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REFRACTORY ROOF

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Fig. 1.

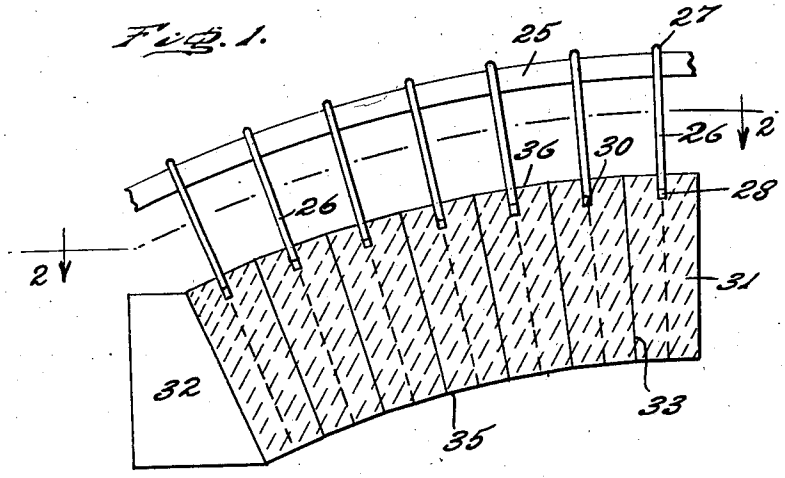


Fig. 2.

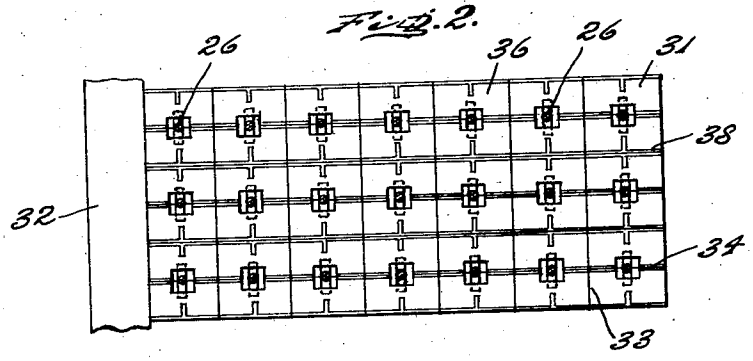
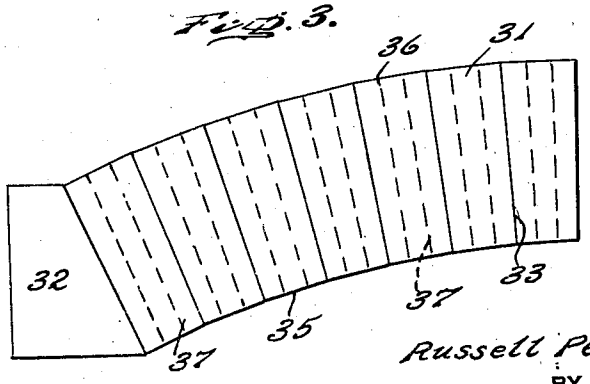


Fig. 3.



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Fig. 4.

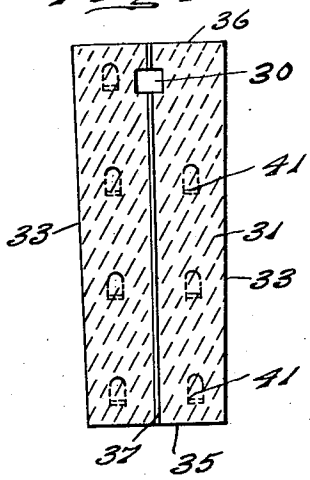


Fig. 7.

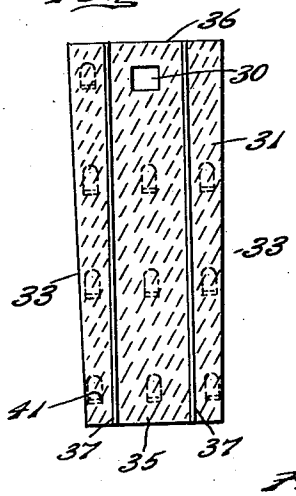


Fig. 10.

