United States Patent

Norris et al.

[15] **3,698,068**

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[54] **METHOD OF APPLYING A METAL PLATE TO A REFRACTORY BRICK**

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[52] **U.S. Cl.** ....**29/509,** 29/521, 29/243.57, 52/599, 113/116 FF

[51] **Int. Cl.** **B21d 39/00, B23p 11/00**

[58] **Field of Search** ....29/509, 521, 243.57; 113/116 FF; 52/599

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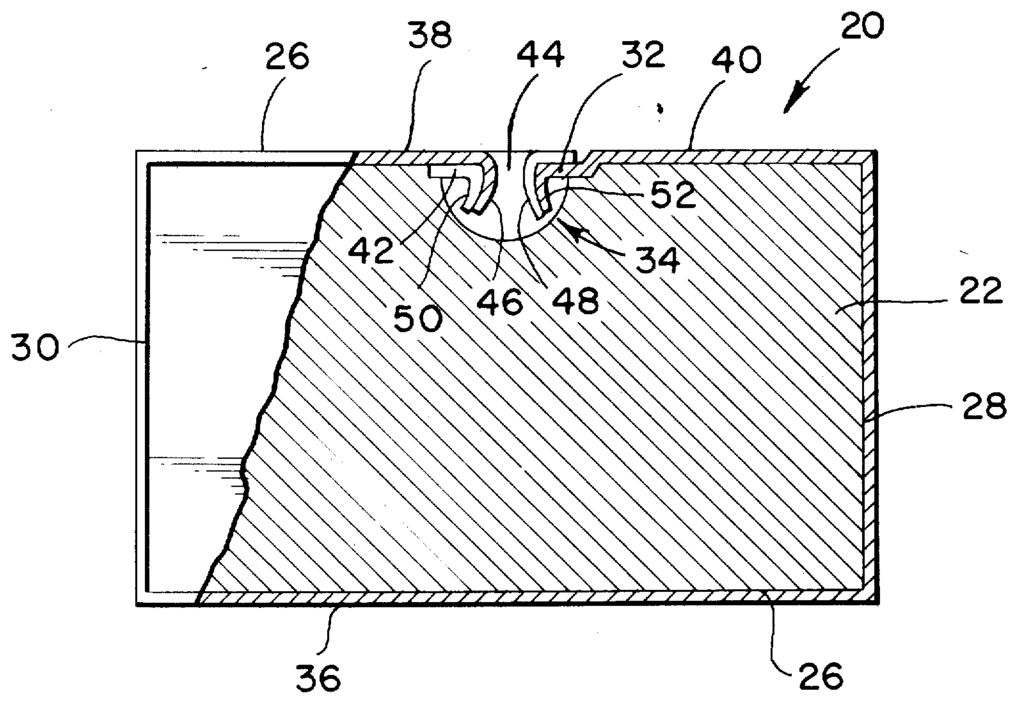
[57] **ABSTRACT**

A furnace block comprising a refractory brick having a metal casing is provided. In the construction of the furnace block, overlapping ends of the metal plate are secured together at an elongated groove formed along one surface of the brick to provide a metal casing for the brick. One end of the metal plate has an offset which is received in the elongated groove. The overlapping ends of the metal plate are connected by puncturing or welding to lock the overlapping ends together and to secure the metal plate to the brick. A method of applying a metal plate to a refractory brick is also provided. In this method, the brick is positioned on one surface of the metal plate at a position intermediate between the ends of the metal plate, and the ends of the plate are bent into contact with the sides of the brick by using the brick as a male die. During the bending, the metal plate is held firmly against the bottom surface of the brick. Then the portions of the metal plate which extend above the top surface of the brick are bent into contact with the top surface to overlap the ends of the metal plate while holding the previously bent portions of the metal plate firmly against the sides of the brick. Finally, the overlapping ends of the metal plate are secured together to provide a metal casing for the brick. An apparatus for producing the metal encased bricks is also provided.

