Fig. 4 is another detail view in the nature of an elevation of a furnace roof portion, same showing parts corresponding to those shown in Fig. 3, but at right angles to the showing in that figure;

Fig. 5 is a detail view corresponding to a sectional elevation of a portion of Fig. 4, showing the relationship and modification of parts consequent upon their being heated to a high temperature, as in the operation of a furnace;

Fig. 6 is a detail similar to Fig. 4 but showing a modified construction; and

Fig. 7 is a detail in the nature of a top view of a furnace roof portion of a construction similar to that illustrated in Figs. 1, 3 and 4, but shown on a somewhat larger scale.

In various temperature ranges, the so-called magnesite (magnesia) and chrome brick refractories undergo thermal expansion to a considerably greater degree than does fire brick. Moreover, they are usually less coherent than most refractory tiles in which alumina and silica predominate. These characteristics may account, in part, for the marked tendency of magnesite and chrome brick refractories to spall in furnace roof structures in which their use has been attempted heretofore. However, their heat conductivity is greater than most alumina or silica refractories.

The present invention provides a construction in which these and other characteristics of magnesite brick refractories are accommodated and availed of in a fashion such as to contribute
to the tightness of the roof against leakage, the preservation of its integrity, and prolonging of its serviceability.

The nature of the invention may be most quickly ascertained by consideration of the examples which are illustrated in the drawings and which will now be described.

The roof structure, in general character, is of a suspended type, in that the respective refractories are hung or suspended by their upper ends. In Fig. 1 is illustrated a typical installation in which the suspending means is substantially that illustrated and described in U. S. Patent No. 1,870,568, granted August 9, 1932 to Louis H. Hosbein. The roof illustrated in this figure is appropriate for use in a reverberatory or open hearth furnace, and, as will be understood from the figure, the construction includes a plurality of upright supporting members 10 ranged at appropriate intervals along the sides of the furnace, these upright members being suitably laterally directed, an lower ends, and connected by horizontal frame members 11. At appropriate intervals, the furnace chamber is spanned by beams 12, which are spaced a substantial distance above the furnace roof and are supported on the members 11 and/or 10. Supported by the beams 12 and extending transversely thereof are the arch suspension beams 14, from which the tile supports 15 are suspended by suspension rods 16. As seen in Figs. 3 and 4, the tile supports 15 carry tile-engaging members 18, on which the tiles or refractories 19 are hung by means of suspension ligaments 18 which are formed as portions of the upper ends of the refractories, the refractories as thus suspended being shiftable on the members 15.

It is of advantage to form magnesite refractories such as these with quite small cross-sectional dimensions in comparison to their length, for example, a refractory fifteen or eighteen inches in length with cross-sectional dimensions of 3/16 by 4 1/8 inches at the top. Preferably, I use tiles which taper slightly from top to bottom, so that the bottom cross-sectional dimensions are, for example, 1/4 inch less than the corresponding top dimensions. In the installation of the roof, the refractory tiles presented are suspended in such a fashion that each hangs approximately plumb. Consequently, when tapering tiles such as above mentioned are thus suspended collaterally, upwardly converging spaces, such as indicated in considerably exaggerated proportion at s in Figs. 3 and 4, will be afforded between them. These spaces are closed more or less upon expansion of the tiles with heating. It is to be observed that the suspension of the tiles is such that each is movable relative to its supporting member in a lateral direction, an lower ends, and upon the several tile supports 15 are likewise free to shift laterally relative to one another. This relative mobility of the suspended tiles accommodates their expansion, the tapering spaces allowing for a differential in expansion between their highly heated lower portions and their less highly heated outer or upper portions. In order to accommodate the cumulative expansion which tends to extend the area of the roof, the marginal tiles adjacent the furnace walls 13 are suspended so their lower ends are slightly higher than the latter, which permits their moving outwardly over the walls incident to expansion of the roof as a whole. In order to effect a suitable joint between the roof and the walls, and accommodate this expansion, a movable seal 18 is provided, consisting of courses of bricks laid loosely on top of the wall in lateral abutment with the marginal roof tiles, so that they are susceptible of being slid outwardly on the wall by the pressure of the outwardly expanding roof. It will be appreciated from the foregoing explanation that the suspended tiles are not subjected to restriction against expansion in either vertical or lateral directions, each being susceptible of movement relative to its support upon its own expansion, and also movable in a fashion such as to accommodate expansion of its neighbors.

Upon the heating of the tiles, as in the operation of the furnace, they undergo thermal expansion both transversely and longitudinally. Their relative mobility, resulting from the manner in which they are arranged and supported, together with the provision of the spaces s, permits them to expand without being subjected to excessive bending or including restrictions in the transverse directions or destructive tearing forces in the longitudinal direction, and with their lateral expansion the spaces s are gradually reduced. The accommodation of expansion is aided by the use of tiles of relatively small cross-section.