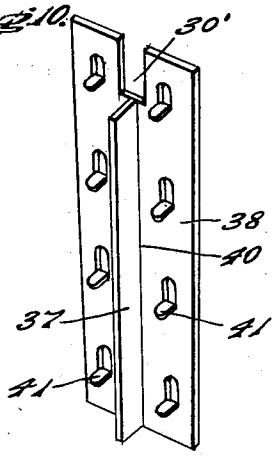


Fig. 6.

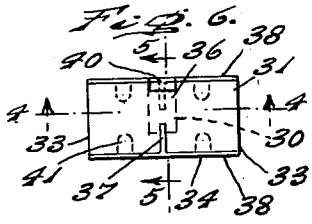


Fig. 9.

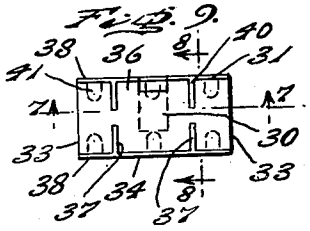


Fig. 11.

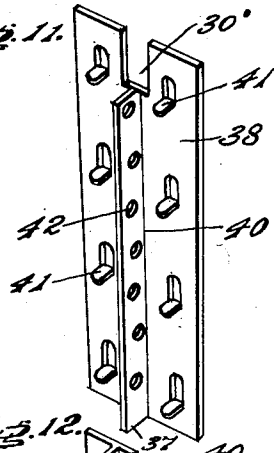


Fig. 5.

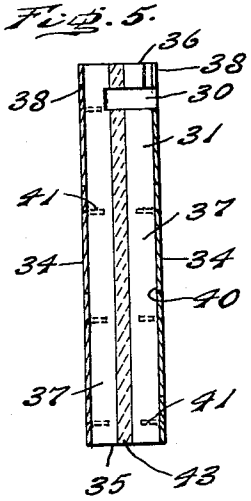


Fig. 8.

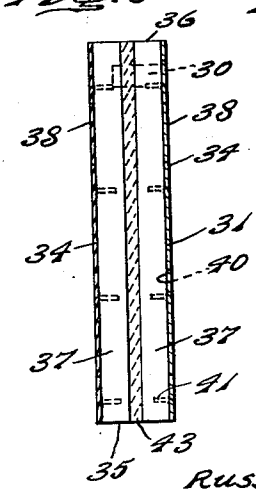
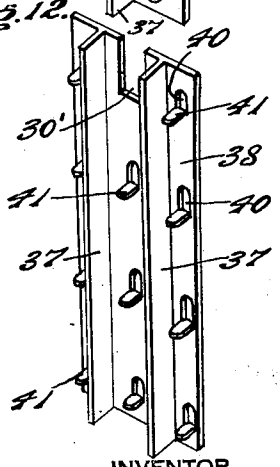


Fig. 12.



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Fig. 15.

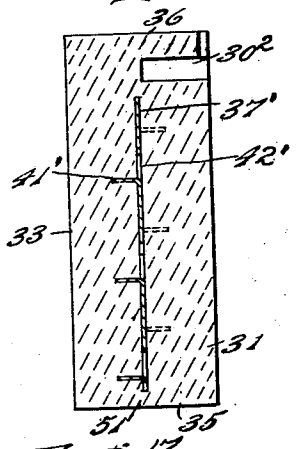


Fig. 18.

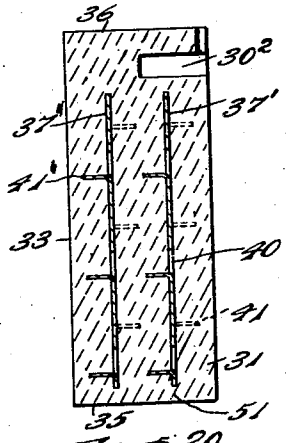


Fig. 21.

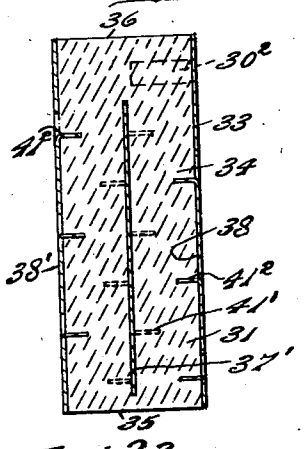


Fig. 17.