13 Claims, 8 Drawing Figures



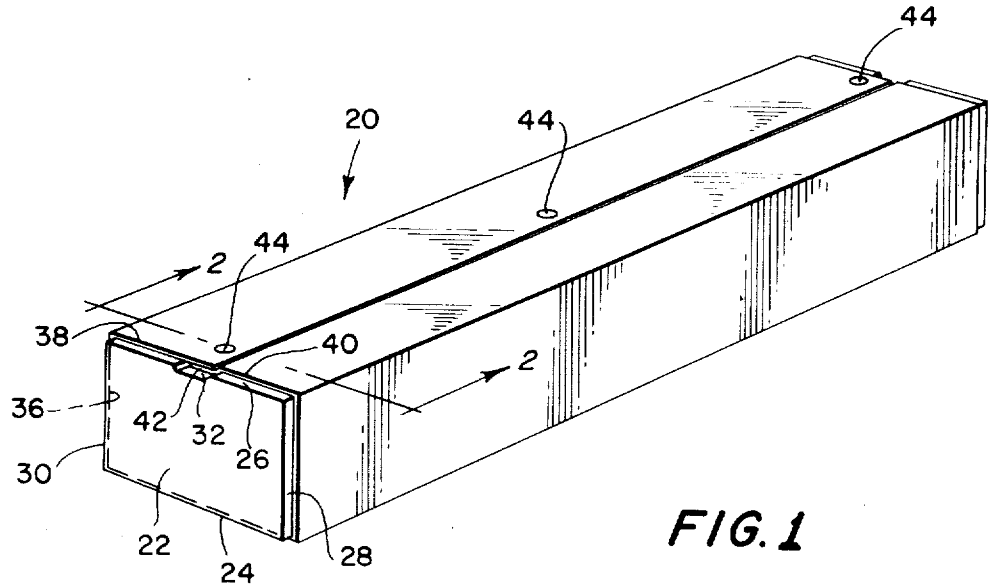


FIG. 1

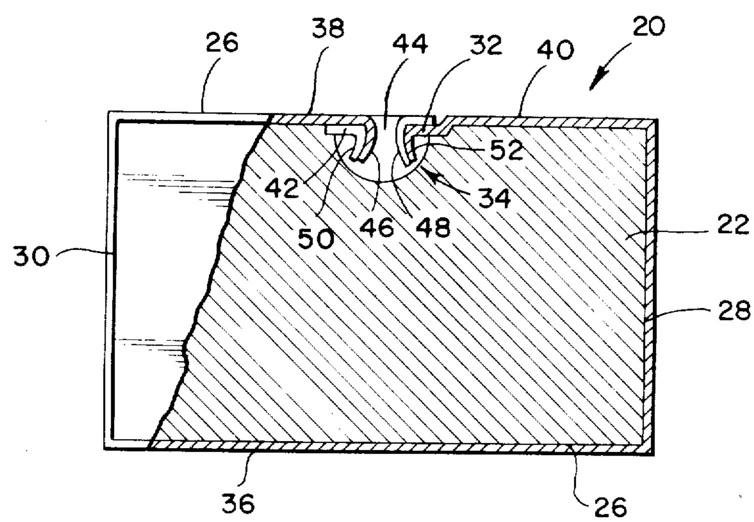


FIG. 2

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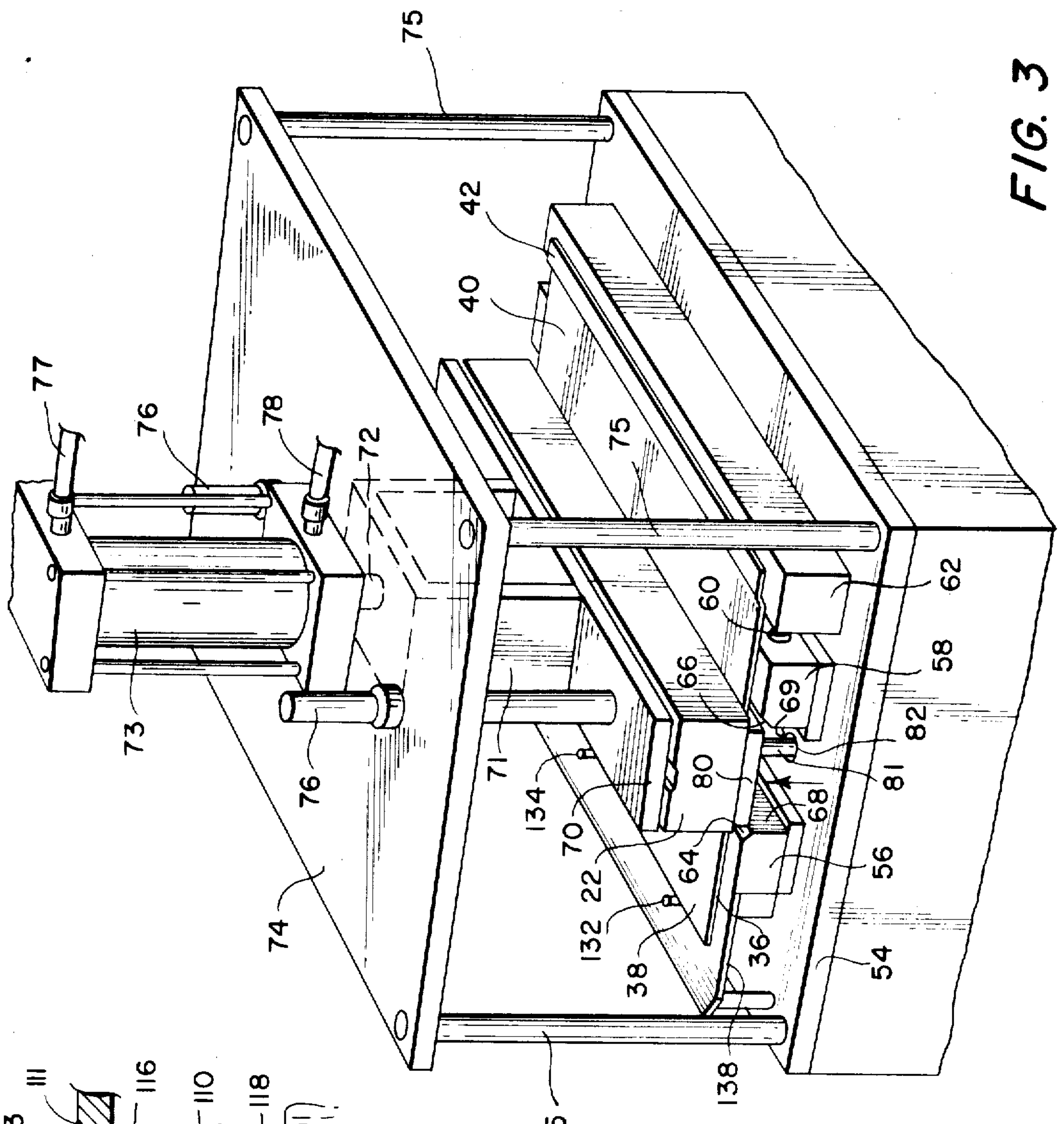

FIG. 3

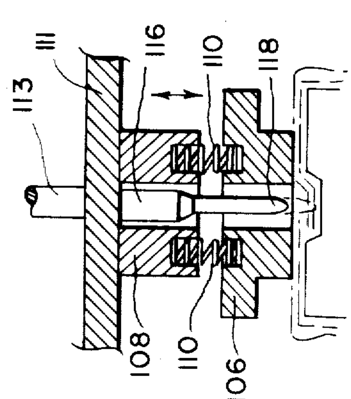

FIG. 8

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FIG. 4

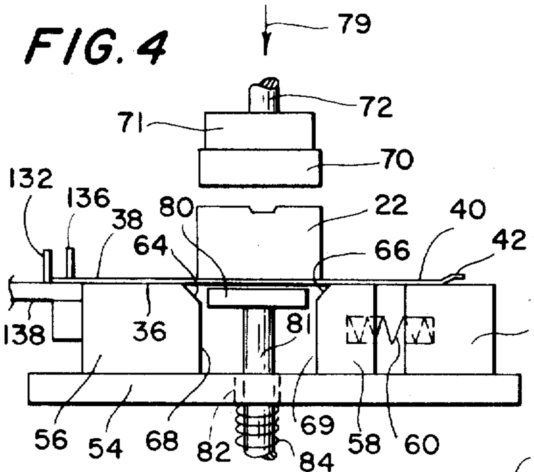
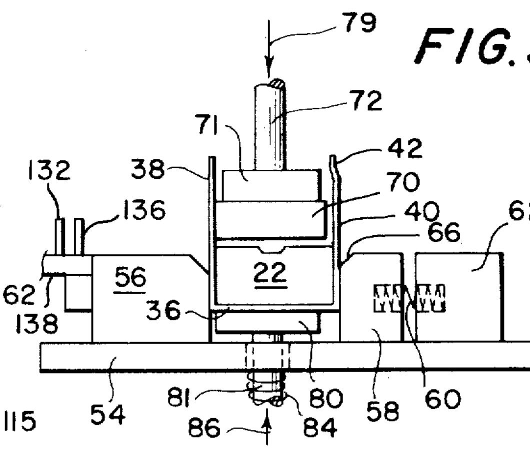


