

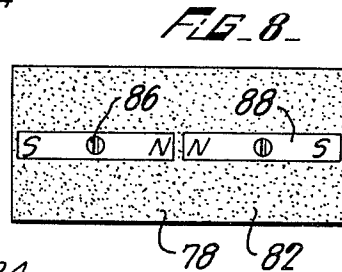
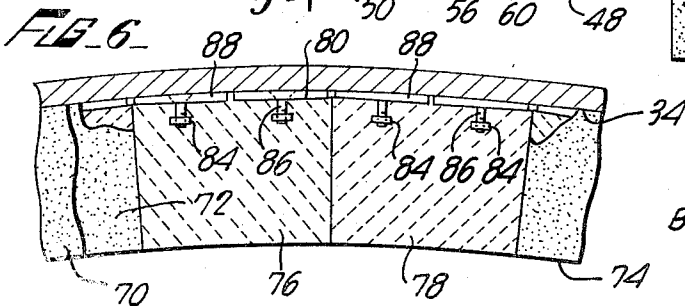
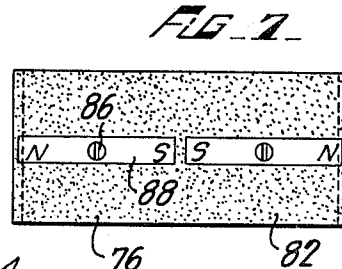
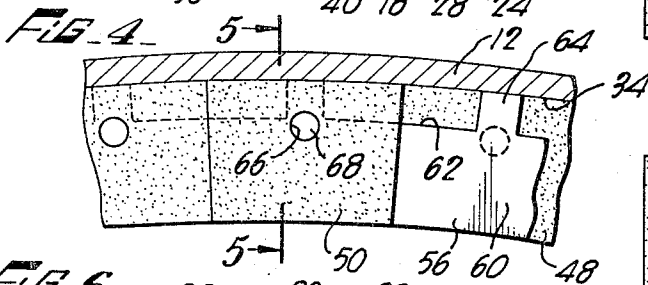
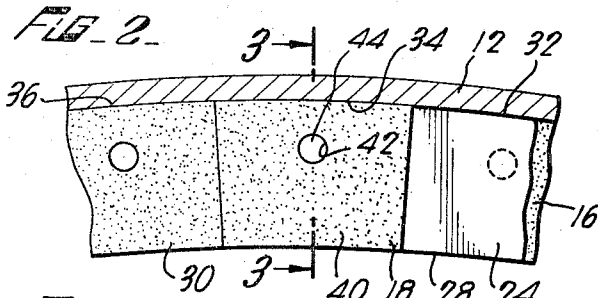
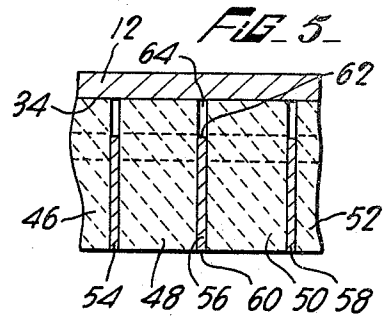
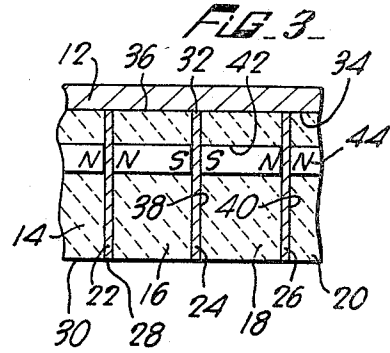
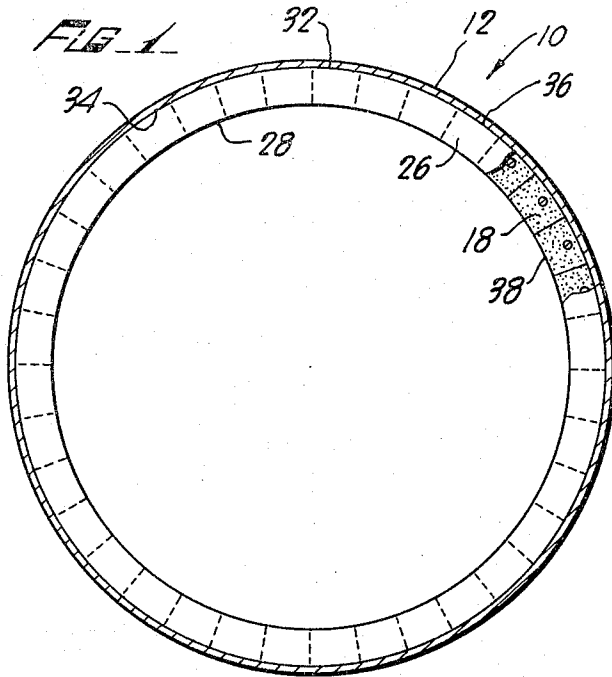
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A. R. BRYAN