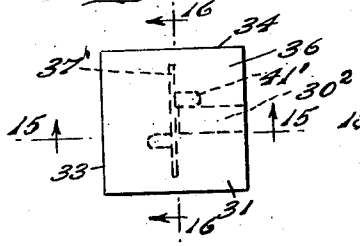


Fig. 20.

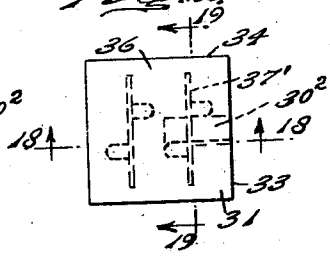


Fig. 23.

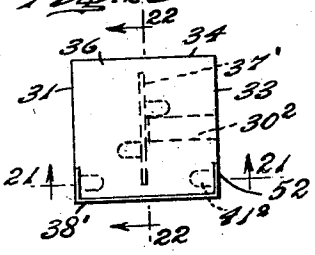


Fig. 16.

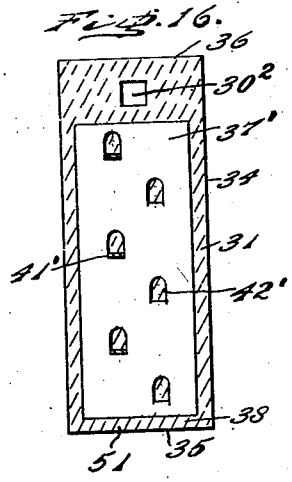


Fig. 19.

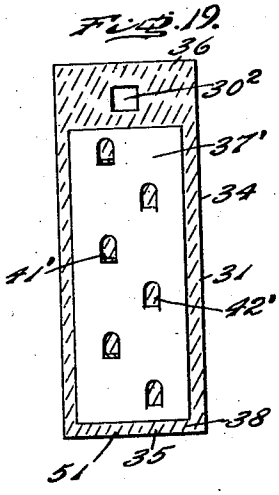
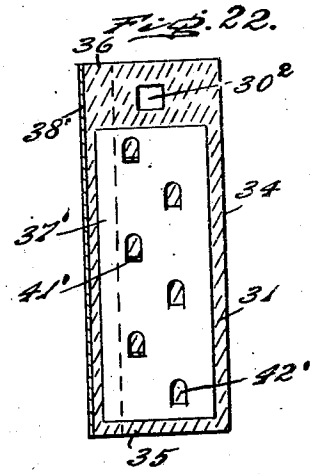


Fig. 22.



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Fig. 25.

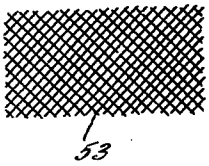


Fig. 24.

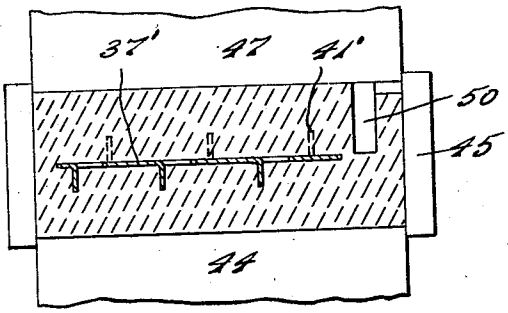


Fig. 13.

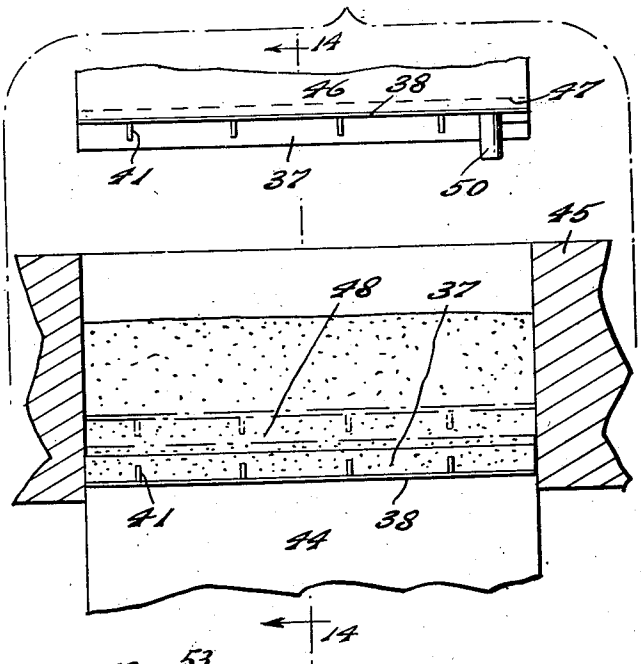
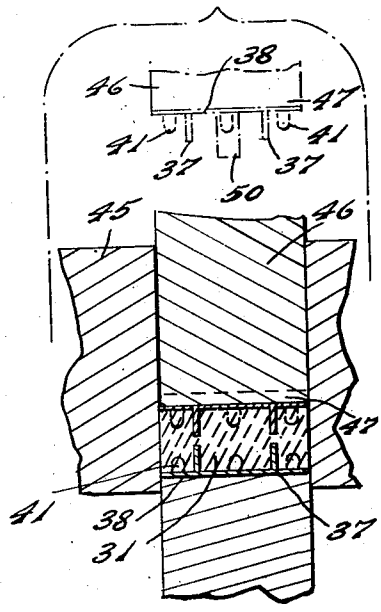