FIG. 5



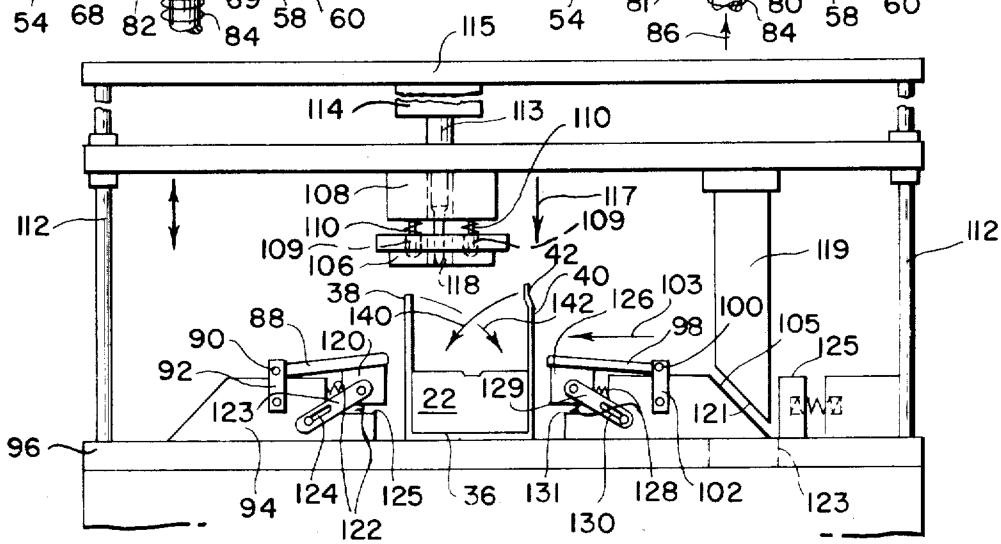


FIG. 6

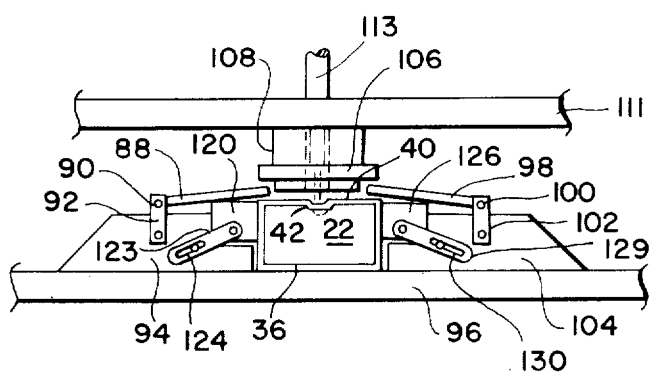


FIG. 7

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METHOD OF APPLYING A METAL PLATE TO A REFRACTORY BRICK

The present invention relates to furnace block comprising a refractory brick having a metal casing, and, more particularly, to a furnace block in which the metal casing extends completely around the exterior surface of the brick and has overlapping ends mechanically locked together and secured to the brick.

The present invention also relates to a method of and apparatus for applying a metal plate to a refractory brick.

In industrial applications, furnace blocks comprising refractory bricks having metal casings are commonly used in the construction of furnaces. This type of furnace block is particularly useful in furnaces designed to perform metal processing operations. In a furnace constructed from such furnace blocks, the heat generated within the furnace causes the metal casings of the furnace blocks to melt together to form a homogeneous lining for the furnace. The fused metal of the casings adds to the mechanical strength of the furnace walls. In addition, a portion of the metal of the casings is dispersed into the refractory material of the brick to adhere to the casing to the brick. Thus, the furnace blocks used in the ceiling of the furnace provide a support, consisting of the fused metal of the casings, to which hangers or other devices can be attached. In view of the above characteristics of the furnace blocks, it is highly desirable to use them in the construction of industrial furnaces.

In the art of encasing refractory brick with metal plates it is necessary to provide a metal casing which is tightly secured to the brick. This tight encasement is required to avoid having the brick slip inadvertently out of its casing during handling of the furnace block, to avoid the formation of extraneous flues in the furnace walls in spaces between the metal casings and the refractory bricks, and to avoid difficulty in maintaining the alignment of the encased bricks during construction of a furnace.

In the prior art, it has been difficult to obtain refractory bricks with tightly fitting metal casings because of the non-uniform size of commercially available refractory brick. This non-uniformity in size is inherent in the manufacturing processes for refractory brick. Thus, it is desirable to provide a technique for applying a metal casing to a refractory brick which compensates for the non-uniform brick size.

Prior art techniques of producing a metal casing for a refractory brick have used from one to four preformed metal plates on the exterior surfaces of the brick, with these plates being secured together by spot welding or secured to the brick with adhesives. In some instances it has been necessary to form elongated slots in the metal plates to facilitate bending of the plates into shapes conforming to the sides of the brick.

The most common arrangements for the metal casing have been (1) a one-piece metal casing made from a partially preformed metal plate and having its ends secured together with spot welds; (2) a pair of U-shaped metal plates overlapping on opposite sides of the refractory brick and secured together with spot welds; (3) a pair of U-shaped plates secured to the brick with adhesives and having ends abutting on opposite sides of the brick; (4) a pair of L-shaped metal plates secured to the refractory brick with adhesives and having abutting ends at opposite corners of the brick; and (5) four L-shaped metal plates having overlapping ends on all surfaces of the refractory brick which are secured together with spot welds.

In industrial applications, it is preferred that the metal casing of the furnace block be mechanically locked. Thus, furnace blocks having metal casings secured by spot welding have been more desirable than furnace blocks having metal casings secured to the surface of the refractory brick with adhesives. However, prior art furnace blocks having welded metal casings have been typically characterized by loose or poorly fitting casings having the disadvantages described above. Moreover, the use of preformed metal U-shaped plates does not permit compensation for variation in brick size.

Prior art casing arrangements which compensate for non-uniform brick size generally provide overlapping ends of the metal plates on all surfaces of the refractory brick. This overlapping arrangement requires an excessive amount of metal to encase refractory brick and, thus, increases the cost of producing the furnace block.

The present invention provides a furnace block having a metal casing which is tightly secured to a refractory brick. In the furnace block it is not necessary to use adhesives to insure that the brick will not slip out of its metal casing. Furthermore, it is not necessary that elongated slots be formed in the metal plate which forms the casing of the furnace block to insure that the metal plate is bent at the proper places to conform to the sides of the brick.

The metal casing of the furnace block is formed from a single metal plate which is bent into contact with the exterior surface of the refractory brick. The metal casing as overlapping ends which are mechanically locked together by at least one deformation formed in the overlapping ends. The deformation in the overlapping ends of the metal casing also secures the casing to the refractory brick.

