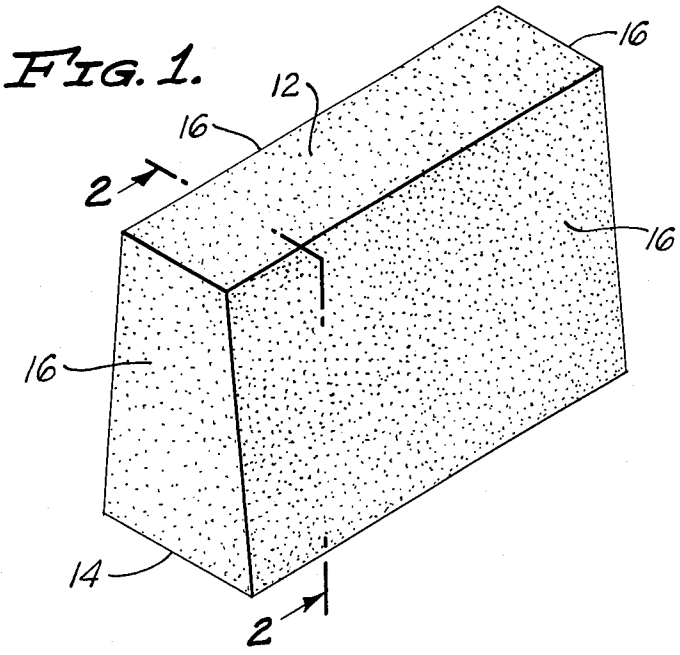
July 19, 1966 G. M. SPENCE ETAL 3,261,138

KILN BRICK OF PORTLAND CEMENT CLINKER WITH A FUSED SHELL

Filed Feb. 6, 1963

FIG. 1.



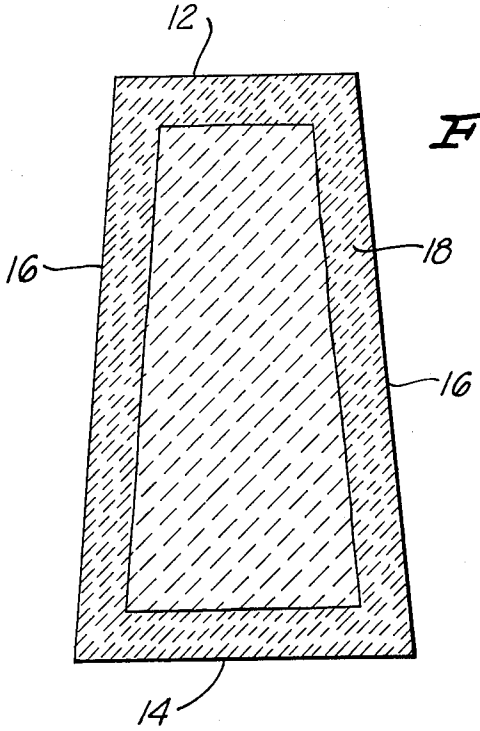


FIG. 2.

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KILN BRICK OF PORTLAND CEMENT CLINKER WITH A FUSED SHELL

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This invention pertains to new and improved kiln bricks, and more specifically to kiln bricks which are designed to be used in rotary kilns such as are used in the manufacture of Portland cement.

In such kilns, the kiln bricks are located against a cylindrical metal kiln shell where they serve a number of distinct and yet related functions. The brick comprising a lining within a rotary kiln shell serve to retain heat within the interior of the kiln, to support the material being treated within the interior of the kiln, to transfer retained heat to this material, to protect the kiln shell against undue heating, and to transfer a restricted amount of heat to the kiln shell so as to aid in maintaining certain operative conditions within the kiln, and to aid in maintaining the shape and rigidity of the kiln structure. These various functions and others served by the brick lining within a kiln are all related to the economics of rotary kiln operation.

It is normally considered that it is comparatively expensive to replace the brick lining within a rotary kiln. For this reason, the life of such a lining is important. The life of the lining must, however, be considered with respect to the cost of replacing it with any particular type of kiln brick and with respect to the cost of shutting down the operation of a rotary kiln. An important factor which is related to lining life is the production which can be achieved during normal operation with any particular type of kiln brick.