Fig. 14.



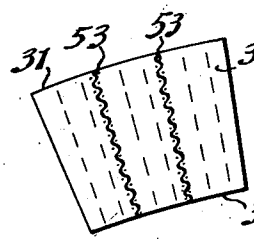


Fig. 25a.

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United States Patent Office 2,799,233 Patented July 16, 1957

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REFRACTORY ROOF

Russell Pearce Heuer, Villanova, Pa., assignor to General Refractories Company, a corporation of Pennsylvania

Application July 31, 1952, Serial No. 301,942

7 Claims. (Cl. 110—99)

The present invention relates to refractory roofs of the character employed in metallurgical furnaces such as open hearth steel furnaces, copper refining furnaces, and the like.

A purpose of the invention is to reduce the pronounced tendency of basic refractory roof brick to spall parallel to the hot face.

A further purpose is to construct a basic refractory roof with bricks which are provided with comolded metallic plates to reduce spalling and at the same time avoid dimensional growth of the brick due to oxidation of the metallic plates which may cause undesirable changes in the dimension of the arch and non-uniform distribution of the arch stresses.

A further purpose is to employ internal oxidizable metallic plates which are comolded into the brick and extend over a major portion of the longitudinal dimension.

A further purpose is to dispose the internal plates substantially radially in a curved arch.

A further purpose is to provide holes in the internal plates through which plugs of refractory can extend and join to unite the brick together from the opposite sides of the plates.

A further purpose is to comold the internal plates in the brick and provide tabs or other projections from one or preferably both faces of the plates which are united in the basic refractory by comolding.

A further purpose is to dispose the internal plates substantially radially in a curved arch together with external plates in the transverse joints of the roof placing the external plates on the brick by comolding or by introducing the plates at the time of assembly.

A further purpose is to comold a refractory roof brick with internal and external plates by disposing the internal plates in the direction of the pressing motion and the external plates at a right angle to the direction of motion.

A further purpose is to comold a refractory brick with two external plates and two or more internal plates disposed at a right angle thereto, each of the external plates being in pressing contact with at least one internal plate.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate a few only of the numerous embodiments in which my invention may appear, selecting the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figure 1 is a fragmentary diagrammatic section transversely of a roof arch according to the invention.

Figure 2 is a fragmentary section in the position indicated by the line 2—2 of Figure 1, substantially in plan.

Figure 3 is a fragmentary diagrammatic vertical section in the transverse direction through a modified arch of the invention.

Figure 4 is a central section through a brick according to the invention, the section being taken on the line 4—4 of Figure 6.

Figure 5 is a section on the line 5—5 of Figure 6.

Figure 6 is a top plan view of the brick of Figures 4 and 5.

Figure 7 is a section on the line 7—7 of Figure 9 showing a variant form of brick according to the invention.

Figure 8 is a section on the line 8—8 of Figure 9 of the brick of Figure 7.

Figure 9 is a top plan view of the brick of Figures 7 and 8.

Figure 10 is a perspective of a plate assembly as used in Figures 4 to 6.

Figures 11 and 12 are perspectives of modified plate assemblies.

Figure 13 is a diagrammatic vertical longitudinal section showing the molding of a brick according to Figures 1 to 9, with the dies separated.