It is therefore a primary object of the present invention to provide an improved furnace block and a method and apparatus for producing this product.

Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention, the objects and advantages being realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

In accordance with the present invention a furnace block includes a brick of refractory material having an exterior surface, and a metal plate conforming to the exterior surface of said brick to provide a metal casing for the brick. The metal plate has opposite ends which overlap on the exterior surface of the brick. In addition, the furnace block of this invention includes securing means for mechanically locking the overlapping ends of the metal plate together and for securing the metal casing to the brick.

In a preferred embodiment of the furnace block of this invention, the refractory brick has an elongated groove formed along its exterior surface, and the opposite ends of the metal plate overlap at the elongated groove. In addition, this preferred embodiment includes a plurality of deformations formed in the overlapping ends of the metal plate for securing the overlapping ends together and for engaging the brick to secure the metal casing to the brick. Alternatively, the overlapping ends of the metal plate can be secured by a plurality of welded connections rather than the deformations.

Another aspect of the present invention is a method of applying a metal plate to a refractory brick. In the method of this invention, the refractory brick itself is used as a male die member in the formation of a metal casing from a single metal plate. The method compensates automatically for variations in the size of the refractory brick and produces a furnace block having a metal casing which is tightly secured to the brick.

In accordance with the present invention, the method includes the steps of positioning the refractory brick on the metal plate at a position intermediate between the ends of the metal plate, bending the portions of the metal plate located on opposite sides of the brick into contact with the sides of the brick, bending the portions of the metal plate which extend above the brick into contact with the top surface of the brick to overlap the ends of the metal plate, and securing the overlapping ends of the metal plate together to provide a metal casing for the brick. In a preferred method, the metal plate is held firmly against the brick during the bending of the metal plate into contact with the sides of the brick, and the bent portions of the metal plate are held firmly against the sides of the brick during the bending of the metal plate into contact with the top surface of the brick. The brick has an elongated groove centrally located on its top surface and a plurality of spaced depressions formed in the elongated groove. The ends of the metal plate are overlapped at the elongated groove, and the ends are punctured to produce a plurality of interlocking deformations in the metal plate which extend into the depressions in the brick and mechanically lock the metal plate to the brick.

A further aspect of the present invention relates to an apparatus for applying a metal plate to a refractory brick. The apparatus operates in accord with the method of the present invention and produces a furnace block having a metal casing which is tightly secured to a refractory brick.

In accordance with the present invention, an apparatus for applying a metal plate to a refractory brick includes a structure providing a female die cavity and means for forcing the bottom surface of the refractory brick against the metal plate and into the female die cavity to bend the metal plate into contact with the sides of the brick. The apparatus also includes means for bending the portions of the metal plate extending above the brick into contact with the upper surface of the brick to overlap the ends of the metal plate. In addition, the apparatus includes means for deforming the overlapping ends of the metal plate to secure the overlapping ends together and to provide a metal casing for the refractory brick.

In a preferred embodiment of the apparatus, means are provided for holding the metal plate against the bottom surface of the brick as the brick and metal plate are forced into the female die cavity and for holding the bent portions of the metal plate against the sides of the brick as the portions of the metal plate extending above the brick are bent into contact with the upper surface of the brick. The preferred embodiment also includes at least one puncturing device mounted for movement into engagement with the overlapping ends of the metal plate for puncturing the overlapping ends to form interlocking metal curls in the plate to secure the ends together.

The accompanying drawings illustrate preferred embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Of the drawings:

FIG. 1 is a perspective view of a furnace block constructed in accord with the principles of this invention including a refractory brick having a metal casing formed from a single metal plate;

FIG. 2 is a partial sectional view of the furnace block taken along line 2—2 of FIG. 1;

FIG. 3 is a perspective view of the first station of an apparatus for applying a metal plate to a refractory brick which operates in accord with the principles of this invention;

FIGS. 4 and 5 are front elevational views of the apparatus of FIG. 3 illustrating the operation of the first station of the apparatus in bending a metal plate into contact with the sides of a refractory brick;

FIGS. 6 and 7 are front elevational views of a second station of the apparatus illustrating the bending of the metal plate into contact with the top surface of the refractory brick; and

FIG. 8 is an enlarged partial sectional view of a pressure applying element and a puncturing device which are located at the second station of the apparatus.

In accordance with the invention, a furnace block includes a brick of refractory material having an exterior surface. FIGS. 1 and 2 illustrate a preferred embodiment of a furnace block constructed according to the principles of this invention. As shown in FIG. 1, furnace block 20 includes a brick 22 of refractory material. The brick of the preferred embodiment is rectangular in shape and has a bottom surface 24, a top surface 26, and sides 28 and 30. In alternative embodiments the brick can have tapered sides, as in the case of a brick of trapezoidal shape, or it can be irregular in shape.

In the preferred embodiment, the brick of refractory material has an elongated groove formed along one of its exterior surfaces. As shown in FIGS. 1 and 2, brick 22 has an elongated groove formed in its top surface 26 and extending in a direction parallel to sides 28 and 30 of the brick. In the case of a rectangular refractory brick, as shown, the elongated groove preferably is centrally located on the top surface of the brick.

Further, in the preferred embodiment a plurality of depressions are formed in the elongated groove on the refractory brick. Referring to FIG. 2, brick 22 has a plurality of depressions 34 (one of which is shown) formed in elongated groove 32 on top surface 26 of the brick. Depressions 34 are preferably spaced uniformly along groove 32.

In accordance with the invention, the furnace block includes a metal plate conforming to the exterior surface of the refractory brick to provide a metal casing for the brick. The metal plate has its opposite ends overlapping on the exterior surface of the brick. As embodied, a metal plate 36 (FIG. 1) is provided which conforms to bottom surface 24, top surface 26, and sides 28 and 30 of refractory brick 22. Metal plate 36 has overlapping ends 38 and 40 which overlap at elongated groove 32 of the refractory brick.

The metal plate of the preferred embodiment is a flat steel plate and it can be embossed to allow for expansion, if desired. The metal plate does not have to be slotted at the corners of the brick to permit the plate to be bent into a casing conforming to the sides of the brick. The preferred embodiment of the furnace block can include a sheet of asbestos material interposed between the refractory brick and metal casing to allow for expansion.

In the preferred embodiment, one end of the metal plate has an offset which is received in the elongated groove of the refractory brick to provide a substantially flat exterior surface for the metal casing at the elongated groove. Referring to FIGS. 1 and 2, end portion 40 of metal plate 36 has an offset portion 42 which is located in elongated groove 32 beneath end 38 of the metal plate. Since offset portion 42 is received in the elongated groove, the upper surfaces of ends 38 and 40 of the metal plate provide a substantially flat exterior surface for the metal casing of the refractory brick.

