March 29, 1960 R. P. HEUER 2,930,601

OPEN-HEARTH FURNACE CONSTRUCTION

Filed Nov. 6, 1956 4 Sheets-Sheet 1

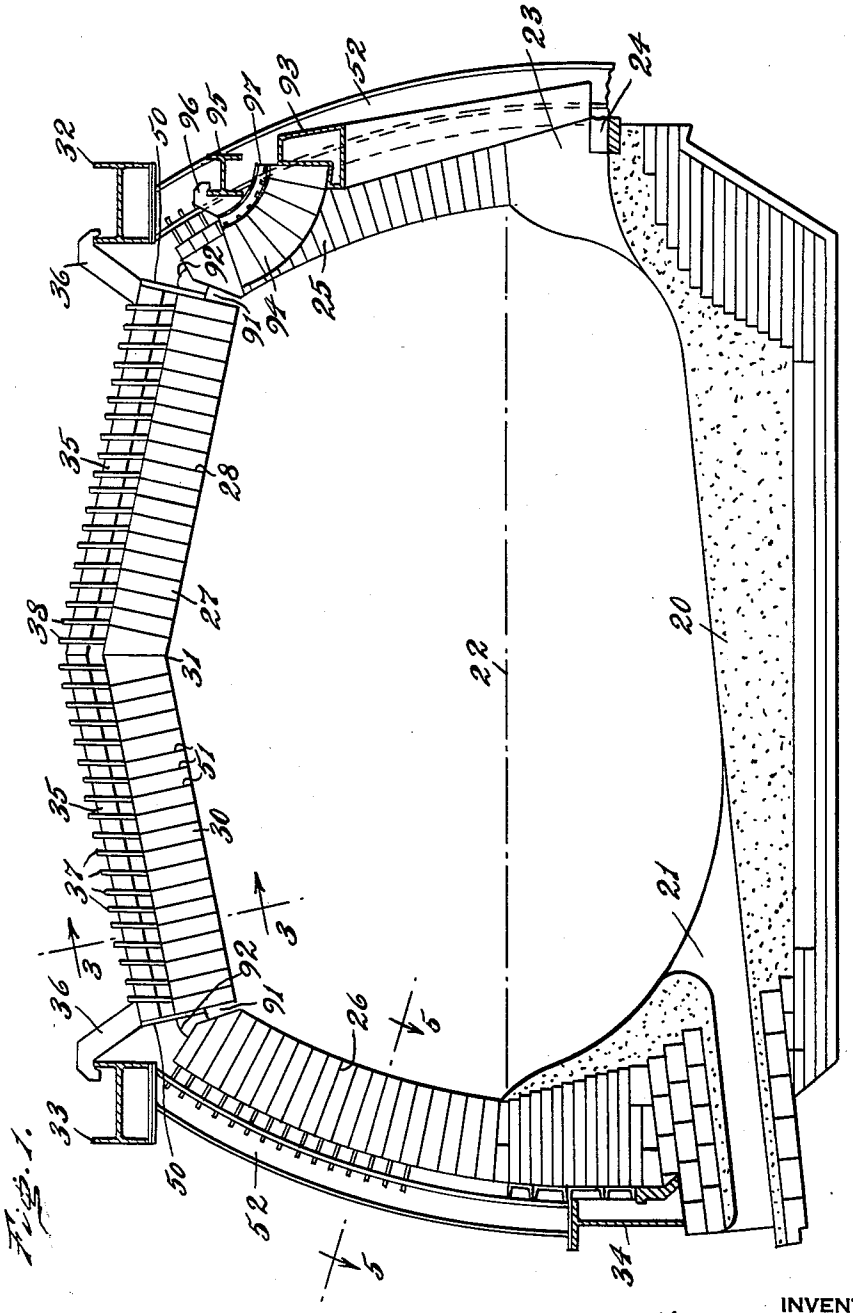


Fig. 1.

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4 Sheets-Sheet 2

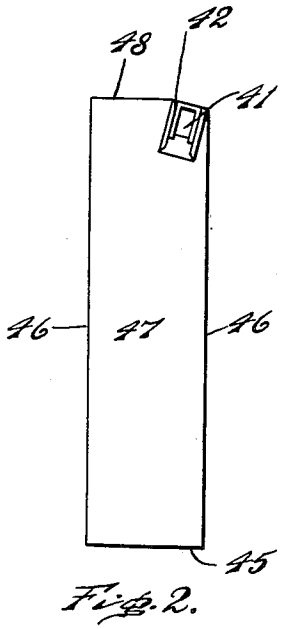


Fig. 2.