For the purpose of overcoming the propensity of magnesite and chrome tiles to break down or spall upon heating, I employ, in the structure, what I shall term "spacers" or "bonding plates". Two of such bonding plates are illustrated in Fig. 2, and designated by reference numerals 20 and 28. These are thin (e.g., 1/8 inch) plates of iron or steel and preferably extend the full length of the tiles. Preferably they are supported freely or movably as by being suspended by their upper ends from the tile supports or on the upper ends of the tiles by means of flanges 20. It is quite desirable that the bonding plates associated with opposite sides of any one tile be susceptible of movement relative to one another, so that they will exercise no limiting or constricting forces upon the tile incident to its thermal expansion. In Fig. 7 is illustrated an assembly wherein a bonding plate is provided at each vertical side of each tile, such plates being interposed between the tiles such as indicated in such a fashion that each such bonding plate acts as between those carried on the same tile support. While these bonding plates may be loose in the roof as initially assembled, which is a desirable feature in that it permits them to accommodate themselves to the expansion of the tiles, they are retained against dropping out, and upon the initial heating up of the furnace they become suitably adjusted in relation to the butting tiles. Moreover, upon the heating of the roof to a sufficient temperature, the metal of the bonding plates, some of the oxidized metal enters or coalesces with the structure or material of the refractories, with the result of uniting or bonding the refractories, or portions of them, with the plates. This bonding of the metal and the tiles is most marked in their lower portions where they are subjected to the highest temperature. The result is illustrated in a general way in Fig. 5. Accordingly, it will be seen that the plates function to maintain the integrity of the tiles, for even though the lower portion of a tile might be molten, the upper portion, it will still be maintained in place by plates which are united to it as above described and supported in the roof by their upper ends. As the roof gradually becomes thinner
with use, this uniting of the plates with the tiles progresses upwardly, so that the lower portion of the tile always remains bonded to the plate, while the upper end of the plate remains secured against falling out. Consequently, even though the furnace may be operated intermittently, and allowed to cool down between successive charges, the tiles are effective for sealing against spalling off, the plates being movable relative to one another so as to come and go with the contraction and expansion of the tiles to which they are bonded.

In addition to this bonding effect, the plates are effective also to seal the joints between the tiles. At high temperature, the oxidized metal swells and takes on a plastic character, so that it becomes molded into and closely fills the spaces between the tiles, thereby effectively sealing the roof against infiltration of air. This is a very definite contribution to the longevity of the roof, as refractory tiles are usually subject to very rapid disintegration in locations where there are leaks such as to permit ingress of air into contact with their highly heated portions.

While the provision of plates on all four sides of the respective tiles obtains the advantages of the combination to the most thorough-going extent, such is not essential in all embodiments of the present invention. Moreover, in order to facilitate the removal of certain portions of the roof while it is hot, as for the purpose of making repairs while the furnace is in operation, and to accommodate expansion of roof portions in which the tiles are bonded to one another by the plates, I find it desirable to omit the plates along various intersecting joint lines which mark off the roof into sectional subdivisions, for example, subdivisions of an area eight tiles long and eight tiles wide. This renders it possible to remove any one of such sections as a unit and with minimum injury to adjacent sections. The bonding plates in the remaining portion of the roof are found to be of particular advantage on such occasions, as they effectively retain the tiles in the roof about the opening made by the removal of a section.

In the construction of the roof with the suspended tiles and suspended bonding plates and subdivided into sections as just described, it will be understood that as initially assembled, the various parts are relatively mobile or adjustable as above pointed out, so that upon heating up of the furnace, with the several attendant effects in the roof structure as above explained, the various parts may adjust themselves into proper relationships. Likewise, as above explained, with such heating to a sufficient temperature, the several tiles in each section become in a manner bonded together by the plates, so that each section is, in effect, consolidated into a unit; but due to the fact that the tiles in such a section unit are all individually movable relative to their supporting members, expansion and contraction of the section is accommodated without tearing the bonded tiles apart or subjecting their supporting ligaments to breaking pressures.

As stated above, the construction may be variously modified as to the manner in which the tiles are supported, as well as in other features. One example of a modified construction is illustrated in Fig. 6, wherein the alternate tiles are suspended by suitable hangers, and the interposed tiles are supported by means of shoulders or ledges which rest on top of the adjacent tiles. This figure serves to illustrate also another modification of the construction which may be employed in conjunction with tile supporting arrangements such as those previously described, the sides of the tiles being parallel, instead of tapering toward their lower ends.

What I claim is:

1. Furnace roof construction comprising supports, non-acidic refractory tiles suspended thereon by their upper ends, said tiles tapering toward their lower ends and arranged in lateral association with one another, and ferrous metallic plates supported at their upper end portions and arranged between the lateral surfaces of adjacent tiles and having some of their material coalesced with some of the material of the lower portions of tiles which they contact.

2. In a suspended furnace roof, a plurality of preformed basic refractory bricks arranged side by side and tapered from upper ends of larger cross section toward lower ends of smaller cross section, means for suspending the individual bricks, and metallic spacers between the bricks, said spacers being composed of a metal which, under application of heat, permanently increases in overall thickness to span the space between the bricks occasioned by the taper.

3. In a suspended furnace roof, a plurality of basic refractory bricks tapered towards their lower ends and arranged side by side, hangers engaging and suspending the bricks with the juxtaposed faces of adjacent bricks in divergent relationship, a plurality of oxidizable metallic spacers between some of the adjoining lateral faces of the bricks and means for holding the spacers against displacement from between adjoining bricks, the lower portions of said spacers being in an oxidized and thickened condition so that they span the spaces provided by the tapers and bond with the bricks.

4. In a suspended furnace roof, a plurality of initially unburned pre-formed basic refractory bricks tapered from their upper ends to their lower ends and arranged side by side, means for suspending the bricks by their upper ends, and laterally incompressible sheet metal spacers supported at their upper ends and interposed between some of the adjacent faces of the juxtaposed bricks, said spacers being composed of a metal which is subject to oxidation and increase in thickness when subjected to furnace temperature, thereby to fill the spaces between the lower portions of the bricks occasioned by their tapering form.

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