In accordance with the invention, the furnace block includes securing means for mechanically locking the overlapping ends of the metal plate together and for securing the metal casing to the refractory brick. In the preferred embodiment, the securing means includes at least one deformation formed in the overlapping ends of the metal plate for securing the overlapping ends together and for engaging the brick to secure the metal casing to the brick.

In the embodiment of FIGS. 1 and 2, the deformation comprises a puncture formed in the overlapping ends of the metal plate. FIG. 1 illustrates a plurality of punctures 44 formed in overlapping ends 38 and 40 of metal plate 36.

In FIG. 2, one of the punctures 44 is illustrated in more detail. As shown, ends 38 and 40 of metal plate 36 are punctured, and a portion of the metal from each end of the metal plate is displaced to form interlocking metal curls. The punctured portion of end 38 of the metal plate provides metal curls 46 and 48. Similarly, the punctured portion of offset 42 formed on end 40 of the metal plate provides metal curls 50 and 52 which are in interlocking relationship with the metal curls 46 and 48.

The interlocking metal curls of punctures 44 prevent ends 38 and 40 of the metal plate from separating. Thus, the metal curls secure the ends of the metal plate together to provide a mechanically locked metal casing for refractory brick 22.

In addition, since the metal curls of punctures 44 extend into the corresponding depressions 34 in refractory brick 22, the metal curls engage the refractory brick to secure the metal casing to the brick. In this manner, refractory brick 22 is prevented from sliding out of the metal casing. Thus, adhesives or other separate means are not required to insure that the brick cannot slip from its casing.

In an alternative embodiment, offset portion 42 of the metal plate can be secured to end 38 of the metal plate by welding. In this embodiment, a plurality of welded connections are made between the overlapping portions of the metal plate over elongated groove 32 of the brick to provide a substantially flat exterior surface for the metal casing at the elongated groove.

Considering the apparatus of this invention, a two-station apparatus which forms a metal casing for the refractory brick from a single metal plate is provided. FIGS. 3–5 illustrate the first station of a preferred embodiment of the apparatus, and FIGS. 6 and 7 illustrate its second station.

In accordance with the invention, the apparatus includes a structure providing a female die cavity. In the preferred embodiment, the structure providing the female die cavity includes a first stationary die member and a second die member movable relative to the first stationary member and spaced from the member to provide an opening for receiving the metal plate and refractory brick. The preferred embodiment includes biasing means for urging the second die member toward the first stationary die member.

As embodied, a first station of the apparatus includes a base 54 (FIG. 3) on which a first stationary die member 56 is mounted. In addition, a second die member 58 is slidably mounted on base 54 for movement relative to first die member 56. The biasing means of this embodiment is a spring 60 connected to second die member 58 and to a support 62 mounted on base 54. Spring 60 urges second die member 58 toward first stationary die member 56. The spring normally maintains the second die member in a position such that the space between the die members is less than the width of brick 22.

Stationary die member 56 and movable die member 58 have first chamfered surfaces 64 and 66 (FIG. 4), respectively, and second vertical surfaces 68 and 69. The chamfered surfaces are provided for engaging portions of the metal plate located on opposite sides of the brick to partially bend those portions toward the sides of refractory brick 22. The vertical surfaces are provided for engaging the same portions of metal plate 36 to bend those portions into contact with the sides of the refractory brick. The operation of these surfaces in bending the metal plate is described below.

In accordance with the invention, the apparatus includes means for forcing the refractory brick against the metal plate to move the bottom surface of the brick and the metal plate into the female die cavity to bend the metal plate into contact with the sides of the brick. As embodied, this means includes a pressure applying element 70 (FIGS. 3 and 4) for applying downward pressure to refractory brick 22. Pressure applying element 70 is connected by a frame 71 and a shaft 72 to a suitable operating device, such as a hydraulic cylinder 73. The hydraulic cylinder is supported by a fixed platform 74 which is mounted on a plurality of support rods 75 extending from base 54. A pair of guide rods 76 extend upward from pressure applying element 70 and are slidably received in a pair of openings formed in platform 74.

The hydraulic cylinder has two hydraulic lines 77 and 78 for receiving pressurized fluid from a source (not shown) to operate the hydraulic cylinder. When pressurized fluid is applied to the hydraulic cylinder through hydraulic line 77, the cylinder applies downward forces (indicated by arrow 79) to shaft 73 and pressure applying element 72 to move refractory brick 22 and metal plate 36 into the female die cavity as shown in FIG. 5. When pressurized fluid is applied to the hydraulic cylinder through hydraulic line 78, shaft 72 is raised to its initial position, as shown in FIG. 4.

In a preferred embodiment of the apparatus, means are provided for holding the metal plate against the bottom surface of the refractory brick as the refractory brick and metal plate are forced into the female die cavity. As embodied, this means includes a platform 80 mounted for vertical movement into the female die cavity between stationary die member 56 and movable die member 58. As shown in FIGS. 3 and 4, the platform is normally located in an upwardly extended position relative to the female die cavity. Platform 80 is fixed to the end of a shaft 81 which is mounted for vertical sliding movement through an opening 82 formed in base 54.

In addition, biasing means are included for maintaining the platform in its normally extended position and for applying an increasing force to the platform as the brick and metal plate are moved into the female die cavity to hold the metal plate firmly against the bottom surface of the brick. As shown in FIG. 4, platform 80 and shaft 81 are biased into a normally raised position, relative to base 54, by a tension spring 84 secured at one end to shaft 81 and at its other end to base 54.

When platform 80 and shaft 81 are moved downward by the forces applied to shaft 72 and pressure applying element 70, tension spring 84 exerts an increasing upward force indicated by arrow 86 (FIG. 5) on shaft 81 and platform 80 to hold metal plate 36 firmly against the bottom surface of refractory brick 22.

In accordance with the invention, the apparatus also includes means for bending the portions of the metal plate extending above the refractory brick into contact with the upper surface of the brick to overlap the ends of the metal plate. In the preferred embodiment, this means includes a first pivot arm for engaging one portion of the metal plate to partially bend that portion toward the upper surface of the brick and a second pivot arm for engaging the other portion of the metal plate to partially bend that other portion toward the upper surface of the brick. In addition, this means includes a pressure plate movable into engagement with the partially bent portions of the metal plate for bending those portions into contact with the upper surface of the brick.

As embodied, a second station of the apparatus (FIG. 6) includes a first pivot arm 88 pivotally mounted by a pin 90 on a support arm 92 fixed to a block 94. Block 94 is mounted in a stationary position on a base 96. A second pivot arm 98 is pivotally connected by a pin 100 to a support arm 102 fixed to a block 104. Block 104 is slidably mounted on base 96 for movement relative to block 94. A tapered camming surface 105 is formed on block 104. The camming surface cooperates with a pair of vertically movable cams, described below, to move block 104 relative to block 94, as indicated by arrow 103.

