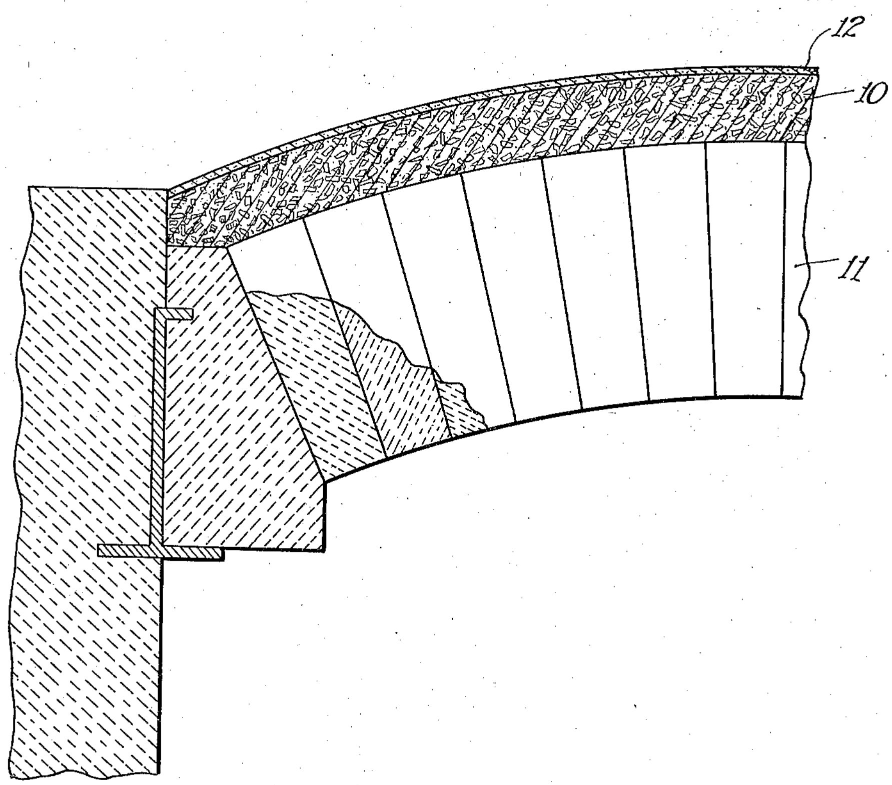
Dec. 6, 1938.

A. S. NICHOLS

2,139,172

HIGH TEMPERATURE FURNACE INSULATION

Filed May 12, 1934



Inventor
Arthur S. Nichols
By: Roland C. Rehm
Atty.

Patented Dec. 6, 1938

2,139,172

UNITED STATES PATENT OFFICE

2,139,172

HIGH TEMPERATURE FURNACE INSULATION

Arthur S. Nichols, Forest Park, Ill., assignor to The Illinois Clay Products Company, Joliet, Ill., a corporation of Illinois

Application May 12, 1934, Serial No. 725,257

4 Claims. (Cl. 110—99)

This invention relates to high temperature furnaces and the like, and among other objects, aims to insulate and improve insulation of the roof construction of high temperature furnaces and the like.

The nature of the invention may be readily understood by reference to one illustrative construction embodying the invention and shown in the accompanying drawing.

In the drawing, the figure represents a partial transverse section through the roof of an open hearth furnace provided with the inventive insulating construction, other details of the furnace construction are shown diagrammatically.

The advantages of the present invention are well illustrated in the insulation of the roof of an open hearth furnace. While the problems solved by the present invention are not necessarily confined to the open hearth furnace roof, the latter presents unique difficulties which emphasize the importance of the present invention. The roof is the least stable portion of the furnace enclosure as compared to a wall for example, and because of its large transverse span (from twenty to thirty feet) it rises and falls as much as a foot under expansion and contraction of the roof brick, thus making it by far the most difficult portion of the open hearth enclosure to insulate satisfactorily, as will presently appear. Furthermore, the high cost of the open hearth roof makes it essential that nothing be done which would shorten its life.

Prior to the present invention it was considered impractical or impossible to insulate an open hearth roof because, among other reasons, of its weakness when hot. The temperatures just inside the roof may reach 3000° F. or about the melting point of the silica brick of which the roof is composed; and although the roof be from nine to eighteen inches in thickness when originally installed, it was regarded as incapable at such high temperatures of supporting even the load of insulating material than available. Moreover, it was thought essential to expose the roof so that its temperature might be reduced by radiation and thereby resist more effectively the melting temperatures to which the inside surface of the roof was exposed. In such cases the temperature gradient in the roof brick was over 2000° F., that is, from 3000° F. on the inside to less than 1000° F. on the outside. For these and other reasons it was thought preferable to endure the expense of the great heat loss from the roof rather than run the risk of a premature collapse of the roof through over-heating or by imposing on it the load of insulating material.

