July 30, 1968 B. D. McKENNA 3,394,511

REFRACTORY CONSTRUCTION

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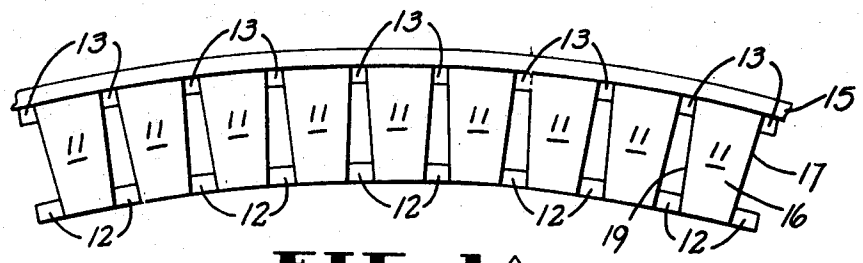


FIG_1A

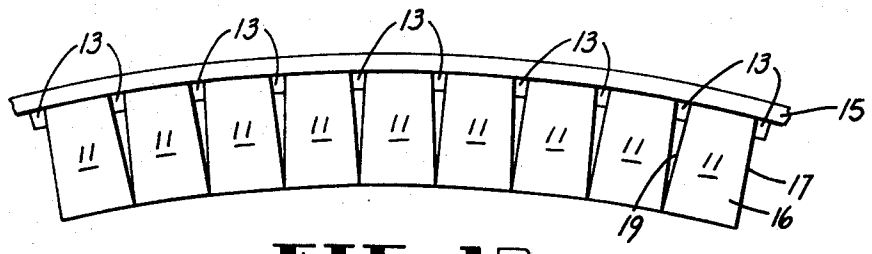


FIG_1B

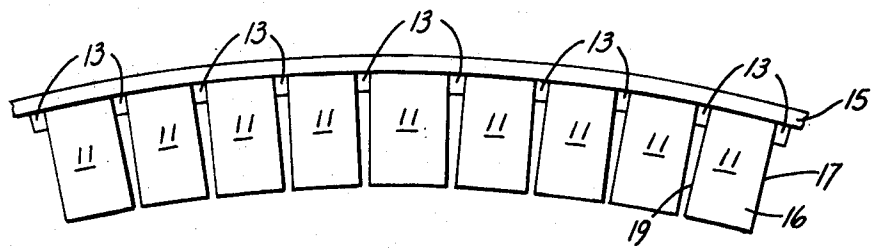


FIG_1C

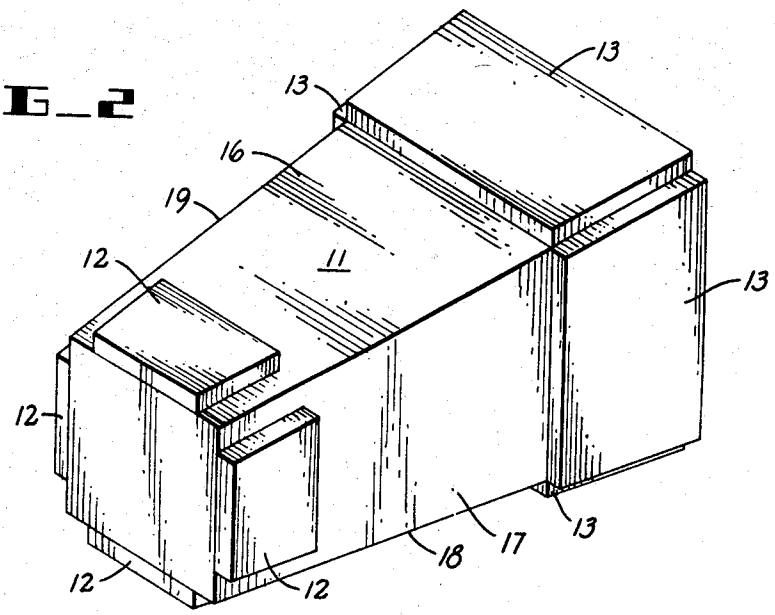
INVENTOR.
BERNARD D. McKENNA
BY James E. Toomey