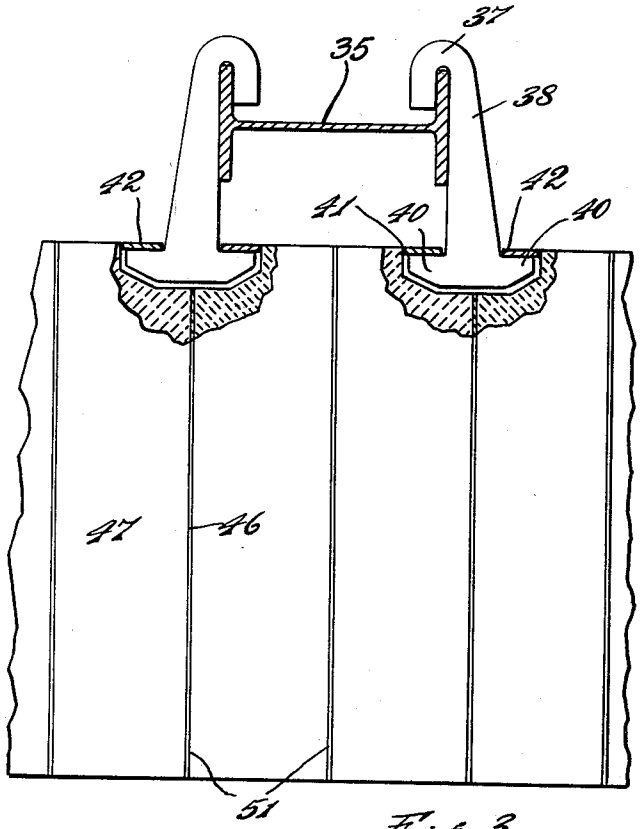


Fig. 3.

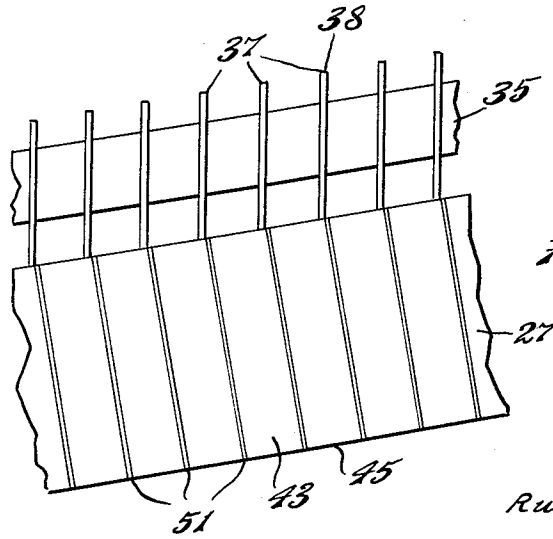


Fig. 4.

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OPEN-HEARTH FURNACE CONSTRUCTION

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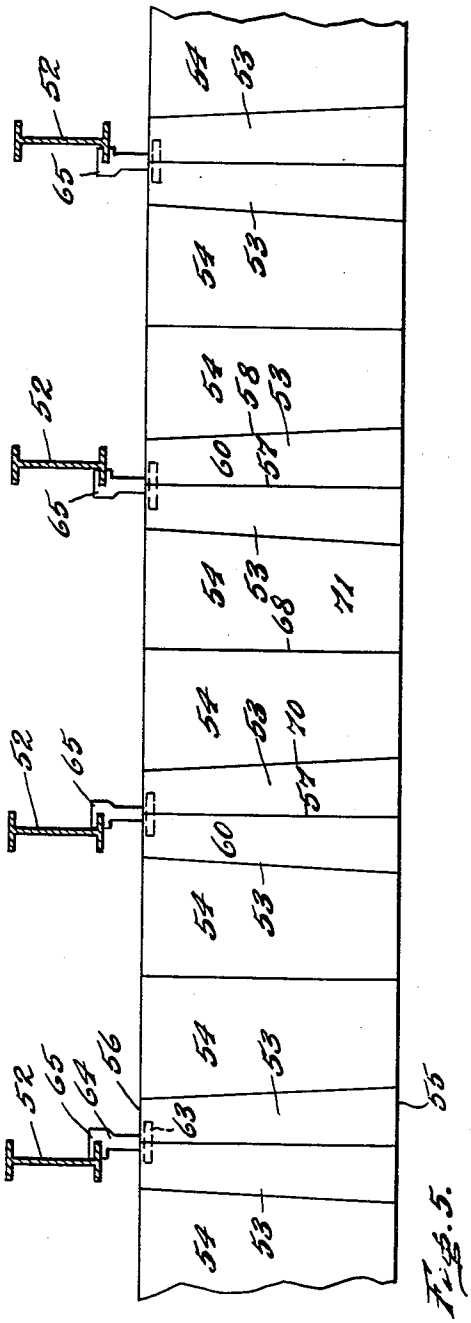