Figure 14 is a section of Figure 13 on the line 14—14, showing the dies in brick compression position, but with the dies shown separated in dot-and-dash lines.

Figure 15 is a section on the line 15—15 of Figure 17, showing a variant brick in accordance with the invention.

Figure 16 is a section of the brick of Figure 15 on the line 16—16 of Figure 17.

Figure 17 is a top plan view of the brick of Figures 15 and 16.

Figure 18 is a section of a variant brick according to the invention, the section being taken on the line 18—18 of Figure 20.

Figure 19 is a section of the brick of Figure 18 on the line 19—19 of Figure 20.

Figure 20 is a top plan view of the brick of Figures 18 and 19.

Figure 21 is a section of a further variation in the brick of the invention, the section being taken on the line 21—21 of Figure 23.

Figure 22 is a section of the brick of Figure 21 on the line 22—22 of Figure 23.

Figure 23 is a top plan view of the brick of Figures 21 and 22.

Figure 24 is a vertical longitudinal section showing the molding of a brick according to Figures 15 to 23 inclusive.

Figure 25 shows in elevation iron or steel wire mesh which in some cases is interposed in the radial joints.

Figure 25*a* is a fragmentary view similar to Figure 3, showing the placement of the gauze of Figure 25 between the radial faces of the refractory brick.

Describing in illustration but not in limitation and referring to the drawings:

Basic refractory brick have been employed in roof construction with oxidizable metallic spacer plates applied on all faces. As the furnace continues in service, the metal of the spacer plate, which is usually iron or steel, oxidizes, and the iron oxide reacts with the basic refractory of the brick at either side, which is usually of chromite, magnesia or a mixture of the two predominating in either of the components. This tends to integrate the roof together, preventing leakage of gases at the joints, preventing infiltration of air, and reducing the tendency of the brick to crack and spall.

The metallic spacer plates in the joints have one objection in that the oxidation which occurs in service increases the thickness of the plates by 100 percent or more. Furthermore, the oxidation is not uniform throughout the length of the brick since it is practically negligible at the cold face and increases with increasing distance toward the hot face. This non-uniform degree of oxidation causes non-uniform dimensional changes in the brick which localizes the strains in a curved arch

and concentrates them at or near points where oxidation has been the greatest.

Difficulty has been encountered in sprung arches and in combined sprung arches and suspended roofs due to the tendency of the arch to elongate in the direction of the arc when the plates oxidize at the radial joints. This develops a comparatively high and localized pressure in the direction of the arc, subjecting the brick to high compression forces which may cause failure or cracking.

The basic refractory brick of the character which have previously been used with oxidizable metallic plates on the lateral faces have shown a tendency to spall along a line parallel to the hot face and at a distance of one to three inches from it.

I have discovered that if an oxidizable metallic plate is comolded in the interior of the basic brick containing at least 10 percent of magnesia, and extends longitudinally of the brick throughout the major portion of the length of the brick, a wholly different and more advantageous behavior occurs. As the plate oxidizes, instead of growing and increasing the over-all dimension of the brick in the direction of the arc, the plate which is buried in the brick by comolding does not cause any overall dimensional change. It appears that the iron oxide formed by the oxidation of the plate reacts with the basic ingredients of the refractory, for example with the magnesia present in the refractory, to form magnesioferrite, which diffuses into the refractory without causing a volume change. The same thing occurs in a brick of chromite where the magnesia content exceeds 10 percent by weight.

I have also discovered that the oxidizable metallic spacer plate which extends throughout the interior of the brick exerts a pronounced tendency to prevent spalling off of the hot ends of the brick. This would appear to be due to the fact that the magnesioferrite is highly refractory and tends to create a strengthening rib running lengthwise through the brick, and also the magnesioferrite tends to break up the force distribution and prevent crack propagation across from one side to the other of the magnesioferrite band.

By avoiding spacer plates on the radial joints while providing buried oxidizable metallic spacer plates in the bricks, the build-up of excessive arcuate dimensional changes and pressures is avoided, and spalling adjoining the hot face is greatly reduced.

To be most effective the buried plate should extend almost to the hot face or preferably to a distance not in excess of one inch from it. It is less important that the plate extend to the cold end, although it is desirable to extend to a position close to the cold end.

The number of plates which are buried in the interior of the brick by comolding may vary. In some cases a single plate is sufficient, although in other cases two or more plates extending in the longitudinal direction will be used.