Apart from considerations of overloading the roof, it now appears that the long standing objection to attempted insulation of the roof has not only been ill-founded but that in addition to economies in operation affirmative advantages can be secured by insulation. Insulation substantially eliminates the internal strains in the roof brick produced by the great temperature difference between the inside and the outside of the brick (from 3000° F. to less than 1000° F.) by bringing the brick more nearly to a uniform temperature throughout.

Appropriate insulation which raises the minimum temperature of the brick (which exists at the outside face of the brick) to about 2000° F. gradually brings about a beneficial change in the crystalline structure of the brick which is believed to consist in a more complete conversion of the brick into tridymite, a more stable and advantageous material.

Under former conditions great range of temperatures in the brick caused a number of objectionable consequences: The great expansion of silica brick at high temperatures in a restricted portion of the brick (adjacent the furnace side of the brick) while other portions were relatively cool, resulted in spalling and cracking. Indeed, the wedging action set up by the great expansion of the furnace end of the brick tended to cause cracked-off portions of the brick to be loosened and to fall into the bath, thereby creating a spot where the cutting action of the flame and slag would eventually burn a hole through the roof. The wide range of temperatures contributed to weakening of the brick or transverse cracking in still another way by causing relatively abrupt changes in the structure of the brick. Adjacent the furnace end of the brick the high temperatures would convert the silica into tridymite, a hard and stable structure which would terminate quite abruptly in the plane where the temperature of the brick fell below that at which tridymite was formed. Beyond this plane would remain the original silica brick structure which not only had a substantially higher coefficient of expansion as compared to tridymite, but was relatively more friable and weaker. This produced a plane of weakness along which the brick frequently cracked.

By proper control of heat input, presently discussed, the temperature throughout the bricks is raised above 2000° without increasing the maximum temperature of the brick. Indeed, the minimum temperature in the bricks is above that at which conversion into tridymite takes place. Hence it is possible in use to convert the brick from top to bottom into the stronger, denser and more stable tridymite and thus greatly increase the length of life of the roof. While it is not fully understood whether high temperatures alone or some catalytic agent contributed by the molten bath and slag together with high temperatures produces this conversion, it would be impractical and prohibitively expensive to burn or fire the silica brick during the process of manufacture to such high temperatures for a sufficiently long time, to effect conversion of the brick into the desirable tridymite.

It should be understood that the input into an open hearth furnace and an insulated roof must be reduced and controlled, in order to avoid excessively high temperatures and of course to effect the desired fuel economies. Depending upon the character of furnace, these fuel economies range from 10% to 50%. With the better constructed furnaces the economies are of course less than 50% and more nearly 10%. Stated differently, the reduction in heat loss through the roof is about 70%. During the campaign of a roof, the cost of the insulation is saved several times over.

The reduction in heat input makes possible another very desirable modification of operation, namely, a substantial reduction in the velocity of the gases through the furnace and across the bath. This results in a very substantial reduction in the burning effect of the gases and slag (carried along by gases traveling at high velocity) upon the structure at the opposite end of the furnace. Moreover, the slow moving gases linger longer over the bath and impart their heat thereto more efficiently and thereby increase the speed of heating.

The only satisfactory insulating material for the foregoing purposes which research has thus far developed is exfoliated vermiculite. The latter is an alteration product of particles of certain micaceous minerals, such as biotite, which exfoliate or expand to many times their original size upon the application of heat and produce a granular insulating material both highly refractory and extremely light in weight (about six pounds per cubic foot). While vermiculite has served as an insulator in a number of uses, its unique appropriateness as an insulation for silica brick open hearth roofs has never heretofore been discovered. Its efficiency at high temperatures depends not alone on the resistance to conduction of heat, but to the heat reflecting action of the multitude of minutely separated polished surfaces which characterize the structure of the particles or granules. Because of its extreme lightness, it imposes no substantial load upon the open hearth roof. No other known refractory insulating material is as light in weight as exfoliated vermiculite. Moreover, its highly refractory character enables it to withstand the high temperatures existing on top of the roof. Unlike most insulating materials when subjected to extremely high temperatures, exfoliated vermiculite does not lose its insulating efficiency. Other materials capable of resisting high temperatures generally glow at such temperatures and transmit heat by radiation or otherwise lose their insulating efficiency.

