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FURNACE ROOF AND METHOD OF PRODUCING THE SAME

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FIG. 1

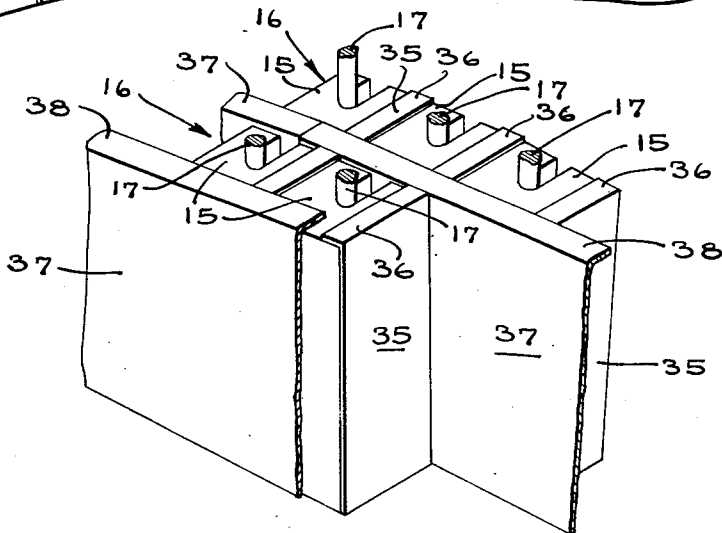
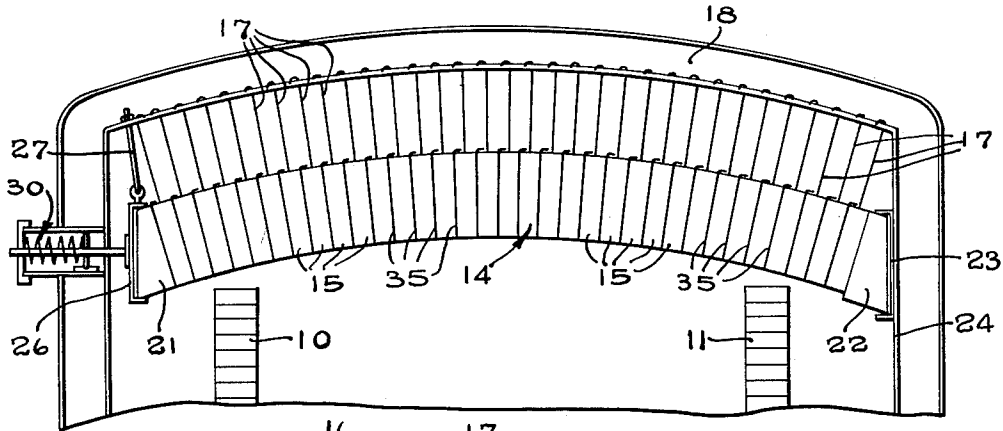


FIG. 2

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FURNACE ROOF AND METHOD OF PRODUCING THE SAME

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The present invention relates to industrial furnaces operating at high temperatures such as open hearth furnaces, electrically heated furnaces and the like. More particularly the present invention relates to the roof of furnaces of the type characterized and to methods of producing such roofs.

Furnaces of the type referred to are made from refractory materials in the shape of blocks, bricks or tiles. During operation of the furnaces these refractory shapes are subjected to severe and complicated stresses. Thus, the refractory shapes expand as the temperature in the furnace rises, and due to the fact that their inner regions, i. e., the regions adjacent to the furnace chamber, will heat up to very high temperatures while their outer regions remain relatively cool, stresses are set up in the interior of said refractory shapes that may rupture them even though they may be made of refractory material of the highest quality. While the described tendency of refractory materials to succumb to the deteriorating influence of high temperatures, severe temperature gradients or severe temperature variations, exists in all parts of the furnace structure, it is more destructive in the furnace roof than in the furnace walls, for even though crevices and gaps may exist between or may form in bricks of the walls, the walls are held together by the weight of the superposed layers of bricks, but the fragments of a disintegrating roof are free to fall into the combustion zone and when cracking and spalling becomes severe, part or all of the roof may follow the force of gravity and collapse into the combustion chamber which ends the life of the furnace and may endanger the lives of attending personnel.