From the preceding it will be apparent that the subject matter of bricks for use in rotary kilns, such as rotary cement kilns, is relatively complex. It is considered that this field is not completely understood. Experience has shown that different results are often obtained with the same type of brick lining in identically formed rotary kilns which are operated under substantially identical conditions. Because of these factors, it is considered that any generalized statements with respect to rotary kiln brick or the linings created from them must be carefully considered, and that any such statement may have various exceptions and limitations.

In spite of the complexity of an understanding of bricks for use in rotary kilns, certain factors are commonly recognized. One of these concerns the necessity for physical rigidity and strength in a kiln brick. Unless kiln brick is physically strong in a relative sense under the conditions to which it is subjected in a rotary kiln, it will not hold up for an economically satisfactory period in a kiln. Another of these factors is the tendency of the so-called hot or inner ends of kiln brick to change dimensions in a kiln as a kiln is heated from ambient temperature. This change in dimensions results in what is commonly referred to as "pinching" of the adjacent hot edges of the brick, and is considered to result in conditions tending to detrimentally affect the life of the brick lining.

An object of the present invention is to provide new and improved kiln brick which are constructed so as to avoid or substantially avoid any tendency toward undue "pinching" of the hot ends of the brick as these bricks are used. Another object of this invention is to provide new and improved kiln brick which, on a relative basis, are sufficiently strong so as to be capable of being handled and used in a rotary kiln without significant danger of

breaking. A further object of this invention is to provide new and improved kiln brick which contribute significantly to the economics of kiln operation.

These and other objects of this invention, as well as various specific advantages of it, will be more fully apparent from a detailed consideration of the remainder of this specification, the appended claims, and the accompanying drawing in which:

FIG. 1 is a perspective view of a kiln brick of the present invention; and

FIG. 2 is a cross-sectional view of this kiln brick taken at line 2–2 of FIG. 1.

As an aid to an understanding of this invention it can be stated in essentially summary form that it concerns kiln bricks for use in rotary kilns, each of these bricks having been heated so as to possess an external "shell" of a fused or vitrified character which is physically stronger than its interior. From this it will be apparent that the "shell" or surface of a kiln brick of this invention is formed of the same material as the remainder of the brick and differs from the remainder of the brick only as to its physical character. Preferably a kiln brick as herein described is formed of a composition having various characteristics as described in subsequent portions of this specification.

The actual details of this invention are best more fully explained by referring to the accompanying drawing. Here there is shown a kiln brick **10** of this invention having a so-called "hot end" **12**, a so called "cold-end" **14** and four sides **16** connecting the ends **12** and **14**. The end **12** of the brick **10** is referred to herein as a "hot end" beacause it is intended to be located so as to face or be exposed to the interior of a rotary kiln when the brick **10** is used. The end **14** of the brick **10** is referred to herein as a "cold end" because it is intended to be located away from the source of heat within a kiln against the kiln shell. When the brick **10** are installed in a kiln the sides **16** may be located against one another or they may be separated from one another through the use of inert metal shims such as shims as shown and described in the Anderson U.S. Patent No. 2,895,725.

The shape of the brick **10** is normally determined by the specific manner in which these brick are to be installed in a kiln. When the brick **10** are to be used in a rotary kiln they are preferably not of a complete rectangular shape, but have a configuration of a type conventionally referred to in the kiln refractory art as a "wedge" or "arch" shape. With bricks **10** of either of these shapes the ends **12** are of smaller dimensions than the ends **14**. It is not considered necessary to more specifically point out and discuss the shapes of brick **10** and the dimensions of these brick since these are matters of choice, and are discussed in established publications.

Although the brick **10** can be formed of various known or conventional refractory compositions such as are set forth in various texts such as Mark's Mechanical Engineer's Handbook, 5th Edition, published 1951 by McGraw Hill Book Co., New York, N.Y., on pages 731 to 740, such brick are preferably formed of either a cement clinker composition or a related composition containing principal ingredients of cement clinker. The entire disclosure of these pages of Mark's Handbook is incorporated herein by reference in the interest of brevity.