It is possible to provide openings at intervals along the plates and to permit plugs of refractory to extend through the openings and join, thus strengthening the brick across the plate prior to the time when it oxidizes in use.

It is also possible to provide tabs or projections suitably lanced from the plate which are imbedded in the brick by comolding. These tabs preferably extend from the opposite faces and suitably at the openings.

While plates are eliminated at the joints between the brick in the radial direction, plates are desirably used on the joints in the transverse direction. The increase in dimension in this case does not matter as it merely lengthens the roof and does not create excessive localized stresses or force the skewback supports apart. The plates on the transverse faces are conveniently comolded with the brick, although they will in some cases be assembled to the brick when the roof is made. The plates which are comolded on the transverse faces perform the desirable function of strengthening the brick during shipment.

Considering now the arch as shown in Figures 1 and 2, I there illustrate a suitably arch shaped overhead steel supporting member **25** running in the arc direction, and receiving and supporting at intervals T-shaped hangers **26** having hooked upper ends **27** engaged over the supporting element, and having opposed projections **28** at the lower ends which are received within hanger openings **30** of the respective brick of any character well known in the art. It is immaterial from the standpoint of the present invention whether the hanger recesses **30** are of the character which are entirely formed of refractory, entirely formed of metal imbedded in the refractory, or formed of a combination of the two.

Basic refractory roof brick **31** suspended from the hangers are also partially supported by skewbacks **32** as well known (only one skewback is shown). The skewbacks are conveniently backed up by springs as is well known (not shown).

Each of the brick **31** has radial faces **33**, transverse faces **34**, hot ends **35**, and cold ends **36**. The brick may be wedge shaped as shown in Figures 1 to 9, or rectangular as shown in Figures 15 to 23.

Extending preferably in the radial direction through the basic refractory brick and imbedded or buried therein by comolding with the refractory is an oxidizable metallic plate **37**. When a single plate is used it is preferably located in the middle. The plate (or pairs of aligned plates) preferably extends over the major portion of the length and width of the brick and is in no respect comparable with separate wires or a mere screen mesh. The plate extends desirably to about one inch from the hot end, and this distance should not exceed 5 inches. The plate **37** will normally extend to the hanger socket which is adjacent the cold end and will where required to be cut out to avoid the hanger.

The plates **37** are of any suitable oxidizable metal, preferably low alloy or plain carbon steel, but permissibly also stainless steel. The plate thickness will normally be less than ¼ inch and preferably between 1/16 and 3/16 inch.

In the preferred embodiment the internal plates are comolded with the refractory. External plates **38** are provided on those faces of the brick which are placed in the transverse joints. The external plates cover approximately the full width of the brick and the preponderance of the distance between the hot face and the cold face. The internal plates are preferably sheared longitudinally into two approximately equal pieces. One piece is welded or mechanically affixed at **40** in a vertical position to one of the external plates **38** and the other piece is affixed in a counterpart position to the other external plate. Preferably two internal plates are attached to each external plate. A hole **30'** in the external plate at one side connects with the hanger opening. The external plates are preferably the same material as the internal plates, their thickness being between 1/32" and 3/16". Instead of a welded assembly of the internal and external plates, it is also desirable in some cases to use a single plate formed to provide an external portion and an internal portion disposed at a right angle to each other.

When the molding operation is effected one external plate with preferably attached internal plate or plates protruding upward, is placed in the bottom of the mold and the refractory mixture is placed on top of it in the mold. The other external plate with its internal plate or plates protruding downward is placed in the top of the mold or affixed to the top die of the molding press. The pressing operation is completed by pressing upon the external plates to comold the refractory to the plates. In order to permanently affix the external plates, tabs **41** may be punched from the external plates to engage and comold with the molded refractory. Inasmuch as no plates appear in the radial joints, the internally molded plates can be placed approximately radial and so located in the back that in the assembled roof the distance be-

tween the internal plates in the direction across the arch of the furnace is approximately uniform.

It is not necessary that the external plates be placed perpendicular to the internal plates. Internal plates can be placed in a position at right angles to movement of the molding die and parallel to the external plates if any are present. In such case the external plates would be placed in the mold first, then part of the refractory mixture, then an internal plate, then more refractory mixture, etc. until the desired number of plates have been included in the mold with the final external plate on the top. This molding procedure is not so easily effected as the molding process with vertical internal plates, nevertheless, the brick is quite suitable for the purpose.