Fig. 5.

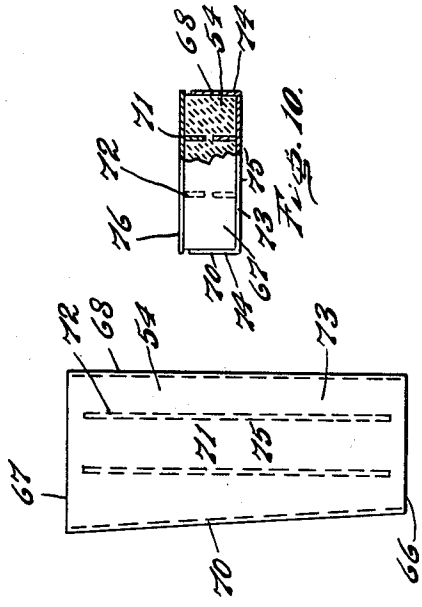


Fig. 9.

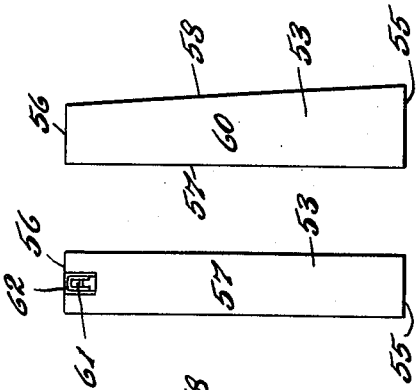


Fig. 8.

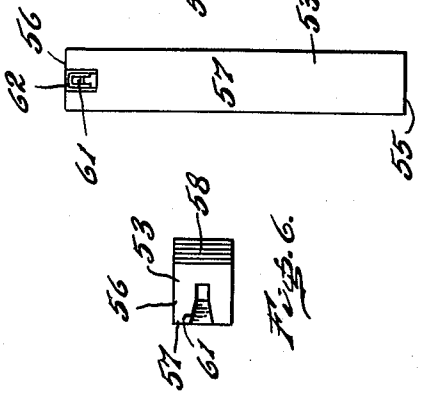


Fig. 7.

Fig. 10.

Fig. 6.

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OPEN-HEARTH FURNACE CONSTRUCTION

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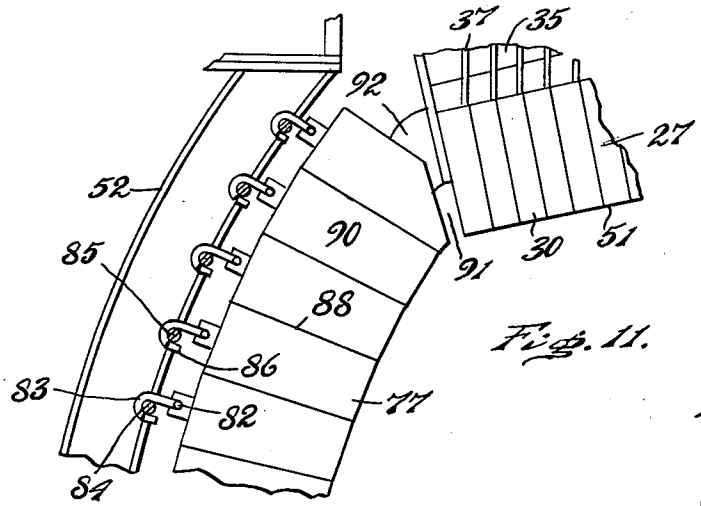


Fig. 11.