Referring to FIG. 6, the apparatus includes a pressure plate 106 attached to a block 108 by a pair of stripped bolts 109. The bolts are secured to block 108 by a pair of stripped bolts 109. The bolts are secured to block 108 and are received in oversize openings formed in pressure plate 106. A pair of coil springs 110 are located on bolts 109 between block 108 and pressure plate 106. Block 108 is mounted on an operating platform 111 which is slidably mounted on guide rods 112 extending from base 96 for vertical movement relative to the base.

Platform 111 is connected by a shaft 113 to a suitable operating device, such as a hydraulic cylinder 114. The hydraulic cylinder is mounted on a platform 115 which is fixed to the upper ends of guide rods 112. Hydraulic cylinder 114 is operated by pressurized fluid supplied through a pair of hydraulic lines (not shown). When pressurized fluid is applied to the hydraulic cylinder through one of the hydraulic lines, the cylinder applies downward forces to shaft 113 to move platform 111 and pressure plate 106 downward, as indicate; by arrow 117. When pressurized fluid is applied to the hydraulic cylinder through the other hydraulic line, shaft 113 is raised to its initial position, as shown in FIG. 6.

The preferred embodiment of the apparatus includes a pair of cams 119, one of which is shown in FIG. 6, mounted on platform 115. Each cam 119 has a tapered camming surface 121 for engaging camming surface 105 of block 104 to move that block toward stationary block 94. The cams are moved vertically downward when hydraulic cylinder 114 is operated to move platform 111 in a downward direction. A pair of openings 123 are formed in base 96 for receiving cams 119 during their downward movement A spring-biased backup block 125 is provided for urging the cams toward block 104.

Further, in accordance with the invention the apparatus includes means for deforming the overlapping ends of the metal plate to secure the overlapping ends together and to provide a metal casing for the refractory brick. In the preferred embodiment, this means includes at least one puncturing device mounted for movement into engagement with the overlapping ends of the metal plate for puncturing the overlapping ends to from interlocking metal curls in the metal plate to secure the ends together.

As embodied, a puncturing device 116 (FIG. 6) is secured in an opening formed in block 108. As shown in FIG. 8, the puncturing device has a pointed tip 118 which is normally located in an opening formed in pressure plate 106 when platform 111 is in its raised position (FIG. 6).

When platform 111 is moved downward to bring pressure plate 106 into engagement with the ends of metal plate 36, the pointed tip 118 of puncturing device 116 is exposed to the overlapping ends of the metal plate, as the pressure plate is moved upward relative to block 108 and against springs 110. The tip 118 of the puncturing device is thus allowed to puncture the overlapping ends of the metal plate to form interlocking curls in the metal plate, as shown in FIG. 2.

If it is desired to puncture the overlapping ends of the metal plate at more than one location, the apparatus can be provided with additional puncturing devices similar to puncturing device 116. The puncturing devices can be mounted in spaced openings formed in block 108 to produce a set of punctures 44, as illustrated in FIG. 1.

In an alternative embodiment of the apparatus, the puncturing devices of the second station can be replaced by a plurality of welding heads. In the operation of this apparatus, the overlapping ends of metal plate 36 are joined together by a plurality of welded connections to secure the metal plate to refractory brick 22.

In the preferred embodiment of the apparatus of this invention, clamping means are provided for holding the bent portions of the metal plate against the sides of the refractory brick as the portions of the metal plate extending above the brick are bent into contact with the upper surface of the brick. As embodied, this clamping means comprises a pair of pressure blocks for engaging the bent portions of the metal plate on opposite sides of the refractory brick to hold the bent portions against the sides of the brick.

Referring to FIG. 6, a first pressure block 120 is mounted by a pair of springs 122 and a lever 123 on block 94. Lever 123 is pivotally attached to pressure block 120 and has an elongated slot 124 for receiving a pivot pin projecting from block 94. The lever is provided for guiding the movement of pressure block 120 relative to block 94. Block 94 has a cutout portion 125 for receiving pressure block 120.

In addition, a second pressure block 126 is mounted by a pair of springs 128 and a lever 129 to block 104. Lever 129 is pivotally attached to pressure block 126 and has a elongated slot 130 for receiving a pivot pin projecting from block 104. The lever is provided for guiding the movement of pressure block 126 relative to block 104. Block 104 has a cutout portion 131 for receiving pressure block 126.

As shown in FIG. 6, springs 128 normally maintain pressure block 126 out of engagement with cutout portion 131 of block 104. Similarly, springs 122 normally maintain pressure block 120 out of engagement with cutout portion 125 of block 94.

The preferred embodiment of the apparatus also includes guide means for locating the metal plate in a predetermined position relative to the female die cavity. Referring to FIGS. 3 and 4, the guide means is provided by a set of positioning pins 132, 134, and 136 projecting vertically from a plate 138 mounted on the side of stationary die member 56. Positioning pins 132 and 134 contact the edge of end 38 of metal plate 36, and positioning pin 136 contacts the back edge of metal plate 36 to locate the metal plate in a predetermined position relative to the female die cavity provided by stationary die member 56 and movable die member 58.

The method of the present invention can be understood by considering the operation of the apparatus illustrated in FIGS. 4–7. In the method of applying the metal plate to the refractory brick, portions of the metal plate are bent into contact with the exterior surfaces of the brick while holding other portions of the metal plate firmly against the brick to provide a furnace block with a metal casing which is tightly secured to the refractory brick.

In accordance with the method, the refractory brick is positioned on the metal plate at a position intermediate between the ends of the metal plate. Referring to FIG. 4, at the first station of the apparatus metal plate 36 is positioned on the upper surfaces of die members 56 and 58, support 62, and platform 78 with its edges in contact with positioning pins 132, 134, and 136. Refractory brick 22 is then centrally positioned on metal plate 36 so that ends 38 and 40 of the metal plate extend from opposite sides of the refractory brick.

As mentioned above, it may be desirable to provide a sheet of asbestos material between the brick and the casing formed from the metal plate. In this instance, a flat sheet of asbestos (not shown) is placed on metal plate 36 adjacent to brick 22 on the plate.

In accordance with the method, the portions of the metal plate located on opposite sides of the refractory brick are bent into contact with the sides of the brick. Referring to FIGS. 3 and 4, pressurized fluid is supplied to hydraulic cylinder 73 through hydraulic line 77, and a downward force indicated by arrow 79 is applied to shaft 72. The shaft transmits the downward force to pressure applying element 70. The pressure applying element thus exerts a downward pressure on refractory brick 22 which forces the refractory brick, the metal plate, and platform 80 downward against the tension of spring 84.