Each internal plate may have distributed at intervals over its area holes **42** (Figure 11) which receive plugs of refractory which joins across between the holes as the plate is molded by pressure applied between the radial faces **33**. The plugs of refractory tend to integrate together the refractory brick on the two sides of the plate prior to the oxidizing of the plate. The area of the holes in total should not exceed 20 percent of the area of the plate.

The internal plate may also have tabs or projections **41'** extending out from one and preferably from both sides, and united to the refractory by comolding. As shown in Figures 15 to 25, projections **41'** are suitably formed by lancing from the plate. The projections are suitably staggered, at one hole extending in one direction and at the next hole extending in the other direction or from one side of a hole extending in one direction and from the other side extending in the other direction.

While the employment of the projections **41'** is desirable, holes where desired will be used without projections.

It is preferable to employ two or more plates **37** extending in a longitudinal direction and in the forms of Figures 7 to 9 and 18 to 20 I show this construction with the plates spaced approximately equal with respect to one another when placed in the roof.

In the assembled roof, the radial adjoining faces of the brick **33** are without spacer plates, and have the refractory of one brick in contact with the refractory of the other brick or a refractory mortar can be placed in the joint, or a thin metallic (iron or steel) mesh or gauze, which permits the refractory to have contact through the mesh.

On the transverse faces **34** however spacer plates are provided. This is preferably accomplished by comolding spacer plates **38** on the corresponding faces of the brick.

In the form of Figures 4 to 6 inclusive, only a single internal plate **37** is provided on each side at the middle extending the bulk of the distance to the center of the brick, but leaving a strip of refractory **43** where the internal plates **37** from the opposite sides do not quite meet. This strip of refractory **43** will preferably not have a width of more than one-fourth of the corresponding dimension of the brick.

In the form of Figures 7 to 9 there are two internal plates **37** extending from each side. The plates from the opposite sides are aligned and preferably spaced so that the internal plate spacing will be equal throughout the roof. The plates **37** preferably extend transverse to the transverse faces **34** of the brick.

Figure 10 shows a plate assembly of the character employed at each side in Figures 4 to 6 without holes through the internal plate, and Figure 11 shows a form having holes **42** through the internal plate to permit plugs of refractory to extend through when the external and internal plates unite to the refractory by comolding. Figure 12 shows a plate assembly of the character used at each side in Figures 7 to 9, the holes **42** which are optionally employed being omitted in this form.

In molding the brick of Figures 4 to 9 inclusive, as shown in Figures 13 and 14, the lower plate assembly consisting of the external plate **38** with the upstanding internal plate or plates **37** and the upstanding tabs **41** is placed on the bottom die **44**, the plate assembly extending the preponderant part of the length of the mold surrounded by the mold sides **45**, and the plate **38** resting on the lower die **44**. The cooperating opposed plate assembly consisting of the external plate **38**, the aligned downwardly extending internal plate or plates **37** and the downwardly extending tabs **41** is placed on the bottom of the upper die **46** and extends the preponderant part of the length of the mold, with the plate **38** held to the die **46** in any suitable way as by the magnetic clutch **47** in the face of the upper die. Refractory in a loose mass **48** is inserted in the mold on the lower plate assembly, and the dies brought together, suitably under a pressure exceeding 1000 p. s. i., and preferably under a pressure exceeding 5000 p. s. i., as shown in Figures 13 and 14. Thus the internal plates and the tabs from the upper plate assembly are forced into the refractory and the refractory is comolded around the upper and lower plate assemblies, including the internal and external plates and the tabs.

In the form of Figures 1, 2 and 4 to 14, an axial hanger recess **30** is formed in the brick due to a projection **50** which extends suitably from the upper die in the direction of motion. In some cases as shown in Figures 15 to 22 the hanger recess extends radially. In this form a single internal plate **37'** (Figures 15 to 17) or a plurality of such spaced plates (Figures 18 to 20) is provided with openings **42'** through which plugs of refractory extend and join, and preferably also with tabs **41'** extending out on opposed sides suitably in staggered relation, comolded with the brick. In this case the hanger opening 30^2 extends in the arc direction. This brick may be formed as shown in Figure 24 by placing a mass of refractory in the mold, then placing the plate **37'** in the mold aligned parallel to the opposed molding faces with the tabs **41'** extending in the direction of die motion and then placing more refractory on top of the plate. The dies are then brought together to comold the brick and the plate with the tabs and form a hanger recess 30^2. In case two plates are used in this form, the refractory is added in three increments, before the first plate, after the first plate, and after the second plate.