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MEANS FOR HOLDING KILN BRICK WITHIN A ROTARY KILN

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INVENTOR.
ALIF R. BRYAN
BY.
EDWARD D. O'BRIAN
ATTORNEY.

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MEANS FOR HOLDING KILN BRICK WITHIN A ROTARY KILN

Alif R. Bryan, Tehachapi, Calif., assignor to Monolith Portland Cement Co., Los Angeles, Calif., a corporation of Nevada

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This invention is directed to means for holding kiln brick within a rotary kiln, and particularly to magnetic means wherein a magnet is fixed to the kiln brick and magnetic flux passes through the kiln shell to provide a brick holding force.

The retention of kiln brick within a rotary kiln presents a difficult problem. A rotary kiln usually has a steel cylindrical hollow shell which forms the main structural element thereof. Brick is placed within this shell to act as wear liner and insulation therefor. Interior temperatures in such rotary kilns range upwards to 3000° F., depending on the functional purpose of the kiln. The hot end of the kiln brick is directly adjacent this interior temperature. Furthermore, in view of the insulation qualities of the kiln brick, the kiln shell frequently reaches a temperature up to 300° F. As a result of this temperature differential, different portions of the brick are at different temperatures. Furthermore, since there are different temperatures the thermal expansion of the brick is different at different zones of the brick. The largest expansion is at the hot end of the brick. If the bricks are originally installed in a closely interfitting relationship, this thermal expansion causes the bricks to become very tightly wedged against one another. Such expansion causes considerable forces, with the result in a serious problem of brick cracking. These forces can be decreased or eliminated by spacing the bricks during installation far enough apart so that the expected thermal expansion will bring the bricks into contact without excessive forces. However, this presents the serious drawback that the bricks are loose when cold. If the bricks are located too far apart, they will fall out upon initial start up, for they are loose until they reach temperature.

Accordingly, it is an object of this invention to provide means for holding kiln brick within a rotary kiln in such a manner as to eliminate the need for tightly fitting kiln brick upon installation and thus avoid high thermal stresses.

It is a further object of this invention to provide means for holding kiln bricks within a rotary kiln by magnetic forces.

It is another object of this invention to provide magnetic means for holding kiln bricks within a rotary kiln wherein at least one permanent magnet is secured with respect to each kiln brick, and the magnet is arranged so that its flux is directed through the shell of the kiln to cause retention forces on the brick with respect to the kiln shell.

It is a further object of this invention to provide each kiln brick within a rotary kiln with a permanent magnet and arrange the polarity of the magnet so that flux is directed through the kiln shell to retain the kiln bricks in place.

Further objects and advantages of this invention will become apparent from a study of the following portion of the specification, the claims and the attached drawings in which:

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FIG. 1 is a section taken through a rotary kiln at right angles to the axis of rotation thereof showing the preferred embodiment of this invention;

FIG. 2 is an enlarged, partial, sectional view of the shell and the adjacent kiln bricks;

FIG. 3 is a section taken along the line 3—3 of FIG. 2;

FIG. 4 is a view similar to FIG. 2 showing a modified form of the shim used in association with the bricks in the preferred embodiment;

FIG. 5 is a section taken generally along the line 5—5 of FIG. 4;

FIG. 6 is a view similar to FIG. 2 showing a further embodiment of bricks magnetically held within a kiln shell;

FIG. 7 is a top plan view of one brick used in the embodiment of FIG. 6; and

FIG. 8 is a top plan view of another brick when may be used in the embodiment of FIG. 6.