It is an object of the present invention to provide a refractory roof structure, for furnaces of the type referred to, which will remain intact under extremely high temperatures and severe temperature changes over extended periods of operation.

It is another object to so arrange the roof structure, of furnaces of the type characterized, that fragments cracked from the individual bricks thereof are effectively retained in said roof structure.

Yet another object is to provide a roof structure, for furnaces of the type referred to, which is composed of adjacently positioned rows of bricks wherein the crevices between adjacent bricks are and remain completely closed.

To hold the bricks of roofs together in a manner which tends to close the crevices that exist between or may form in the individual bricks, said roofs have been constructed from bricks of wedge shape, and the arches formed by placing such wedge-shaped bricks side by side have been contained between pairs of skewbacks that present converging supporting surfaces to the end bricks of said arches. Moreover, suitable spring means may be provided to hold one or both of said skewbacks in such a manner in their supporting positions that they may resiliently yield away from one another and thus provide space for the expansion of the intermediate bricks during the operation of the furnace. As an additional protection against the formation of crevices and the loss of brick fragments from the roof structure, it has been proposed to place plates of steel or iron between the adjacent bricks of the roof. When such steel or iron plates are heated, they oxidize and the resultant iron oxides fill the crevices between adjacent bricks and penetrate into the adjacent refractories, and in this manner bond the bricks of the roof into an integral structure so that fragments of cracked bricks are held in position by adjacent bricks.

Roof structures made in this manner have proven advantageous only when used in furnaces operating at temperatures below 2800° F. They failed for various reasons when used in furnaces operating at materially higher temperatures, such as the furnaces employed in processes

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for the thermal fixation of nitrogen. First of all, the inner end portions of these steel or iron plates which are directly exposed to the heat of the combustion process melt even if oxidized and leave voids between the bricks which extend a considerable distance into the roof structure; consequently when cracks are formed in the bricks, the brick portions adjacent to these voids are unable to support one another and spalling will occur. Moreover, the molten steel or iron penetrates into the pores of the adjacent refractories and oxidizes in situ, and the resultant swelling disrupts the structure of the refractory material so that the disintegration of the particular brick portions is accelerated rather than inhibited. Furthermore, the remaining portions of the steel or iron plates above the open voids oxidize unevenly since oxidation occurs to a much greater extent in the plate portions adjoining the voids than in the more remote portions; as a result thereof the lower ends of the remaining plate portions swell to a greater extent than the upper ends thereof, and this unequal expansion of the remaining plate portions exerts strong localized strains upon the adjacent bricks which contribute materially toward the disintegration of the brick structure.

It is another object of the invention to provide a furnace roof structure that will withstand such high temperatures as are developed in open hearth furnaces, nitrogen fixation furnaces and the like.

Still another object is to provide a roof structure, of the type referred to, wherein the lower portions of the bricks from which the roof structure is composed, are and remain bonded to one another for extended periods of operation even at temperatures in excess of 2800° F., so that spalling will not occur or will at least be held within negligible limits.

An additional object is to provide a method of producing an integral roof structure, of the type referred to, that is capable of withstanding such high temperatures as are employed in nitrogen fixation furnaces over extended periods of operation without separation or spalling of the bricks.

Furthermore, it is an object to provide a method of producing an integrated composite roof structure, of the type referred to, wherein the refractory blocks or bricks are not subjected to excessive stresses resulting from swelling of metal plates due to oxidation.

Another object is to provide a roof structure such that at high temperature the exposed ends of the individual bricks rapidly grow together so as to form an integral layer of a homogeneous material with refractory properties closely approaching those of the original bricks.