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FIG_2



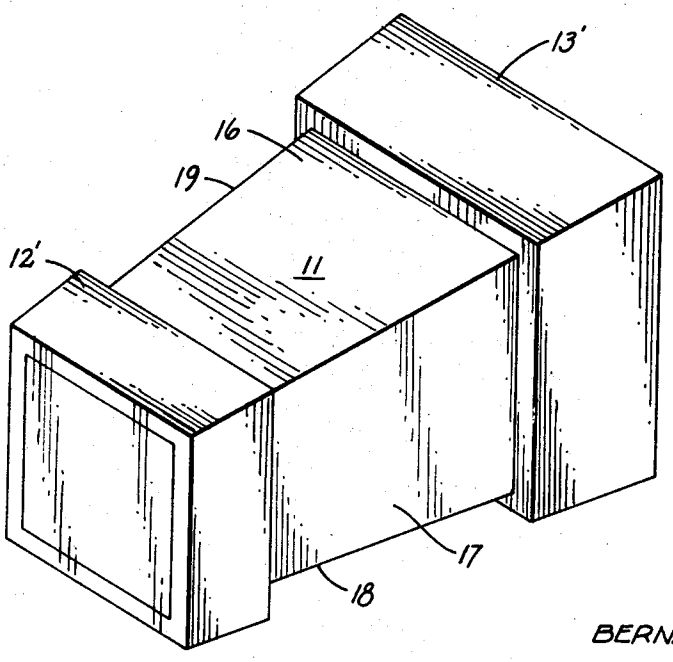


FIG_3

INVENTOR.
BERNARD D. McKENNA
BY James E. Toomey

United States Patent Office 3,394,511 Patented July 30, 1968

3,394,511

REFRACTORY CONSTRUCTION

Bernard D. McKenna, San Jose, Calif., assignor to Kaiser Aluminum & Chemical Corporation, Oakland, Calif., a corporation of Delaware

Filed Nov. 27, 1964, Ser. No. 414,315
11 Claims. (Cl. 52—232)

This invention concerns refractories and refractory construction.

It has long been known that refractory materials used in the construction of furnaces and other high temperature devices expand upon being heated and various means have been devised to allow for such expansion. For example, it is known to leave spaces between the refractory shapes during construction of a furnace, the refractories expanding into and filling these spaces when they are heated. It is also known to place combustible materials such as wood or cardboard or compressible materials such as asbestos in joints between refractory units of a furnace wall, the combustible material burning upon heating of the furnace and providing room for expansion of the refractories or the compressible material being compressed by the expanding refractories.

However, such prior art methods of allowing for the expansion of refractories have had shortcomings, mainly due to the fact that the refractories in a furnace wall, for example, are not uniformly heated throughout and that, accordingly, the amount of expansion varies at different points within the wall.

For example, in the construction of an electric furnace wall, it is known to place combustible strips of uniform thickness between the refractory shapes making up the furnace wall. Upon heating up of the furnace these combustible strips, cardboard for example, are burned out and the heated refractories can expand into the space provided. However, upon cooling down again of the electric furnace, the refractories contract, become loose, and tend to become dislodged from their position in the wall. This problem is particularly acute in the case of electric furnaces, many of which are tipped or tilted to pour out the metal melted within them. Thus, any loosening of the brick work in the electric furnace wall can lead to total collapse of the furnace lining, a clearly undesirable situation.

To overcome this disadvantage of combustible expansion allowance joints, it has been known to construct electric furnace walls with no expansion joint allowance. However, when such a furnace wall is heated up, the refractories are subjected to large compressive stresses due to the restraint on the thermal expansion of the refractories. Since such thermal expansion is greatest at the point where the refractories are hottest and since, in most cases, the strength of refractories fall off with increasing temperature, it can be seen that these stresses are generated in those portions of the refractory which are least fitted to withstand them. Since above about 1600° C. most refractories will relieve themselves of stress by creep or slow deformation, the most destructive stresses generally occur about one inch back of the hot face in, for example, a steel melting furnace. Thus, the result is, in many cases, a fracturing or spalling of the refractories with consequent premature loss of some or all of the furnace lining.

According to the present invention, there has been found a way of constructing furnace walls, and a refractory unit for use in such construction, which overcomes these prior art problems. A construction according to this invention provides proper thermal expansion allowance for the refractories while at the same time maintaining these refractories in tight engagement in the

furnace wall, both at the operating temperature of the furnace and during intervals when the furnace is cooled down.

The invention will best be understood from the following description, taken in conjunction with the drawings in which:

FIGURE 1A is a partial plan view of a circular furnace wall after construction and before the first heating up of the furnace;

FIGURE 1B is a similar view of the same wall upon heating up of the furnace;

FIGURE 1C is a similar view of the same furnace wall after cooling from the operating temperature;

FIGURE 2 is a perspective view of a refractory unit for use in a furnace construction according to this invention; and

FIGURE 3 is a similar perspective view of an alternative embodiment.

In a structure according to this invention, refractory shapes **11** having longitudinal faces **16**, **17**, **18**, and **19** are placed in a furnace wall, for example a circular furnace wall as shown in FIGURE 1A, B, or C, with strips of combustible material **12** between opposed longitudinal faces of adjacent refractory shapes **11** near the inner end of such shapes, the material **12** between longitudinal faces **17** and **19** of adjacent shapes being shown in FIGURE 1A. By the term "inner end" is meant the end of the refractory shape **11** disposed toward the interior of the furnace and intended to be exposed to the high temperature within the furnace when it is at operating temperature. The combustible material **12** will preferably extend from adjacent the inner end to a point not more than 20% of the distance along the longitudinal face of the refractory from the inner end toward the outer end of the refractory. By the term "outer end" is meant the end of the refractory opposite the inner end, being the end furthermost from the high temperature of the furnace.