As an aid to understanding this invention it can be stated in essentially summary form that it is directed to magnetic means for holding kiln bricks within a rotary kiln. The normal rotary kiln, particularly the type used for the making of cement and similar products, has a cylindrical steel shell which has a relatively thin wall as the main structural part thereof. The shell is described as being thin with respect to its overall diameter. Bricks are placed within the shell. Each of the bricks has a hole therethrough positioned to be substantially axial to the axis of rotation of the kiln shell. A bar magnet is placed in the hole in each of the bricks. As the bricks are laid in a complete course within the kiln, a steel shim is placed adjacent the course. Each steel shim is in contact with the shell to provide a low-impedance magnetic flux path. Each magnet in each brick is in contact with a shim on each side of each course. Thus, a magnetic flux path is created through each magnet, its adjacent shims and the adjacent portion of the kiln shell. The magnetic holding force from this magnetic flux retains the brick in position and it need not be fitted tightly against the remaining bricks in the course. In the preferred embodiment, the shims are circular on the inner diameter, which diameter is substantially equal to the inner diameter of the course of bricks and are circular on the outer diameter which is substantially equal to the inner diameter of the shell. In an alternative embodiment, each shim is circular on the inner diameter, substantially equal to the inner diameter of the brick course. The outer diameter is somewhat larger than the inner diameter of the shell, to decrease heat conducted through the shims. However, each shim has shim spacing lugs thereon which maintain the shim in position. Furthermore, these spacing lugs are in contact with the shell and are preferably positioned adjacent the magnets in the bricks to convey magnetic flux to the shell. In each of these embodiments the adjacent bricks in adjacent courses preferably have their magnets placed so that north magnetic poles are together to drive maximum flux through the shell. In an alternative embodiment, at least one permanent magnet is secured to the shell side of each brick. Preferably two are so positioned. When two are used, they are preferably arranged with similar poles together so as to drive maximum flux through the shell for maximum holding properties. In this alternative embodiment, the magnets are directly in contact with the shell so that no shims are necessary for the conduction of magnetic flux.

This invention will be understood in greater detail by reference to the following portion of this specification wherein the drawings are described. Referring now to FIG. 1, a rotary kiln is shown at 10. The illustration of the rotary kiln 10 is shown as a section at right angles to the axis of rotation. The actual construction of rotary kiln 10 is conventional, and reference can be made to various patents and publications for its detailed construction. The rotary kiln 10 has a steel shell 12. The kiln 10 and the shell 12 are identical in each of the embodiments wherein kiln bricks are magnetically held within the shell 12. The shell 12 is suitably supported for rotation and is relatively thin compared to its diameter. However, it is the main structural part of the kiln 10 and accordingly has sufficient thickness and rigidity to be adequately self supporting to a reasonable portion of its length, and be sufficiently strong to support the brick therein as well as the load therein.

It is obvious that with interior temperatures approaching 3000° F., and the kiln having a steel shell, it is necessary to provide some insulative factor for the shell. Bricks are used for this purpose. Originally, alumina bricks were used. These bricks have a relatively high thermal conductivity with the result that a considerable amount of heat is transferred through the bricks and out of the shell to be wasted. However, this had the result of reducing the temperature of the working face of the brick so that a portion of the semi-fluid load in a cement kiln would solidify on the brick to protect the brick. This layer, called the eutectic layer on account of its eutectic composition, would build up to a moderate thickness and remain in place. In addition to the insulative factor of the bricks, a great deal of heat is transferred from the hot combustion gases in the upper part of the kiln to the brick, and thence from the brick to the load which is in direct physical contact with the brick in the lower portion of the kiln. Thus, the brick also serves a heat transfer function.