Refractory insulating material of the diatomaceous earth variety is not satisfactory among other reasons, because of the tendency for the material to sift down and accumulate between the roof brick joints, thereby causing dangerous roof strains. This is particularly aggravated in the open hearth roof by reason of the "breathing" of the roof, i. e., its alternate raising and lowering during expansion and contraction, since it tends to cause any fine material to work down between the brick, thereby producing dangerous strains on the roof. Moreover it would be impossible to apply insulation of this character to the roof when cold, since the "breathing" movement would be much more extreme and much more material would sift down between the bricks. Furthermore, insulating materials of this character contain substances which act as a flux when they reach the inner surface of the roof bricks, as aforesaid, and are exposed to the temperatures of the furnace, producing rapid fusing of the roof at the brick joints.

While exfoliated vermiculite, on the other hand, has no tendency to sift between the bricks, its mass is relatively so small that occasional granules between the brick would cause no difficulty. They would simply be crushed to negligible thinness and would thereafter not creep farther down between the brick. It can therefore be applied to the roof while cold without fear of any objectionable results. It is not essential therefore that all granules of the exfoliated vermiculite be substantial in size. Preferably the vermiculite is graded in size from particles of one-half inch mesh down.

As illustrated in the drawing, a layer 10 of exfoliated vermiculite granules from one to three inches in thickness is preferably placed directly upon the roof brick constituting the open hearth roof 11. Because of the coarseness of the granules of insulating material, the layer of insulation is preferably covered by a sealing covering here represented by a sealing layer 12 of refractory cement spread over the exfoliated vermiculite. This prevents the passage through the insulating layer of currents of hot gases which may escape through cracks in the roof brick. The refractory cement may advantageously comprise a mixture of exfoliated vermiculite and a refractory binder such as clay. The cement layer itself therefore possesses insulating properties. The vermiculite layer insulates the sealing covering from the high temperatures of the roof brick to prevent disintegration of the sealing layer. The sealing of the roof in this manner is advantageous not only to prevent heat loss but to protect the roof brick more effectively against the fluxing action of the hot slag dust and vapors which might otherwise pass through the cracks. This is particularly important in the basic open hearth furnace (which is now generally used), since the silica roof brick are acid in character.

At the end of the campaign of the roof it is possible to salvage much of the loose vermiculite and use it again on a new roof. The protection thus afforded the roof and the conversion of the silica brick throughout into the more stable tridymite, substantially minimizes the necessity for roof patching. It is now possible for the roof to go through an entire campaign without patching.

It is apparent from the foregoing that the unique properties of vermiculite in relation to high temperatures and the conditions of open hearth furnace operation, has made it possible for the first time reliably and safely to secure important economies in open hearth furnace maintenance and operation.

Obviously the invention is not limited to the details of the illustrative construction since these may be considerably varied. Moreover it is not indispensable to use all features conjointly since various features may be used to advantage in different combinations and sub-combinations.

Having described my invention, I claim:

1. The method of improving the durability of the silica brick roof of a high temperature open hearth furnace which is characterized by operating the furnace at an internal temperature of about 3000° F., heating the outer face of the silica brick in the roof to about 2000° F. by reducing radiation from the top of the roof by a layer of light weight exfoliated vermiculite for a prolonged period to effect a substantial conversion of the outer portion of the silica brick into more stable forms of silica such as tridymite having a lower coefficient of expansion.

2. A high temperature furnace comprising in combination a silica brick roof, a layer of exfoliated vermiculite over said roof of a substantial depth to raise the outer surface of the silica brick to about 2000° F. with furnace temperatures of about 3000° F., and means for sealing the layer of insulation to prevent gas leakage through the roof, said silica brick having been converted substantially throughout into the more stable forms of silica such as tridymite having a lower coefficient of expansion.

3. The method of prolonging the life of a silica brick roof in an open hearth furnace which is characterized by operating the furnace at internal temperatures of about 3000° F., reducing the radiation from the top of the roof so as to heat the outer faces of the roof brick to about 2000° F. by covering the roof with a substantial layer of granules of exfoliated vermiculite, said granules being of substantial size so as not readily to fall between the silica brick but of negligible thinness when compressed between the brick so as not to create additional strain in the roof, and prolonging the aforesaid temperatures to effect a gradual conversion of the silica of said brick into more stable forms of silica which have a lower coefficient of expansion.

4. The method of prolonging the life of a silica brick roof in an open hearth furnace which is characterized by operating the furnace at internal temperatures of about 3000° F., reducing the radiation from the top of the roof so as to heat the outer faces of the roof brick to about 2000° F. by covering the roof with a substantial layer of material so light in weight as not to impose any substantial stress on the roof and being of such character as not to react with or flux the silica brick, said material comprising granules of exfoliated vermiculite weighing about six pounds per cubic foot, said granules being of substantial size so as not readily to creep between the silica brick but being easily compressible to negligible thinness as not to create additional strain in the roof if any granules fall between the brick, and prolonging the aforesaid temperatures to effect a gradual conversion of the silica of said brick into more stable forms of silica which have a lower coefficient of expansion.

ARTHUR S. NICHOLS.