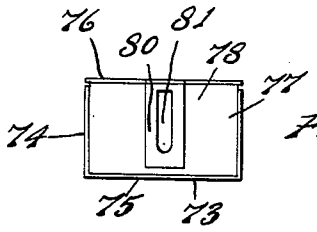


Fig. 12.

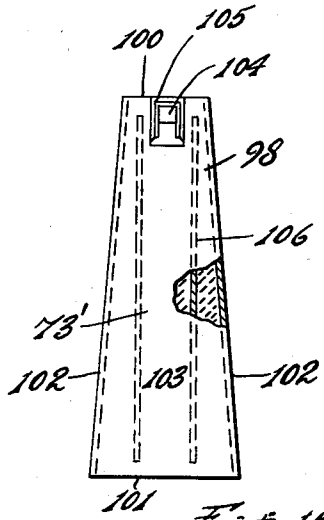


Fig. 15.

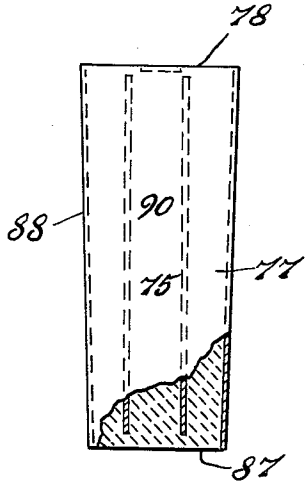


Fig. 13.

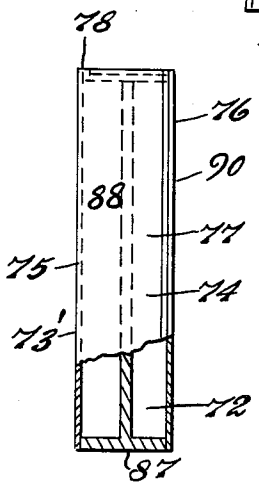


Fig. 14.

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United States Patent Office 2,930,601
Patented Mar. 29, 1960

2,930,601

OPEN-HEARTH FURNACE CONSTRUCTION

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Application November 6, 1956, Serial No. 620,731

4 Claims. (Cl. 263—46)

The present invention relates to the construction of open-hearth furnaces and other similar metallurgical furnaces having the roof and side walls constructed at least in part of basic refractory.

A purpose of the present invention is to construct the side walls of open-hearth furnaces and other similar metallurgical furnaces so that the width of the roof of the furnace is substantially smaller than the width of the interior of the furnace measured at the maximum width between the side walls at or just above the hearth, and to make such roof of suspended basic refractory brick preferably having improved resistance to spalling.

A further purpose is to construct the above described roof having smaller width without the use of refractory skewbacks by using suspended basic refractory brick which are so supported that the point of support of each brick is substantially to one side of the center of gravity and near one edge, thereby reducing the lateral force component which tends to urge the hot end of the brick away from the center of the roof when considered in transverse section.

A further purpose is to secure the outer sides of the sidemost brick of the roof by metallic retainers holding the brick in their inclined position.

A further purpose is to provide a gable near the longitudinal center of the open-hearth roof.

A further purpose is to provide expansion cushions between the basic roof brick and preferably between the longitudinal and transverse side faces thereof.

A further purpose is to construct a furnace having a roof and side walls as described which are so spaced with relation to each other as to make permissible a relative movement of the adjoining edges of the roof and side walls.

A further purpose is to make the converging side walls of a combination of basic refractory brick, metallic supports and hangers connecting the metallic supports with the refractory brick.

A further purpose is to construct the side walls of brick, a portion of which are supported in position from metallic supports and a portion of which are restrained by contact with the brick connected to the metallic supports, suitably by lateral interlock, for example, through wedge action.

A further purpose is to make the side walls of relatively smaller or narrower supported brick and relatively larger or thicker restrained brick and to improve the resistance of the larger brick to spalling by internal oxidizable metallic plates disposed perpendicular to the hot face of the restrained brick.

A further purpose is to provide external plates on the brick face which are connected to the internal plates.

A further purpose is to support all of the side wall refractory brick from the metallic supports, desirably providing oxidizable metallic internal plates in planes perpendicular to the vertical brick faces, and preferably also to make the vertical brick faces parallel to one another.