Magnesia bricks were developed for use in such kilns. These magnesia bricks have lower thermal conductivity, but are considerably more sensitive to thermal and mechanical shock than the old alumina brick. In order to reduce the shock on the bricks, full circle steel shims were placed between each circumferential course of bricks. In view of the lower thermal conductivity of the magnesia bricks, they did not tend to build up a substantial protective eutectic layer. However, with the introduction of shims, heat is transferred to the shell with the result that the eutectic layer would build up adjacent the shims. The eutectic layer was uneven because the shims had such a greater thermal conductivity than the magnesia bricks. However, this effect was modified by forming the shims so that they were not in continuous contact at their outer edge with the shell. The outer diameter was reduced, and feet or flanges extending outward from the main outer diameter of the shim extended to the shell for heat transfer and for positioning of the shim. With proper dimensioning, the loss through the shim became substantially that of the loss through the brick with the result that heat loss was minimized and the eutectic layer was even.

From this discussion, it can be seen that the means for holding kiln brick within a rotary kiln, in accordance with this invention, is capable of use with any kind of bricks and with any kind of shim.

Referring now to the preferred embodiment of FIGS. 1, 2 and 3, courses 14, 16, 18 and 20 of brick are circularly laid around the interior of shell 12. As is seen in FIGS. 1 through 3, shims 22, 24 and 26 are placed between the courses of brick. In FIG. 1, shim 26 is partially broken away to show the course 18 of brick. In FIG. 2, the course 18 of brick is terminated to show the shim 24 therebelow and shim 24 is broken away to show the course 16 therebelow.

Each of the shims 22, 24 and 26 is relatively thin from one side to the other axially of the kiln 10. Each of the shims has an interior surface 28 which is of cylindrical

form and generally in line with the interior surface 30 of the bricks in each of the courses. The interior surfaces 30 of the brick may be partially cylindrical to form an interior cylindrical surface. However, should these surfaces be planar, they are sufficiently close to the large interior substantially cylindrical surface to be adequate in form.

The exterior surface 32 of each of the shims is of appropriate diameter to reasonably firmly fit on the interior cylindrical surface 34 of the kiln shell 12. Similarly, each of the bricks has an exterior surface 36 which is preferably a section of a cylindrical surface so as to closely fit against the surface 34. Each of the bricks also has planar side surfaces adjacent the shims and planar side surfaces adjoining adjacent brick. The side surfaces against the adjacent brick are preferably at such an angle that they lie in planes which intersect at the axis of rotation of the kiln 10. As is seen in FIG. 3, the shim side surfaces of a brick in course 18 are indicated at 38 and 40.

A cylindrical hole 42 is formed through each of the bricks. The hole 42 extends from surface 38 to surface 40 and is preferably perpendicular to these surfaces. Bar magnet 44 is inserted in each of these holes 42. Bar magnet 44 is of cylindrical configuration and is magnetized so that it has a north pole on one end and a south pole on the opposite end, as is shown in FIG. 3. Each of the bar magnets 44 extends to the surfaces 38 and 40 so that the bar magnets are in intimate magnetic association, with each of the shims. As is illustrated in FIG. 3, bar magnet 44 is magnetically associated with shims 38 and 40. Furthermore, the shims 38 and 40 are in contact with the shell 12. Thus, a closed magnetic flux path is formed through the shims and the shell to hold the brick in place. In order to provide a maximum flux path through the shell, to provide a maximum holding force, the bricks in adjacent course are laid with similar poles together. Since the south poles face together at shim 24, see FIG. 3, the flux from both of these poles must pass through shim 24 into shell 12. Thus, no flux short circuiting occurs through adjacent magnets as would occur if opposite polarities were adjacent.

The embodiment of FIGS. 4 and 5 is quite similar to the embodiment of FIGS. 1 through 3. Again, courses 46, 48, 50 and 52 of brick are laid around the inside of shell 12. They present a substantially cylindrical interior surface within the kiln. Furthermore, the bricks in each course lie closely adjacent each other, and lie closely adjacent the interior of the shell 12. The courses are respectively separated by shims 54, 56 and 58. As is best seen in FIG. 4, each of the shims, as is exemplified by shim 56, has a substantially cylindrical interior surface 60 and a substantially cylindrical exterior surface 62. However, in this embodiment, the exterior surface 62 is of larger diameter than the interior surface 34 of shell 12. This spacing reduces the heat loss through the shims to shell 12. However, in order to properly space the shims, and in order to provide a magnetic flux path, each of the shims is provided with spacing lugs. Spacing lug 64 on shim 56 is illustrative.