As the refractory brick, metal plate, and platform 80 are moved downward, metal plate 36 and refractory brick 22 are moved into the female die cavity in the space between die members 56 and 58. Metal plate 36 first engages chamfered surfaces 64 and 66 (FIG. 4) of the die member, and ends 38 and 40 of the metal plate are partially bent toward an upward position.

During continued movement of refractory brick 22 and metal plate 36 into the female die cavity, movable die member 58 is moved against spring 60 to expand the size of the female die cavity to allow the brick and metal plate to move downward between die members 56 and 58. As the brick and metal plate move downward between the die members, the metal plate is bent into a U-shaped configuration conforming to the bottom surface and sides of the refractory brick. Since movable die member 58 is biased toward stationary die member 56 by spring 60, the metal plate is bent into a tightly fitting relationship with the refractory brick.

Platform 80, under the action of tension spring 84, holds metal plate 36 firmly against the bottom surface of the refractory brick during the bending of the metal plate into contact with the sides of the brick. As platform 80 moves downward, the force applied by tension spring 84 to hold the metal plate against the brick increases gradually. The operation of platform 80 and die members 56 and 58 insures that the metal plate is formed into a tightly fitting metal casing for the refractory brick. Then pressurized fluid is supplied to hydraulic cylinder 73 through hydraulic line 78 to return shaft 72 and pressure applying element 70 to their initial positions (FIG. 4).

After metal plate 36 is bent into a U-shaped configuration conforming to the bottom surface and sides of refractory brick 22, the partially formed brick and plate assembly is moved to the second station (FIG. 6) of the apparatus. At the second station, the bending of the metal plate into contact with the refractory brick is completed.

In accordance with the method, the portions of the metal plate which extend above the refractory brick are bent into contact with the top surface of the brick to overlap the ends of the metal plate. Referring to FIG. 6, at the second station of the apparatus of this invention, the partially formed metal plate and refractory brick assembly is positioned between blocks **94** and **104**. Hydraulic cylinder **114** is operated to move platform **111** downward, as indicated by arrow **117**. Initially, camming surfaces **121** of cams **119** act against camming surface **105** of block **104** to move the block toward stationary block **94**, as indicated by arrow **103**.

As block **104** is moved toward block **94**, pressure block **126** and the extended end of pivot arm **98** are moved into contact with the upwardly bent portion of plate **36** on the right side of refractory brick **22**, as viewed in FIG. **6**. As the movement of block **104** continues, the refractory brick and U-shaped metal plate are moved to the left until the opposite upwardly bent portion of metal plate **36** engages pressure block **120** and the extended end of pivot arm **88**.

At this time, the leftward force applied to movable block **104** is transmitted to metal plate **26** by pivot arm **98**. This force partially bends end **40** of the metal plate toward the top surface of refractory brick **22**, as indicated by arrow **140** (FIG. **7**). At the same time, pressure block **126** exerts a clamping force on the metal plate to hold the metal plate against the right side of refractory brick **22** during the partial bending of end **40** of the metal plate.

A similar force is applied to the opposite upwardly bent portion of metal plate **36** by pivot arm **88**. This force partially bends end **38** of the metal plate toward the top surface of refractory brick, as indicated by arrow **142**. At the same time, pressure block **120** exerts a clamping force on the metal plate to hold it firmly against the left side of refractory brick **22** during the partial bending of end **38** of the metal plate.

After both ends **38** and **40** are partially bent toward the top surface of refractory brick **22**, continued downward movement of platform **111** results in pressure plate **106** moving into engagement with end **38** of the metal plate. After pressure plate **106** engages this end of the metal plate, further downward movement of platform **111** causes the pressure plate to bend ends **38** and **40** of the metal plate into contact with the top surface of refractory brick **22**.

During the final bending of ends **38** and **40** of the metal plate, offset portion **42** of end **40** of the metal plate is first moved into the elongated groove formed in the top surface of the refractory brick (FIG. **7**). End **38** of the metal plate is moved downward into an overlapping relationship with offset portion **42** of the metal plate. It should be noted that metal plate **36** is firmly held against the sides of refractory brick **22** by pressure blocks **120** and **126** during the completion of the bending of its ends **38** and **40**.

Finally, in accordance with the method, the overlapping ends of the metal plate are secured together to provide a metal casing for the brick. In a preferred method, the overlapping ends of the metal plate are deformed to produce a plurality of deformations in the metal plate which mechanically lock the ends of the plate together. As embodied, the deformations are produced by puncturing the overlapping ends of the metal plate to form interlocking metal curls in the metal plate to mechanically lock the ends of the plate together. As explained above, the metal curls also secure the metal casing to the refractory brick.

Referring to FIG. **7**, as ends **38** and **40** of the metal plate are bent into contact with the top surface of refractory brick **22**, pressure plate **106** is moved upward relative to block **108** and against springs **110** to expose pointed tip **118** of puncturing device **116** to the overlapping ends of the metal plate. Under the action of the downward forces applied to platform **111** by hydraulic cylinder **114**, the pointed tip of the puncturing device pierces the overlapping ends of the metal plate and deforms the metal of the overlapping ends into the depression **34** formed in the refractory brick.

As shown in FIG. **2**, the deformation formed in the metal plate comprises interlocking metal curls which extend into depression **34**. Curls **46** and **48** are formed from the deformed metal of end **38** of the metal plate, and curls **50** and **52** are formed from the deformed metal of offset portion **42** of end **40** of the metal plate. The curls are interlocking to provide a mechanically locked metal casing for the refractory brick. In addition, since the metal curls extend into the depressions formed in the refractory brick, the curls also secure the metal casing to the refractory brick and prevent the brick from slipping out of its metal casing during handling.

As explained above, the apparatus of this invention can be provided with a plurality of puncturing devices **116**, if it is desired to puncture the overlapping ends of the metal plate at more than one location. Thus, a plurality of punctures can be formed in the overlapping ends of the metal plate at uniformly spaced positions to produce a furnace block having a tightly fitting metal casing, as shown in FIG. 1

In the operation of the alternative embodiment of the apparatus in which the second station includes welding heads rather than puncturing devices, the overlapping ends of the metal plate are secured together by welded connections.

In the preferred method of this invention, the refractory brick includes an elongated groove formed along its top surface and a plurality of depressions formed in the elongated groove to receive the deformed metal curls of the punctured portions of the overlapping ends of the metal plate. The preferred method of the present invention can be modified, however, to produce the desired furnace block from a refractory brick which does not contain such a groove and depressions, if desired. The modified method includes the steps of: (1) forming an elongated groove extending along the top surface of the brick; and (2) forming a plurality of depressions in the elongated groove.