These and other objects of my invention will be apparent from the following description of the accompanying drawings which illustrate a preferred exemplary embodiment thereof and wherein:

Figure 1 is a vertical section through a furnace roof and surrounding structure and,

Figure 2 is a fragmentary perspective illustrating the manner in which the roof structure shown in Figure 1 is assembled from refractory bricks and metal plates.

My invention is based upon the discovery that when bricks of a specific refractory material are employed in combination with plates of a specific metal, in the construction of composite furnace roofs of the type here under discussion, an integrate structure may be formed in which the lower ends of the bricks are firmly bonded to one another without the formation of intermediate voids and without setting up stresses that weaken the structure of the refractory material. The resultant roof is able to withstand even such extremely high temperatures as are developed in furnaces for the thermal fixation of atmospheric nitrogen over extended periods of time without spalling and in fact without appreciable deterioration of any kind.

In accordance with my invention I construct a furnace roof from rows of bricks or blocks of magnesia (MgO) of as high a purity as is practicable for refractory purposes, such as a refractory material containing from 96% to 97% of pure magnesia, and I interpose between the adjacent faces of said refractory bricks or blocks sheets or plates of pure nickel. When exposing a roof of the described construction to high temperatures the

lower portions of the nickel sheets oxidize into nickel oxide at such small an increase in volume that no harmful stresses are exerted upon the adjacent bricks, and said nickel oxide penetrates into the adjacent strata of magnesia forming solid solutions of great mechanical strength and durability and of high melting points intermediate of the high melting points of magnesia and nickel oxide. Thus, an integrate structure is produced in which the lower ends of the bricks are thoroughly bonded to one another without any intermediate voids that might permit brick fragments to drop off; and wherever the nickel oxide has penetrated into the refractory material, the structure of the roof is strengthened rather than weakened.

Having reference to Figure 1, the numerals 10 and 11 designate the side walls of a furnace, such as may be used for the thermal fixation of nitrogen. Held above said side walls is an arched roof 14 composed of bricks or blocks 15 that are arranged in parallel rows 16 and which may be suitably suspended by metal hooks 17 from a plurality of parallel beams 18, only the foremost one of which is visible in Figure 1. Each row of bricks is contained between a left and right skewback 21 and 22, respectively. In the particular furnace illustrated in the accompanying drawings all the right skewbacks 22 are mounted in a horizontal channel 23 that is secured to a metal wall 24. The left skewbacks 21 are likewise mounted in a horizontal channel 26, which is suspended from the aforementioned beams 18 by means of hangers 27. Adjustable spring means 30 urge the channel 26 and the skewbacks 21 carried by said channel to the right, as viewed in Figure 1, to hold the individual bricks 15 of the various brick rows 16 closely together, and yet permit expansion of said bricks in response to the high temperatures developed in the furnace.

Interposed between each two adjacent bricks of every brick row and also between each two adjacent rows of bricks are plates 35 of pure nickel. Having reference to Figure 2, plates 35 co-extensive in size with the transverse faces of the bricks 15 are hung between adjacent bricks of the same brick row in any suitable manner, such as by means of horizontal lips or flanges 36 that engage over the top surfaces of the bricks as shown. In addition a plurality of plates 37 of a size designed to cover the longitudinal faces of several adjacent bricks are hung between adjacent brick rows by means of horizontal flanges 38 that engage over the top surfaces of the bricks and the horizontal flanges 36 of the plates 35.

After a complete roof has been assembled and installed in the described manner, the furnace is fired, but the temperature in the furnace is held at a value somewhat below the melting point of nickel, such as for instance 2500° F., for a sufficient period of time to permit the lower portions of the plates 35 and 37 to oxidize. It will be understood that the time required to completely oxidize the lower plate portions to an adequate depth will vary depending upon the thickness of the plates employed and the temperature maintained in the furnace. For instance, when employing nickel plates of a thickness of .025 of an inch in producing a furnace roof in accordance with my invention, I found a period of about 20 hours adequate when heating the furnace to about 2500° F. in a highly oxidizing atmosphere.