The reasons why it is preferred to form the brick **10** of this invention from either cement clinker or a related composition containing or consisting of primarily the principal ingredients of cement clinker pertain to the economics of the manufacture of these brick and to the operation of a rotary cement kiln. Cement clinker and the ingredients of cement clinker are much less expensive than conventional refractory materials such as magnesite, alumina and the like. Clinker and clinker ingredients in kiln bricks

are considered to facilitate the operation of a rotary cement kiln so as to aid in achieving relatively long lining life and satisfactory production because of their chemical character.

This is a matter of primary importance in the so-called "burning zone" in a rotary kiln. In this portion of a rotary kiln the highest temperatures within the kiln are achieved. As a consequence of this the bricks composing a burning zone kiln lining are subjected to comparatively extreme temperatures at the same time they are contacted by the material reacting within the kiln. At these temperatures there is a tendency for this material to react with conventional refractories in a manner which is believed to be detrimental to brick lining life. Since the ingredients of cement clinker are of the same generalized character as the material being formed into cement clinker in a kiln burning zone any tendency for reactions to take place between the material being treated and the brick in a kiln burning zone is effectively minimized with this invention when the brick **10** are formed out of a preferred composition as herein indicated.

Such a preferred composition is also considered beneficial in the burning zone of a rotary cement kiln because of the fact that it tends to promote so-called "coating" formation of the material within the kiln. Such a coating is in effect a layer of material being treated within the kiln which accumulates on the exposed surface of the lining. In some respects such a coating acts as a part of the lining for heat transfer and other purposes; in other respects such a coating acts to physically protect the brick constituting a kiln lining.

It is well known that the primary or principal ingredients of cement clinker are tetracalcium aluminum ferrite, tricalcium aluminate, dicalcium silicate and tricalcium silicate. A conventional Portland cement composition consisting essentially of these ingredients can be used in creating a brick falling within the scope of this invention. Such compositions will normally have an analysis as specified in The American Society For Testing Materials specifications for types 1 to 5 Portland cements, inclusive. Since these specifications are well known at the present time they are not set out at length herein, but are incorporated herein by reference as though set out at length herein.

Although such a conventional Portland cement composition can be used in creating a kiln brick in accordance with this invention it is presently considered that even better results can be achieved by forming such brick out of a Portland cement clinker composition which has been stabilized against the possible decrepitation of dicalcium silicate in such clinker from the beta to the gamma physical form of this compound. Such decrepitation is normally accompanied by a volumetric change which is considered to have a detrimental effect on brick life in a rotary kiln. Such better results can also be achieved by using a modified cement type of composition omitting or not containing dicalcium silicate or containing only minor or trace amounts of this compound. Such "stabilized" and "modified" cement or cement type compositions are set forth in the co-pending applications for U.S. Letters Patent (File #1265) Serial No. 256,599, filed Feb. 6, 1963 and entitled "Kiln Brick" and (File #1264), Serial No. 256,547, filed Feb. 6, 1963 entitled "Kiln Brick" and now abandoned. The entire disclosures of these co-pending applications are incorporated herein by reference as though set out at length in this specification. Under the conditions of manufacture and use of kiln bricks as herein described the tendency of tricalcium silicate to decompose and yield free lime and dicalcium silicate is considered to be of insignificant importance.

The steps employed in the actual manufacture of brick of this invention from materials as indicated in the preceding are of an essentially conventional character. First a substantially uniform mixture of these materials (and a molding lubricant if such a lubricant is to be used) is formed. Preferably the particles within this mixture are graded as to size so that a mixture of particles of various sizes are used. Such a mixture of particles of various sizes aids in achieving comparatively dense brick as are desired in order to obtain adequate physical strength and dimensional stability in the final brick as hereinafter indicated. In general the particles used in the raw material mixture should all pass an 8 mesh standard Tyler screen, and approximately one-half of such particles should pass a 30 mesh standard Tyler screen in order to achieve a satisfatcory brick density.