Between the opposed longitudinal faces of adjacent refractory shapes **11** at their outer ends are placed small flat plates or sheets of metal **13**. These plates of metal, which may for example be sheet steel, extend along the longitudinal faces of the refractories, from adjacent the outer end to from 10% to 25% of the distance from the outer end toward the inner end.

Upon heating up of the furnace, the combustible material **12** burns out and leaves a space into which the hot or inner ends of the refractory shapes **11** can expand. The thickness of the combustible material **12** is preferably such that it is just equal to the thermal expansion of the refractory material between the longitudinal faces, for example the faces **17** and **19** of FIGURE 1, of the refractory shape **11** upon heating from room temperature to the operating temperature of the furnace. That is to say, its thickness will be equal to the thermal expansion of the refractory in a direction perpendicular to the face against which the combustible lies. Thus, at the operating temperature of the furnace the longitudinal faces of the refractory shapes **11** are substantially in contact at the inner or hot ends. When, for example, the refractory shapes **11** are made of non-acid metal oxide refractory material such as magnesite or chromite or mixtures of these two with each other, and are installed in a steel melting furnace designed to operate at about 1700° C., the thickness of the combustible material **12** is from about 0.75% to about 2% of the thickness of each refractory shape **11** at its inner or hot end for chemically bonded brick, from about 1.5% to about 2.5% for conventionally fired (for example, to about 1350° C.) brick, and from about 1.75% to about 3% for high-fired or direct-bonded brick.

When the furnace is at operating temperature, the outer or cold ends of the refractory shapes **11** are only slightly above room temperature, for example at about 250° C. Accordingly, there is little expansion of the cold or outer ends of the refractory shapes **11**. However, in a circular furnace such as shown in FIGURE 1, any increase in temperature at the cold end causes some expansion in the refractories and tends to tighten the bricks within the furnace. It will be noted that any compression forces due to heating of the outer ends of the bricks will be applied to the coldest portion of the brick, that is to say the portion of the brick best able to withstand the compressive forces involved.

Upon cooling down again of the furnace, as is illustrated in FIGURE 1C, the inner ends of the refractory shapes **11** contract and part, leaving a gap between these inner ends. However, there is little if any cooling and contraction of the outer ends of the refractory shapes **11** and the shapes are thus still tightly held in place by the wedging action of the metal **13** between the refractory shapes **11**. Thus, in a tilting electric furnace for example, the refractory lining will be held tightly and will not fall out of place during the heating and cooling cycle of the furnace.

It will be found most convenient for the construction of a furnace according to the above description to have the combustible material **12** at the inner ends and the metal strips **13** at the outer ends of the refractory shapes **11** attached to such shapes before the shapes are placed in the furnace structure, preferably before shipment of the shapes to the user. FIGURE 2 shows a refractory unit with combustible material **12**, for example cardboard or wood, attached to two longitudinal faces, **16** and **17**, of the refractory shape **11** and metal strips **13**, for example steel, attached to the outer end of the shape on the same longitudinal faces. As explained above, the combustible material will preferably extend from adjacent the inner end to not more than 20% of the distance from the inner end toward the outer end of the refractory shape **11** and the metal will extend from adjacent the outer end of the face to which it is applied to from 10% to 25% of the distance from the outer end toward the inner end of the refractory shape. The metal plates and combustible sheets can be attached to the refractory by any suitable method, for example by an adhesive.

An alternative method of constructing a refractory unit for use according to this invention, shown in FIGURE 3, is to place the combustible material in the form of a strip or tube **12'** fitting over and completely encircling the inner end of the refractory shape **11**. Likewise, the metal strip can take the form of a band **13'** completely encircling the outer end of the refractory shape **11**.

It will be understood that the total thickness of combustible material on opposite longitudinal faces of the refractory shape **11**, for example on faces **17** and **19**, will be equal to the thermal expansion of the refractory material between said longitudinal faces upon heating from room temperature to the operating temperature of the furnace. It will also be understood that, instead of placing combustible and metal on two opposed faces, for example **17** and **19**, the total thickness of these materials can be placed on one face, for example **17**, only.

Although the invention has been illustrated by examples wherein combustible and metal are placed in all joints, i.e., in both radial and circumferential joints of a circular furnace, it will be understood that, if desired, the use of combustible and metal can be confined to the joints running in one direction, e.g., to the radial joints in a circular furnace.