The internal plate will extend any desired distance from the hot end, preferably not exceeding one inch as indicated at **51**.

In some cases a U external plate **38'** is used, forming it on the outside of the mold by comolding and providing tabs 41^2 which extend from the arms **52** of the U into the brick.

The brick is preferably wedge shaped as shown in Figures 1 to 8, although it may be rectangular as shown in Figures 15 to 23.

The radial joints as already explained will in some cases have nothing at all interposed between the refractory, in other cases will have refractory cement at **33** in Figures 1 to 3, normally not of appreciable thickness, and in other cases will include wire mesh **53** as shown in detail in Figure 25. Unlike plates used on radial joints, the wire mesh when having an open space which is more than 50 percent of the area does not cause appreciable lateral pressure in the direction of the arc, the iron oxide formed from the iron or steel of the mesh merging with the basic refractory of the adjoining bricks without causing growth.

It will be understood that the refractory used is preferably of the type suited for use without kiln firing. The molded brick are cured and/or dried and are then suitable for use. The external plates **38** on the unfired refractory brick tend to protect the brick during shipment.

In some cases separate oxidizable metallic spacer plates are inserted on the transverse faces.

If it is desired that only one thickness of plate will

occur on the transverse faces, the comolded plate is provided on only one transverse face as in Figures 21 to 23.

In some cases the invention is applied to a sprung arch having no hangers as in Figure 3. Except for the absence of hangers and hanger sockets, and the use of two internal lines of plates in each brick, the construction of Figure 3 conforms with that of Figures 1 and 2.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the method and structure shown, and I therefore claim all such insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A melting furnace refractory roof of arch form having a plurality of basic refractory roof brick of the class consisting of magnesia and mixtures of chromite and magnesia containing at least 10 percent magnesia by weight, and arranged side by side and end to end with radial joints, there being a metallic wire mesh interposed between radial faces of successive brick, the refractory of the successive brick being in engagement through the metallic wire mesh, and successive brick having an oxidizable metallic plate extending through the interior of the brick over a major portion of the longitudinal dimension of the brick.

2. A melting furnace refractory roof of arch form having a plurality of basic refractory brick of the class consisting of magnesia and mixtures of chromite and magnesia containing at least 10 percent magnesia by weight and aligned side by side in force transmitting relation to each other in the line of the arch, the confronting faces of said brick in the force transmitting arch line being substantially free of oxidizable separants immediately after said brick are assembled in the arch line, and there being in each of the successive brick at least one oxidizable metallic plate appreciably inside the heated brick and extending outward through the interior of said refractory brick over a major portion of the longitudinal dimension of the brick.

3. A melting furnace refractory roof of arch form as defined in claim 2 and further characterized by said confronting faces of the brick in said force transmitting arch line being radial.

4. A melting furnace refractory roof of arch form as defined in claim 2 and further characterized by said confronting faces of the brick in said arch line being bonded by mortar.

5. A melting furnace refractory roof of arch form as defined in claim 2 and further characterized by said confronting faces of the brick in said arch line having metallic wire mesh between the adjacent pairs of said faces.

6. A melting furnace refractory roof of arch form having a plurality of basic refractory brick of the class consisting of magnesia and mixtures of chromite and magnesia containing at least 10 percent magnesia by weight and aligned in side by side arch rows, the bricks in each of said rows being in force transmitting relation to each other in the line of the arch and the confronting faces of the brick in the force transmitting arch line being substantially free of oxidizable separants immediately after said brick are assembled in the arch line, there being in each of the successive brick in each of said rows at least one oxidizable metallic plate appreciably inside the heated face of the brick and extending outward through the interior of said refractory brick over a major portion of the longitudinal dimension of the brick, and oxidizable metallic plates laterally separating said arch rows.

7. A melting furnace refractory roof of arch form as defined in claim 6 and further characterized by said oxidizable metallic plates laterally separating said arch rows being integral facings on said bricks and integral with said oxidizable metallic plates extending through the interiors of said bricks.

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