After the lower ends of the plates have been oxidized to an adequate depth, the temperature in the furnace may gradually be raised to a suitable value below the melting point of nickel oxide. For instance, in producing a furnace roof in accordance with my invention I raised the temperature every day by about 150° F. until the heat in the furnace had risen to about 3500° F. and I maintained the furnace at said temperature for a period of several days to secure adequate solution of the nickel oxide in the magnesia of the adjacent bricks before raising the temperature above the melting point of the nickel oxide. It will be understood that the above given temperatures and time intervals are interdependent and are therefore purely exemplary. For instance, if after complete oxidation of the lower portions of the nickel plates the temperature is raised very gradually, it may not be necessary to provide a special period over which the temperature in the furnace is held at a specific temperature below the melting point of nickel oxide, because by the time the temperature in the furnace reaches the melting point of nickel oxide, the desired interaction between the nickel oxide and the magnesia may have been completed, and it may therefore be permissible to continue raising the

temperature of the furnace at the same, or even a faster rate, to the level required by the process that is to be performed in the furnace.

In roofs produced in the above described manner the lower ends of all bricks are thoroughly welded together with no noticeable void formations in the interstices originally occupied by the nickel plates. While the upper portions of said nickel plates are still in metallic condition, the lower ones have completely oxidized and have entered into solid solutions with the adjacent magnesia, the resultant bond between the bricks being of such strength that the refractory material in the interior of the bricks rather than the joints will break when the roof structure is subjected to mechanical endurance tests. When roofs produced in accordance with the invention were exposed to temperatures, such as are generated in furnaces for the thermal fixation of atmospheric nitrogen, no spalling could be observed. Some of the bricks developed cracks at their lower ends, but the fragments were firmly held between the bonds provided in the manner described hereinbefore. A furnace roof produced in accordance with my invention was actually employed in a furnace for the thermal fixation of atmospheric nitrogen, which was held at a temperature of about 4000° F. for more than 30 days, and at the end of this period the roof was found to be perfectly intact.

While I have explained and illustrated my invention with the aid of an exemplary embodiment thereof, it will be understood that I do not wish to be limited to the particular constructional details shown and described which may be departed from without departing from the scope and spirit of my invention.

I claim:

1. A roof structure, especially for furnaces operating at very high temperatures, such as the furnaces for the fixation of atmospheric nitrogen, comprising adjacently positioned bricks of magnesia of high purity and plates of substantially pure nickel interposed between adjacent faces of said bricks.

2. The method of producing a roof, especially for furnaces of the type referred to, which comprises placing bricks of high purity magnesia adjacent to each other with plates of substantially pure nickel interposed between the adjacent faces of said bricks, subjecting the surface which is to be exposed to the furnace heat to temperatures somewhat below the melting point of nickel until nickel in the lower portions of said interposed plates has oxidized into nickel oxide and thereafter subjecting said composite structure to temperatures somewhat below the melting point of nickel oxide until the nickel oxide has entered into solid solutions with the magnesia of said bricks.

3. The method of producing a roof, especially for furnaces of the type referred to, which comprises placing bricks of high purity magnesia adjacent to each other with plates of high purity nickel interposed between the adjacent faces of said bricks, heating the surface of the resultant structure which is to be exposed to the furnace heat to a temperature somewhat below the melting point of nickel and maintaining it at said temperature until the lower portions of said plates have oxidized into nickel oxide and thereafter raising said temperature so gradually that the major portion of the nickel oxide has entered solid solution with the magnesia of said bricks before the temperature reaches the melting point of nickel oxide.

4. Roof structure especially for furnaces operating at very high temperatures, such as the furnaces for the fixation of atmospheric nitrogen, comprising adjacently positioned upright bricks of high purity magnesia and plates of high purity nickel interposed between adjacent faces of said bricks to establish, upon subjection to high temperatures, between the lower ends of said bricks a bond formed by solid solutions of magnesia and nickel oxide.

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