Again, each of the bricks has a hole formed there-through which is positioned so as to be substantially parallel to the axis of rotation of the kiln 10. One of these holes is illustrated at 66. Each of the bricks contains a permanent bar magnet 68 in the hole 66 so as to provide the magnetic holding force. Again, each of the magnets 68 is of sufficient length so as to preferably be in contact with the adjacent shims. Furthermore each of the spacing lugs 64 is preferably so positioned as to be adjacent a point of magnetic contact therewith. Furthermore, magnets in adjacent bricks are positioned so that similar poles are together, as is shown in FIG. 3. Thus, the magnetic flux path resulting from the magnet in each brick is forced through the adjacent spacing lug 64 and the adjacent portion of the kiln shell 12. Thus, maximum magnetic holding power results for each individual brick.

In the further embodiment of the invention shown in

FIGS. 6 through 8, courses 70, 72 and 74 of brick are shown laid inside of kiln shell 12. Bricks 76 and 78, in course 72, are shown in section to illustrate their construction. These bricks are illustrated in plan view in FIGS. 7 and 8. Bricks 76 and 78, as well as the remaining bricks in that course and the other courses, are each provided with recess 80 on the outer face 82 thereof which face is adapted to be in contact with the inner surface 34 of kiln shell 12. Inserted within each brick and positioned below each of the recesses 80 is a nut 84. An opening is provided from the recess through to the nut to accept bolt 86.

As is seen in FIGS. 6 through 8, there are two recesses 80 in the outer face of each brick. For convenience, these recesses may be joined, but they are preferably arranged so as to be spaced slightly from each other at their inner ends. A magnet 88 is inserted in each of the recesses 80, and each is maintained in place by means of a bolt 86. The magnets 88 are arranged so that they are flush with the outer face of the bricks so that when the bricks are laid within shell 12, the magnets lie against the inner surface 34 of shell 12. The magnets 88 are placed in each brick so that similar poles are together, as is shown in FIGS. 7 and 8. Furthermore, adjacent bricks in the same course can be arranged so that different poles are together at the faces of the brick where they join with a joining brick in the same course. Thus, the flux path passes through the adjacent halves of the adjacent two bricks and into a shell almost at the mid-point of each of the bricks, and thence through the shell. Thus, adjacent bricks in the same course are held together and are held against the inner surface 34 of shell 12.

With respect to the positioning of the magnet, there are also two schools of thought. In FIGS. 1 through 5, the magnets are described as having similar poles together, throughout the entire construction. In the embodiment of FIGS. 6 through 8, similar poles were shown as being together at the center of the brick, but the bricks being laid so that dissimilar poles were adjacent on adjacent bricks. In the first concept, the similar poles being together forces the major part of the magnetic flux through the shell, rather than through an adjacent magnet. This provides a maximum holding power and also provides a separating force at the brick interfaces. Such separating force tends to hold the bricks apart and thus reduce abrasion therebetween. It is found in such kiln that there is a certain amount of relative brick motion, especially during start up and cool down periods. The magnetic arrangement concept disclosed in FIGS. 6 through 8, provides a tendency for the flux to pass through a pair of magnets, one of each pair being on adjacent bricks. This attracts the bricks together and provides additional holding power. This additional holding power between adjacent bricks may provide additional holding power, but at the expense of abrasion between adjacent bricks. Thus, the construction of FIGS. 6 through 8, can be arranged in either way. It can be arranged as shown in the drawings, or can be arranged so that only similar poles are adjacent. As expressed above, the arrangement of similar poles together provides an individual flux path for each magnet through the shell and repulsion between adjacent bricks.