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 diagrammatic transverse section through an open-hearth furnace in accordance with the invention.

Figure 2 is a side elevation of a basic refractory roof brick of the character employed in Figure 1.

Figure 3 is a fragmentary enlarged section on the line 3—3 of Figure 1.

Figure 4 is a fragmentary enlargement of a portion of the roof of Figure 1.

Figure 5 is an enlarged section of the side wall on the line 5—5 of Figure 1.

Figure 6 is a cold end elevation of one of the hanger engaging basic refractory wall brick shown in Figure 5.

Figure 7 is a vertical side elevation of one of the hanger engaging basic refractory wall brick shown in Figure 5.

Figure 8 is a horizontal side elevation of one of the hanger engaging basic refractory wall brick of Figure 5.

Figure 9 is a horizontal side elevation of one of the intermediate basic refractory wall brick of Figure 5.

Figure 10 is a cold end elevation partly in section showing one of the intermediate basic refractory wall brick of Figure 5.

Figure 11 is an enlarged fragmentary section similar to Figure 1 and showing a variation.

Figure 12 is an elevation of the cold end of one of the side wall basic refractory brick of Figure 11, with the hanger tab extending along the cold end of the refractory, prior to bending outward to the position of Figure 11.

Figure 13 is a vertical side elevation partly in section showing the basic refractory brick of Figure 12.

Figure 14 is a radial side elevation partly in section of the basic refractory brick of Figure 12.

Figure 15 is a vertical side elevation partly in section showing a basic refractory brick suitable for the front wall above the door in the construction of Figure 1.

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

In open-hearth furnaces and other metallurgical melting furnaces, especially those which are changed and tapped intermittently, the life of the roof decreases as the width of the roof increases. It has been customary in open-hearth and similar furnaces to build the side walls either vertical or preferably sloping outwardly and upwardly in order to facilitate the construction and maintenance of the refractory. Thus the maximum width between side walls is at or near the roof. I have observed however that the extra width of roof required by this construction adversely affects the roof life and causes the charge in the furnace to be placed less favorably with respect to the flame and the heating gases, so that the speed of heating and melting is reduced. Nevertheless, in current practice outwardly sloping refractory walls are preferred for open-hearth furnaces.

I find that the disadvantages of such outwardly sloping walls far outweigh the advantages, especially where the roof and side walls are constructed of basic refractory brick, and particularly where such brick are resistant to spalling. I have discovered how to construct upwardly inwardly converging furnace walls, particularly side walls, so that the walls are very serviceable, while the width of the roof at the hot face is substantially reduced and the maximum width between the side walls is at or just above the hearth of the furnace and is more than 10 to 20 percent greater than the width of the roof at the inner face.

In accordance with the invention, I construct the roof and walls of the furnace of brick comprising refractory magnesia and preferably mixed with chromite in amounts from 5 to 75 percent. For the present purposes the brick are used without previous kiln firing. Unfired basic refractory brick according to my prior patents can be used to advantage for this purpose.

Certain of the brick are intended to be externally supported and are provided with suitable hanger means such as recesses, external tabs or protuberances with which the hanger can make proper engagement.

In Figure 1 I show an open-hearth furnace having a hearth **20** provided with a tap opening **21**, and having a maximum width **22** suitably near the top of the hearth.

The furnace has a front wall **25**, a back wall **26**, and a roof **27**, all of unfired basic refractory as previously described. The end walls, not shown in detail, may be of preexisting basic refractory construction as desired. While the roof may be flat or arched, I prefer to use two upwardly inclined sections **28** and **30** joining at the center by a gable **31** provided with wedge gable brick as shown.

The furnace at the front and back has front and back suitable steel beams **32** and **33** suitably supported as at the ends as on a hearth frame **34** (only a portion of which is shown). At intervals along the length of the furnace, suitable steel roof beams **35** extend across and desirably conform to the slope of the front and back roof sections **28** and **30**, the beams **35** at the ends connecting with suitable steel brackets **36** which hook over the front and back beams **32** and **33**, thus making the roof removable by the crane.