It will be understood that the thickness of the metal **13** at the outer end of the refractory shape **11** is not critical and will be chosen with regard to such factors as convenience, economy, and the desire to provide a good bearing surface for the outer ends of the refractory shapes to hold such shapes in position in the furnace. Generally, the thickness of the metal is approximately equal to that of the combustible.

Although cardboard and wood have been mentioned as examples of suitable combustible materials, it will be understood that other materials of equivalent properties can be used. For example, asbestos can be used, although it will generally be found more expensive than cardboard, and may introduce an undesirable amount of silicate into the refractory system.

While the illustrated structure according to this invention has combustible and metal between each refractory shape, it is possible to place such combustible and metal in only every other joint, or even less frequently, if desired, the thickness of each piece of combustible and metal being correspondingly increased.

In the drawings, the thicknesses of the combustible and metal have been exaggerated to show the invention more clearly. Although the invention has been illustrated with refractory shapes of rectangular cross-section, the invention can be used with shapes of other configurations.

Having now described the invention, what is claimed is:

1. A refractory unit comprising:

a refractory shape having an inner end adapted to be exposed to the high temperatures of a furnace, an outer end opposite said inner end, and longitudinal faces between said ends;

combustible material on at least one of two opposed longitudinal faces of the refractory adjacent the inner end of the refractory; and

flat sheet metal attached to at least one of said two opposed longitudinal faces of said refractory shape at the outer end of said shape and extending from adjacent said outer end to from 10% to 25% of the distance from the outer end toward the inner end of the shape, said metal remaining solid at temperatures prevailing at the outer end of the shape.

2. A refractory unit comprising:

a refractory shape having an inner end adapted to be exposed to the high temperatures of a furnace, an outer end opposite said inner end, and longitudinal faces between said ends;

combustible material on at least one of two opposed longitudinal faces of the refractory adjacent the inner end of the refractory and extending to not more than 20% of the distance from the inner end toward the outer end of the refractory; and

flat sheet metal attached to at least one of said two opposed longitudinal faces of said refractory shape at the outer end of said shape and extending from adjacent said outer end to from 10% to 25% of the distance from the outer end toward the inner end of the shape, said metal remaining solid at temperatures prevailing at the outer end of the shape.

3. A refractory unit according to claim **1** wherein the total thickness of said combustible material on opposed longitudinal faces is equal to the thermal expansion of the refractory material in a direction perpendicular to said longitudinal faces upon heating from room temperature to the intended operating temperature of the furnace.

4. A refractory unit according to claim **1** wherein said refractory shape is composed of non-acid oxide refractory material and the total thickness of said combustible material on opposed longitudinal faces of the refractory is equal to from about 0.75% to about 3.0% of the thickness of the refractory material between said faces.

5. A refractory unit according to claim **1** wherein said combustible material is cardboard and said metal is steel.

6. A refractory unit according to claim **1** wherein said combustible material is disposed on each longitudinal face of the refractory at its inner end and said sheet metal is disposed on each longitudinal face of said refractory at its outer end.

7. A refractory lining for a furnace comprising:

refractory shapes, each of said shapes having an inner end exposed to the interior of the furnace, an outer

end opposite the inner end, and longitudinal faces between said ends;

combustible material disposed between opposed longitudinal faces of adjacent refractory shapes, said material extending from adjacent the inner ends to not more than 20% of the distance from the inner ends toward the outer ends of the refractory shapes; and

flat sheet metal disposed between said opposed longitudinal faces of adjacent refractory shapes, said metal extending from adjacent the outer end to from 10% to 25% of the distance along said faces from the outer end toward the inner end of said refractory shapes and remaining solid at temperatures prevailing at the outer ends of the refractory shapes.

8. A refractory lining according to claim **7** wherein the thickness of said combustible material between opposed faces of adjacent refractory shapes is equal to the thermal expansion, upon heating from room temperature to the intended operating temperature of the furnace, of the refractory material between said combustible material.

9. A refractory lining for a furnace according to claim **7** wherein said furnace is of circular section.

10. A refractory lining for a furnace according to claim **7** wherein said furnace is an electric furnace.

11. A refractory lining for a furnace comprising: refractory shapes, each of said shapes having an inner end exposed to the interior of the furnace, an outer end opposite the inner end, and longitudinal faces between said ends;

combustible material disposed between opposed longitudinal faces of adjacent refractory shapes adjacent the inner ends of said shapes; and

flat sheet metal disposed between said opposed longitudinal faces of adjacent refractory shapes, said metal extending from adjacent the outer end to from 10% to 25% of the distance along said faces from the outer end toward the inner end of said refractory shapes and remaining solid at temperatures prevailing at the outer ends of the refractory shapes.

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FRANK L. ABBOTT, *Primary Examiner.*

J. L. RIDGILL, JR., *Assistant Examiner.*