With magnetic flux paths arranged as described above, and the resultant holding forces between the several bricks and the shell, the bricks are maintained in good engagement with the shell, independent of interbrick forces. Thus, the bricks may be laid in the shell in such a manner that they are relatively loose when cold and the magnet forces between each brick in the shell maintain the bricks in position, even in the cold condition. As the kiln is rotated and as the bricks heat up, the interior brick faces expand to a point where they are in reasonably close contact with each other. However, excessive stresses are prevented by originally laying the brick with some space therebetween. Thus, a long life

of lining is assured, without the falling out of brick. It must be noted that the magnets 44, 68 and 88 must be of such nature as to provide adequate flux strength for the holding of the bricks in position when originally laid and whenever the kiln is cooled down. Furthermore, the magnets must be of such nature as to maintain the magnetic strength through heating and cooling cycles encountered in their environment. Adequate magnets are presently available from the market and are made of aluminum-nickel-cobalt alloys. Other alloys may be discovered in the future, or may be developed to provide suitable service in this environment. The particular magnet material is unimportant, except that it must provide adequate magnetic strength in the environment described above.

This invention having been described in its preferred embodiment, and several alternative embodiments disclosed, it is clear that this invention is susceptible to numerous modification and changes within the skill of the routine artisan and without the exercise of the inventive faculty. Accordingly, the scope of this invention is defined by the scope of the following claims.

I claim:

1. Means for holding kiln brick within a rotary kiln having a ferro-magnetic shell, said means comprising a kiln brick, said kiln brick being adapted to engage upon the ferro-magnetic shell of the rotary kiln, a permanent magnet secured to said kiln brick, said permanent magnet being magnetized so as to create magnetic flux, said magnetic flux being adapted to pass through the ferro-magnetic shell of a rotary kiln and being of sufficient strength to hold said kiln brick with respect to the shell, whereby said kiln brick is adapted to be held in place in a rotary kiln by magnetic flux from said permanent magnet interacting with the shell of the kiln.

2. The means for holding a kiln brick within a rotary kiln of claim 1 wherein said magnet has a magnetized north pole and a magnetized south pole, said poles being adapted to be positioned with respect to the ferro-magnetic shell of a rotary kiln to direct magnetic flux through the shell.

3. A rotary kiln, said rotary kiln having a substantially cylindrical ferro-magnetic shell having an interior surface, a kiln brick positioned within said shell, a permanent magnet engaged with said kiln brick, said permanent magnet being magnetized and having a north pole and a south pole, said permanent magnet being positioned with respect to said shell so as to direct magnetic flux through said shell, said magnetic flux being sufficient to hold said brick against said shell.

4. The structure of claim 3 wherein there are a plurality of said bricks within said kiln, each of said plurality of brick having a permanent magnet positioned with respect thereto, each of said permanent magnets being magnetized and each of said permanent magnets directing magnetic flux through said shell with sufficient strength to hold each of said bricks against said shell.

5. The structure of claim 4 wherein each of said magnets has a north pole and a south pole, said magnets being arranged with respect to said bricks and said bricks being arranged with respect to each other so that poles of magnets in adjacent bricks are adjacent to each other.

6. The structure of claim 5 wherein similar poles of the magnets positioned with respect to adjacent bricks are positioned adjacent each other.

7. The structure of claim 5 wherein a hole is positioned through each of said bricks and said magnet is a bar magnet positioned within said hole, said structure further including a ferro-magnetic shim placed circumferentially of said shell, and separating said bricks into courses of bricks, said poles of said magnets being positioned adjacent said shims, said shims directing magnetic flux from said magnets to said shell.

8. The structure of claim 7 wherein at least one of said shims is in limited physical magnetic contact with said shell.

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9. The structure of claim 4 wherein each of said bricks has a face adapted to be positioned adjacent said inner surface of said shell, said magnet being positioned at said face and in physical contact with said shell.

10. The structure of claim 9 wherein two magnets are positioned at said face of each of said brick, each of said magnets having north and south poles, said magnets being positioned at said face in such a manner that similar poles are adjacent each other.

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FREDERICK L. MATTESON, JR., *Primary Examiner.*
J. J. CAMBY, *Assistant Examiner.*