The beams **35** are preferably I-beams set with the web horizontal and the flanges extending vertically and hooked ends **37** of suitable steel hangers **38** are anchored on the beams **35**, and carry opposed hanger extensions **40** at their lower ends which suitably engage in hanger sockets **41**, desirably formed by metallic socket members **42** best seen in Figure 2, which are anchored in the basic refractory brick by comolding with the brick. The socket openings as shown in Figure 2 are provided very close to one side of the brick and therefore displaced considerably with respect to the center of gravity of the brick in relation to the adjoining brick face. Thus, as best seen in Figure 4, the individual brick orient around the hanger projections of the hangers and tend to assume an inclined position as shown by the position of the brick indicated at **43** in Figure 4. In this instance the hot faces **45** of each roof brick are inclined toward the longitudinal center, and the longitudinal side faces **46** are also so inclined, while the transverse side faces **47** of the brick remain suitably vertical. The cold faces **48** of course are also inclined.

In order to achieve this configuration, it will be evident that brick of adjoining rows are in opposite counterpart relation where the hangers are connected to pairs of brick.

Due to the fact that the lateral component of force by the brick is directed toward the longitudinal center of the roof, the lateral force which would normally be present at the edge of the roof is greatly diminished, and the need for refractory skewbacks normally used in an open-hearth roof arch is eliminated so that such refractory skewbacks may be eliminated. As a means of adequately defining the side position of the edgemost roof brick, and preventing the roof brick from swinging around when the roof is lifted by the crane, I provide metallic abutments **50** welded or otherwise secured to the ends of the beams **35** and engaging the outside of the sidemost brick near the cold end.

It will be evident that the roof is capable of maintaining its desired size and shape as an independent structural unit without external support other than support from the front and back beams **32** and **33**.

In many cases it is desirable to interpose expansion cushions **51** between the lateral faces of the roof brick as best seen in Figures 3 and 4. In the preferred embodiment the expansion cushions are placed between longitudinal and transverse lateral brick faces. The preferred expansion cushions consist of cardboard or asbestos paper. They allow for increased size by expansion at the same time holding the roof tight during assembly and during crane transportation if desired, prior to firing.

The side walls are inclined upwardly and inwardly so that the maximum width of the furnace hearth **22** above the molten charge is more than 20 percent greater than the width of the roof, measured at the hot face.

The side walls are preferably formed in an arc with the major axes of the brick radial. The form of the side walls will desirably be determined in the case of both the front and back walls by the convergence of suitable steel buckstays **52** which extend up from the hearth frame **34** and suitably connect with and partially support the beams **32** and **33**. In the form of Figure 1, the vertical side wall buckstays **52** curve inwardly, but it will be understood that they may converge by making one or a series of angle bends or otherwise as desired.

Buckstays **52** are preferably independent of the roof beams **35**, but are suitably connected at the bottom to the hearth beams **34** and at the top to the front and back beams **32** and **33**.

The various buckstays **52** are spaced at appropriate distances longitudinally of the furnace and disposed in proper relation to the brick to be supported. In one construction which is preferable, and is best seen in Figure 5, the wall consists of a series of hanger engaging basic refractory wall brick **53** grouped in pairs and a series of intermediate basic refractory brick **54** supported by the hanger engaging brick.

The hanger supported brick **53** are desirably of wedge shape, consisting of a larger hot end **55**, a smaller cold end **56**, a straight vertical side (in the preferred position in the wall) **57**, a tapering vertical side **58** and horizontal sides **60**.

Adjacent the cold end at the side **57** the opposite counterpart brick pairs **53** have hanger recesses **61** provided with comolded metallic sockets **62** which receive end projections **63** of metallic hangers **64** which carry prong ends **65** suitably making a drive fit over one flange of the buckstay **52**.

The intermediate brick **54**, best seen in Figures 9 and 10, have smaller hot ends **66** and larger cold ends **67**, with a straight vertical side **68** (as preferably positioned in the wall), a wedge vertical side **70** and horizontal sides **71**.

Thus it will be evident that the wedge effect due to the engagement of the wedge surfaces **58** of the hanger engaging brick with the wedge surfaces **70** of the intermediate brick supports the intermediate brick against falling inward and the inward component of the pull of gravity due to the inward convergence of the front and back wall supports of the brick against falling outwardly. It is desirable to space the buckstays **52** as far apart as practical, and in Figure 5 I show two intermediate brick between each pair of hanger engaging brick.