The molding lubricant used in such a mixture can be of a conventional or established character used with virtually any refractory composition. Common diesel fuel, bunker C fuel oil, tall oil or the like can be employed for this purpose. When the composition being processed is cement clinker, or is based on cement clinker so as to contain principal ingredients of cement clinker a 10% by weight aqueous solution of common sucrose is preferably employed as a lubricant for molding purposes. Such a solution is relatively inexpensive, easy to mix with the principal ingredients present and will not cause significant hydration of the cement compounds present during the processing.

In creating bricks of this invention a mixture of particles as indicated in the preceding is pressed to a desired size, shape and density using conventional equipment and techniques. With a mixture of different sized particles as indicated in the preceding pressures of at least 5 tons per square inch are preferably employed during this operation in order to achieve a comparatively great density. After the pressing operation a brick of partially completed character produced by this operation is taken from the mold and heated so as to achieve a final structure in accordance with this invention.

During the heating operation the pressed brick are preferably separated from one another so as to allow the circulation of heated air, and are placed in a conventional kiln of the type used in the brick manufacturing field. In such a kiln they are gradually heated so as to avoid thermal shock to a temperature at which vitrification or fusion of the outer surface of the brick occurs, and are held at this temperature until a completely vitrified or fused shell is formed which completely encases such brick and until this shell extends to a desired depth toward the interior of the brick. During this step the processing conditions (i.e. time and temperature) are controlled so that the fused shell preferably is not of a glazed variety. In effect the shells become of a sintered character. At this point the so heated brick are gradually brought back to ambient temperature so as to avoid an additional thermal shock, and upon cooling are ready to be used.

When these steps are employed in creating a brick such as the brick **10** this brick has an outer shell **18** which differs as to physical structure from the remainder of the brick **10**. In effect the complete final brick **10** of this invention constitutes an unfired, unfused and/or unvitrified core which is completely surrounded by and encased within a vitrified or fused but not glazed shell. This shell, because of its physical character, gives strength to the entire brick **10**, enabling this brick to be handled, installed in a kiln and used within the kiln without danger of significant cracking.

When a brick such as the brick **10** is formed from cement clinker or a modified cement clinker which has been stabilized against dicalcium silicate decrepitation, or which omits this particular compound as, for example, as set forth in the aforenoted co-pending applications another significant result is achieved which is important as the brick **10** is used. This result concerns the expansion of the brick **10** within the interior of a rotary kiln as this kiln is used.

Established refractory bricks normally tend to expand as they are used within a rotary kiln in an amount which is related to their temperature. The temperatures of

various parts of these bricks will vary during such use depending upon the distance from the hot ends or faces of these brick. Thus, for example, it is not uncommon to have the hot end of a single kiln brick maintained at a temperature of about 3000° F. or slightly less during kiln operation while at the same time the other or cold end of such a brick is at a temperature of about 300° F. to about 500° F. Various areas of such a brick intermediate to its ends are at various intermediate temperatures during such use.

Since the sides of kiln brick adjacent to their hot ends are normally located against one another or against reinforcing or other shims as a kiln lining is created at ambient temperatures, the temperature gradients indicated in the preceding paragraph cause undesired results which effect a kiln lining. More specifically they cause the "pinching" phenomena referred to in the initial portions of this specification. This is a consequence of the hot ends of the brick and the adjacent portions of the brick tending or trying to expand to a significant amount against one another when there is no room for such expansion. This results in these portions of the brick which are heated to elevated temperatures tending to give way and crack so as to relieve the stresses and strains caused by expansion. Such cracks detrimentally effect brick so as to tend to shorten the life of a kiln lining. The regions of a brick adjacent to the cold end of a brick in a kiln lining are not so affected to a significant extent because of the fact that they do not become sufficiently hot so as to expand or tend to expand to a sufficient extent to create stresses and strains of a sufficient magnitude so as to significantly alter the stress and strain pattern within these "colder" regions of the brick.