In addition, if the metal plate used to form the metal casing for the refractory brick does not have a preformed offset at one of its ends, the method of the present invention can include the step of forming an offset along one end of the metal plate to be received in the elongated groove of the refractory brick when the metal plate is bent into contact with the top surface of the brick.

Further, the apparatus of this invention can be modified to produce a metal casing for a refractory brick which is not rectangular in shape in accord with the principles of the invention. In this instance, the die members of the apparatus can be shaped to conform to the exterior surface of the brick.

The present invention thus provides a furnace block including a refractory brick having a metal casing which is tightly secured to the brick. The metal casing is formed from a single metal plate having overlapping ends which are mechanically locked together. The metal plate is also mechanically secured to the brick. The method and apparatus of the invention provide automatic compensation for the non-uniform size of the refractory brick to which the metal casing is applied. The compensation is achieved automatically by using the refractory brick as a male die member in the method of this invention. As a result, the furnace block produced by the method and apparatus of this invention has a tightly fitting metal casing.

The invention in its broader aspects is not limited to the specific details shown and described, and modifications may be made in the details of the disclosed embodiments without departing from the principles of the present invention.

What is claimed is:

1. A method of applying a metal plate to a refractory brick having an elongated groove extending along a top surface, which comprises:
forming an offset along one end of the metal plate to be received in the elongated groove;
forming a plurality of depressions in the refractory brick at spaced locations in the elongated groove;
positioning the brick on the metal plate with its bottom surface at a position intermediate between the ends of the metal plate;
bending the portions of the metal plate located on opposite sides of the brick into contact with the sides of the brick;
bending the portions of the metal plate which extend above the brick into contact with the top surface of the brick to move the offset into the groove and overlap the ends of the metal plate; and
forming a plurality of deformations in the overlapping ends of the metal plate extending into the depressions to mechanically lock the ends of the metal plate together and provide a metal casing for the brick.

2. The method of claim 1, which includes:
holding the metal plate firmly against the brick during the bending of the metal plate into contact with the sides of the brick; and
holding the bent portions of the metal plate firmly against the sides of the brick during the bending of the metal plate into contact with the top surface of the brick.

3. A method of forming a metal casing for a refractory brick provided with an elongated groove extending along a top surface from a metal plate, which comprises:
forming an offset along one end of the metal plate to be received in the elongated groove;
forming a plurality of depressions in the refractory brick at spaced locations in the groove;
forcing the bottom surface of the brick as a male die against the metal plate and into a female die cavity to bend the metal plate into contact with the sides of the brick;
bending the ends of the metal plate which extend above the top surface of the brick into contact with said top surface to move the offset into the groove and overlap the ends of the metal plate; and
forming a plurality of deformations in the overlapping ends of the metal plate extending into the depressions to mechanically lock the ends together to provide a metal casing for the brick.

4. The method of claim 3, wherein the overlapping ends of the metal plate are secured by:
deforming the overlapping ends of the metal plate to produce a plurality of deformations in the metal plate to mechanically lock the ends of the plate together.

5. The method of claim 1, wherein the step of forming a plurality of deformations in the overlapping ends of the metal plate is performed by:
puncturing the overlapping ends of the metal plate to form interlocking metal curls in the metal plate extending into the depressions to mechanically lock the ends together and to secure the plate to the brick.

6. The method of claim 3, which includes:
forming an elongated groove extending along the top surface of the brick; and
forming an offset along one end of the metal plate to be received in the elongated groove of the brick when the metal plate is bent into contact with the top surface of the brick.

7. The method of claim 6, which includes:
forming a plurality of depressions in the elongated groove of the brick; and
deforming the overlapping ends of the metal plate to produce a plurality of deformations in the metal plate which extend into the depressions in the brick and mechanically lock the metal plate to the brick.

8. The method of claim 7, wherein the step of deforming the overlapping ends of the metal plate is performed by:
puncturing the overlapping ends of the metal plate at a plurality of spaced locations corresponding to the depressions in the brick to form interlocking metal curls in the overlapping ends which extend into the depressions to mechanically lock the overlapping ends together and to secure the metal plate to the brick.

9. The method of claim 3, which includes:
holding the metal plate firmly against the bottom surface of the brick during the movement of the metal plate and brick into the female die cavity and the bending of the metal plate into contact with the sides of the brick; and
holding the bent portions of the metal plate firmly against the sides of the brick during the bending of the metal plate into contact with the top surface of the brick.

10. A method of encasing a refractory brick in a metal casing, which comprises:
forming an elongated groove along one surface of the refractory brick;
forming a plurality of depressions in the refractory brick at spaced locations in the elongated groove;
forming an offset along one end of a metal plate to be received in the elongated groove formed in the brick;
positioning the surface of the brick opposite to the elongated groove at the center of the metal plate;

bending the portions of the metal plate located on opposite sides of the brick into contact with the sides of the brick to provide a U-shaped plate about the brick;

bending the portions of the metal plate which extend above the brick surface having the elongated groove formed therein into contact with that surface to move the offset into the groove and to overlap the other end of the metal plate with the offset; and

deforming the overlapping ends of the metal plate at locations corresponding to the depressions in the groove to form a plurality of deformations which extend into the depressions to secure the ends of the plate together and to lock the plate to the brick to provide a metal casing for the brick.

11. The method of claim 10, wherein the step of deforming the overlapping ends of the metal plate is performed by:

puncturing the overlapping ends of the metal plate at a plurality of spaced locations corresponding to the depressions in the brick to form interlocking metal curls in the overlapping ends which extend into the depressions to mechanically lock the overlapping ends together and to secure the metal plate to the brick.

12. A method of applying a metal plate having an offset formed along one edge of the plate to a refractory brick having an elongated groove extending along a top surface and a plurality of depressions formed at spaced locations in the groove, which comprises:

positioning the brick with its bottom surface at a position intermediate between the ends of the metal plate;

bending the portions of the metal plate located on opposite sides of the brick into contact with the sides of the brick;

bending the portions of the metal plate which extend above the brick into contact with the top surface of the brick to move the offset into the groove and overlap the ends of the metal plate; and

deforming the overlapping ends of the metal plate at locations corresponding to the depressions in the groove to form a plurality of deformations which extend into the depressions to secure the ends of the plate together and to lock the plate to the brick to provide a metal casing for the brick.

13. The method of claim 12, wherein the step of deforming the overlapping ends of the metal plate is performed by:

puncturing the overlapping ends of the metal plate to form interlocking metal curls in the metal plate extending into depressions to mechanically lock the ends together and to secure the plate to the brick.

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