It is necessary that the width of the hanger engaging brick **53** should be relatively limited, because this brick should be molded by pressure applied between the faces **57** and **58**, in order to properly form the hanger recess at **61**. There is, however, no such restriction on the width of the intermediate brick **54**, since they have no hanger recesses, and therefore the intermediate brick are desirably considerably wider than the hanger engaging brick.

However, as the width of the intermediate brick increases, the tendency to fail by spalling increases. It is therefore desirable to employ internal oxidizable metallic plates **72** extending between the hot and cold ends, and preferably extending the major portion and most desirably substantially all the distance between the hot and cold ends in the intermediate brick, as shown in Figures

9 and 10. In the preferred embodiment the internal plates 72 are in cooperating parallel aligned pairs 72 each extending slightly less than half the distance across the brick. The external surfaces of the intermediate brick 54 are also preferably encased with oxidizable metallic plates, desirably consisting of a U plate 73 having arms 74 on the surfaces 68 and 70 and having a base of the U at 75 on one of the faces 71. The U plate is suitably opposed to an oxidizable metallic straight plate 76 on the other surface 71. Internal plates are desirably connected to the external plates as by welding.

Each of the internal and external oxidizable plates is preferably made of steel, desirably of the thickness of the order of 1/32 inch to 1/4 inch. The plates are united and placed in and on the brick by comolding, and during service they oxidize and form magnesio-ferrite with the magnesia, protecting the brick against spalling.

It will be understood that less than all of the lateral faces of the intermediate brick may be covered by oxidizable metallic plates. It is desirable that the brick be laid in courses so that the vertical joints are staggered between courses.

In some cases it is preferable to construct the inclined side walls in the manner shown in Figures 11 to 14 inclusive. In this case all of the brick 77 are hanger-connected to the buckstay. While hangers of the character employed in Figure 5 may be used, I prefer in this case to place at the cold end 78 of the brick during molding a metallic hanger tab 80 which is formed in position against the cold end and then bent out at right angles as shown in Figure 11. The tabs have slots 81, which in extended position are engaged by hook ends 82 of metallic hangers 83 which at the reverse ends hook at 84 over spanners 85 which straddle the flanges of the buckstays 52 and are held against sliding along the flanges by lugs 86 suitably welded to the buckstay flanges.

Each hanger desirably has a hook end at 82 arranged so that it can support a pair of brick. The brick are laid in pairs and the two brick making each pair contact each other along the surface 76. In this manner the hangers 80 of each pair adjoin each other and each hook end 82 engages and supports a pair of brick.

Each of the brick 77 has in addition to its larger cold end 78, a smaller hot end 87, radially tapered sides 88, and vertical sides 90.

As in the brick of Figures 9 and 10, there are pairs of spaced parallel internal plates 72 running between the hot end and cold end, generally parallel to the major axis of the brick and suitably joined as by welding to the base portion 75 of a U plate 73 having arms 74 which extend over the wedge sides. At the other side an oxidizable metallic plate 76 is welded to the spaced internal plates. The whole is formed by comolding so that the internal plates extend the majority and preferably almost all the length of the brick and the external plates preferably cover the various sides. The plates will be as above described.

It is preferable in the construction of Figures 11 to 14 to have the principal parallel faces of the brick lie in a vertical position and the internal plates lie in planes perpendicular to the parallel faces and approximately parallel to the major axis of the brick. This produces good resistance to spalling and improved ability to retain shattered fragments of the brick in position in the walls despite their inwardly inclined position.

It is preferable to shape the inclined walls to produce a curved hot face and joints disposed radially as shown in Figure 1. However, if desired, the hot face can be in a flat inclined plane and the joints of the brick can be parallel to each other.

At the corner of the roof at 91, the wall end roof are spaced so that they can independently expand and a deposit of sealing material such as granular or loosely consolidated plastic refractory 92 is introduced to close

the joint while allowing free motion of the roof and wall.

The doors are fitted with inclined water cooled door frames 93, and the front wall above each door is closed by an inwardly converging arc-like basic refractory section 94 of Figure 1, which is supported on a metallic beam 95 by metallic brackets 96, which support arcuate hanger engaging beams 97, which in turn engage hangers of the character shown in Figure 3, each of which supports a pair of wedge brick 98 shown in Figure 15. Each of the wedge brick 98 has a relatively small cold end 100, a larger hot end 101, tapered radial sides 102, and vertically extending sides 103. A hanger recess 104 is provided near the cold end communicating with the face 103, and a comolding metallic socket 105 is placed in the recess. The brick 98 has longitudinally extending oxidizable metallic plates 106 (preferably two pairs in spaced relation) extending substantially across the interior and has a U-shaped external plate 73' on one side 103 and two sides 102 suitably welded to the internal plates, and a flat plate corresponding to the plate 76 on the opposite face 103 welded to a corresponding pair of internal plates. The plates are as described above.