With bricks of the present invention these "pinching" effects occur at the hot end or adjacent to the hot end of a brick when a brick such as the brick **10** which is formed of a cement clinker, a "stabilized" cement clinker or a "modified" cement clinker not containing dicalcium silicate or any significant amount of this compound the unfused "core" or central region of the brick tends to expand to a relatively limited extent as the brick is heated in a kiln lining. At the same time the portion of the shell **18** of the brick along the cold end **14** and extending approximately ⅔ to ¾ of the way along the sides **16** toward the hot end **12** tends to expand. These expansions are of a relatively small character and tend to serve to help hold the individual bricks within the lining tightly against one another and/or the shims used in the lining so as to aid in providing a desirable "rigid" type of lining. During such use the portion of the shell **18** extending along the hot end **12** of a brick **10** and along the adjacent portions of the sides **16** up to the point where expansion of this shell occurs tend to shrink very slowly. Such shrinkage is believed to be related to the softening of this region of the shell **18** of a brick **10** and of internal pressures within the entire kiln lining causing a certain amount of compaction. As a result of this shrinkage any tendency toward "pinching" is effectively minimized.

Bricks such as the brick **10** formed from a cement clinker or a "modified" or "stabilized" cement clinker type composition as indicated in the preceding have their fused or vitrified shells shrink as indicated in the preceding at temperatures of in excess of about 2000° F. The physical phenomena which occurs during such shrinkage s not completely understood; further, it is difficult if not impossible to exactly duplicate the conditions which occur within an operating rotary kiln so that precise measurements can be made in order to determine exactly the precise temperature at which this shrinkage starts to occur in a kiln. For substantially the same reasons it is difficult to accurately estimate the precise thickness of a shell such as the shell **18** previously described which will most satisfactorily serve the desired functions herein described. In general the thicker the shell **18** of a brick **10** the greater the amount of shrinkage which will occur in a rotary kiln during the use of the brick. It is presently considered that this shell should have a thickness of about 10 to 25% of the length of the smallest dimension of a complete brick in order to achieve desired results.

The thickness of a shell **18** of a brick **10** of this invention within this range can easily be obtained by appropriate variation in the firing conditions during the manufacture of the brick. Thus, by way of example, a cement clinker brick of this invention made from standard ASTM type 1 clinker particles varying in size from particles passing a 10 mesh standard Tyler screen to particles which pass a 325 mesh screen of the same type, about one-half of such particles passing a 30 mesh screen of this same type pressed into a standard "arch" shaped brick approximately 3" x 9" x 12" with a pressure of about 5 tons per square inch from one side of the brick can be fired to obtain a shell corresponding to the shell **18** falling within the dimensional range indicated as follows: heat from ambient temperature to 2000° F. at a uniform rate so as to achieve this temperature at the end of a 48 hour period; then rapidly increase the temperature to about 2500° F. and hold this temperature for a 2 hour period; then quickly drop the temperature to 2000° F.; and finally cool at a uniform rate of cooling to ambient temperature over a 36 hour period.

This example is not to be taken as limiting this invention in any respect. It will be recognized that different firing or heating procedures should be followed with various different materials, different brick densities, and brick sizes. The precise firing or heating conditions which should be used with any particular pressed brick or brick form can easily be determined by simple routine experimentation.

We claim:

1. A kiln brick for use in a rotary kiln which comprises a brick-shaped body of a refractory composition, said body having two ends and four sides connecting said ends, one of said ends being adapted to be exposed to the interior of a rotary kiln, the other of said ends being adapted to be located away from the interior portion of a rotary kiln the interior of which body being unfused, the exterior of said body consisting of a shell of a fused, vitrified, unglazed character extending from the surface of said brick towards the interior of said brick.

2. A kiln brick for use in a rotary cement kiln which comprises a brick-shaped body, said body having two ends and four sides connecting said ends, one of said ends being adapted to be exposed to the interior of a rotary kiln, the other of said ends being adapted to be located away from the interior portion of a rotary kiln, said body consisting essentially of ingredients of Portland cement clinker, the interior of said body consisting of compressed particles of Portland cement clinker, the exterior of said body being a shell of fused, vitrified cement clinker, the thickness of said shell being from 10 to 25% of the length of the smallest dimension of said body.

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