In all of the metallic structures which we have been discussing, the beams, hangers, tabs and the like will preferably be of steel. All of the refractories referred to will be basic refractory in the case of wall and roof, and all of the oxidizable metallic internal and external plates referred to are desirably of steel, suitably in the range of thickness between 1/32 and 1/4 inch.

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 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. An open hearth furnace including a hearth adapted to support molten metal, side walls extending upwardly from the hearth and converging over the hearth, a roof having oppositely sloping sections above the hearth, said sections being directed outward and downward toward said side walls and having lower ends terminating inside said side walls at clearance gaps formed by said ends with the inside surfaces of said walls, said side walls and roof being of basic refractory brick, and the furnace having a maximum width between said side walls at or just above the hearth and about 10 percent greater than the width of the roof measured across the inner face of the roof, supports extending upwardly and inwardly outside said side walls, generally horizontal first beams extending along the tops of said supports, means connecting said basic refractory brick of the side walls with said supports, second beams sloping outwardly and downwardly in opposite directions across the furnace above said oppositely sloping sections of the roof, said second beams having their lower ends supported by said first beams to transmit the load of the roof to said supports, means including hangers connecting the individual basic refractory brick of the roof with said second beams, and abutments on the lower ends of said second beams, spaced from said inside surface of the side walls and extending downwardly over the outsides of the sidemost brick in the sections of said roof.

2. An open hearth furnace including a hearth adapted to support molten metal, side walls extending upwardly from the hearth and converging over the hearth, a roof having oppositely sloping sections above the hearth, said sections being directed outward and downward toward said side walls and lower ends terminating inside said side walls at clearance gaps formed by said ends with the inside surfaces of said walls, said side walls and roof being of basic refractory brick, and the furnace

having a maximum width between said side walls at or just above the hearth and about 10 percent greater than the width of the roof measured across the inner face of the roof, supports extending along the tops of said supports, means connecting said basic refractory brick of the side walls with said supports, second beams sloping outwardly and downwardly in opposite directions across the furnace above said oppositely sloping sections of the roof, said second beams having upward extensions of their lower ends resting removably on top said first beams to transmit the load of the roof to said supports, means including hangers connecting the individual basic refractory brick of the roof with said second beams, and abutments on the lower ends of said second beams, spaced from said inside surfaces of the side walls and extending downwardly over the outsides of the sidemost brick in the sections of said roof.

3. An open hearth furnace including a hearth adapted to support molten metal, side walls extending upwardly from the hearth and converging over the hearth, a roof having oppositely sloping sections above the hearth, said sections being directed outward and downward toward said side walls and lower ends terminating inside said side walls at clearance gaps formed by said ends with the inside surfaces of said walls, said side walls and roof being of basic refractory brick, and the furnace having a maximum width between said side walls at or just above the hearth and about 10 percent greater than the width of the roof measured across the inner face of the roof, supports extending along the tops of said supports, means connecting said basic refractory brick of the side walls with said supports, second beams sloping outwardly and downwardly in opposite directions across

the furnace above said oppositely sloping sections of the roof, said second beams having upward extensions of their lower ends resting removably on top said first beams to transmit the load of the roof to said supports, vertically extending hangers connected with said second beams and attached to the cold ends of the individual roof brick at points which are displaced from the longitudinal axes of the corresponding roof brick toward the higher part of the roof, said hangers engaging said roof brick so that the longitudinal axes of the roof brick are individually inclined upwardly and outwardly from the vertical axis of the furnace, and abutments on the lower ends of said second beams, spaced from said inside surfaces of said side walls and extending downwardly over the outsides of the sidemost brick in the sections of the roof.

4. An open hearth furnace of claim 3, in which said second beams are I-beams having vertically disposed flanges, said sloping sections of the roof include adjoining rows of brick extending downward under said I-beams toward said side walls, and said hangers have hooks engaging the top of said flanges to connect corresponding pairs of the brick of said rows to the I-beams.

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