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FURNACE CONSTRUCTION

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2 Sheets-Sheet 1

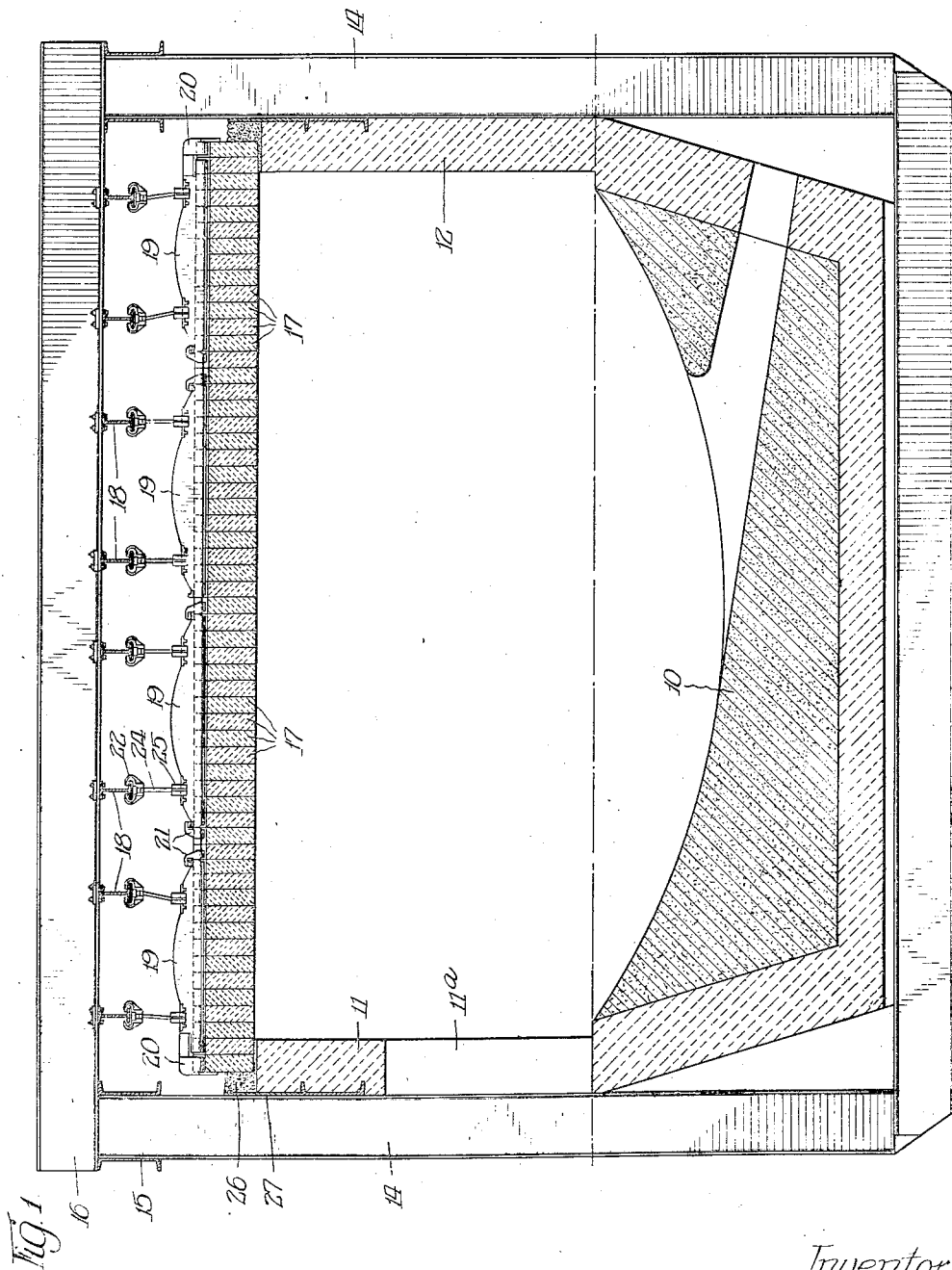


Fig. 1

Witness:

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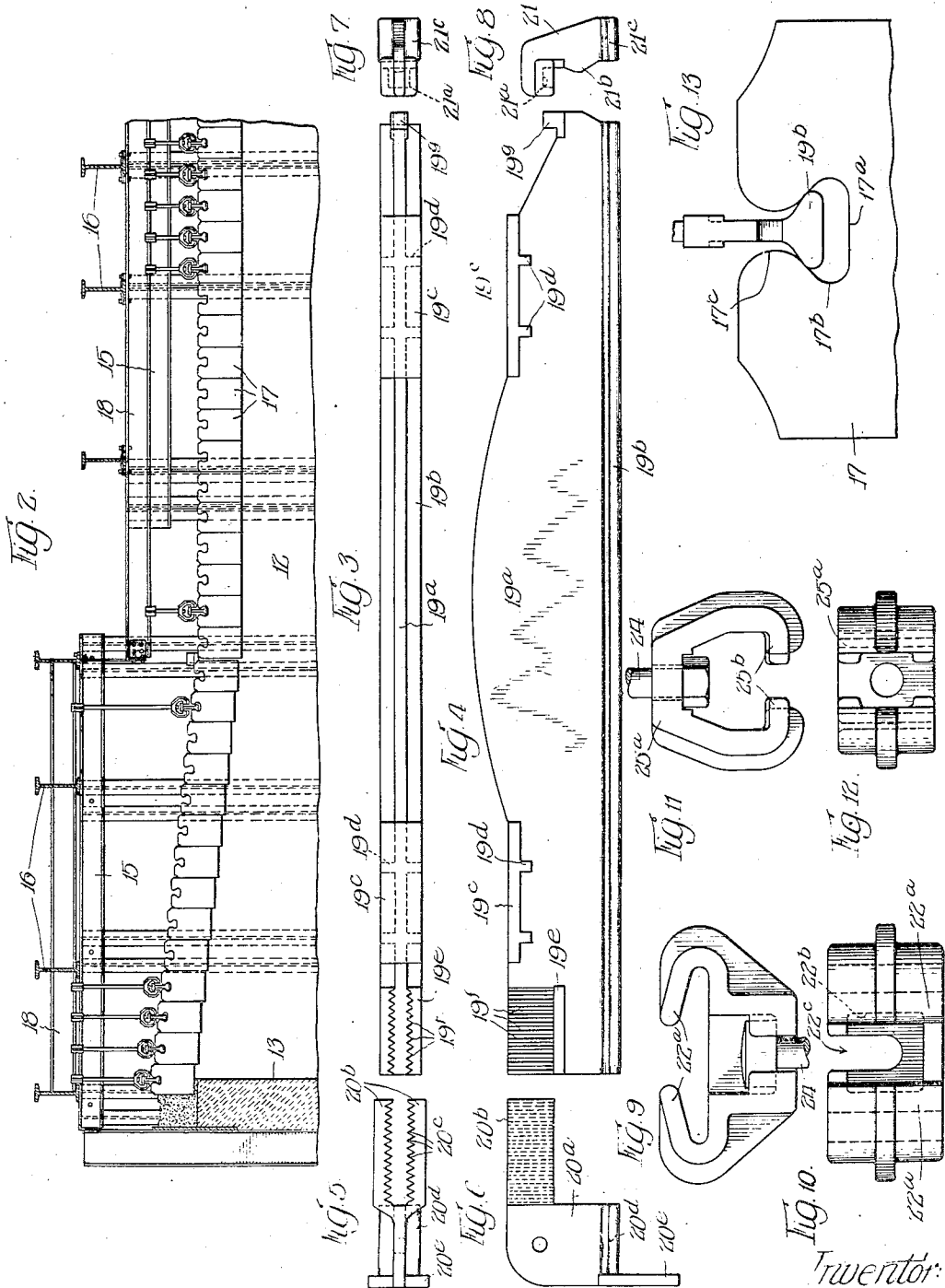
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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FURNACE CONSTRUCTION

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This invention relates to furnace construction and has to do primarily with construction of suspended furnace arches or roofs, and especially of refractory roofs or arches for metallurgical furnaces, such as open hearth furnaces.

The general object of the invention is the provision of a furnace construction which may be utilized with advantage in furnaces in which the heating chamber or combustion chamber is extensive in area and the walls and roof are subjected, in use, to trying conditions or influences, such as extremely high temperatures, frequent alternate intervals of heating and cooling, and destructive erosive effects such as may be occasioned by rapid movement of burning gases or suspended fuel particles or operation with a superatmospheric pressure within a portion of the furnace; the furnace, and particularly the arch, being qualified, by virtue of the improved construction, to withstand these destructive influences to an appreciably increased extent, and to contribute to the efficient performance of the furnace and to its term of usefulness, and to facilitate repair or replacement either in localities of limited extent or as a whole.

One of the specific objects of the invention is the provision of an improved arch construction for open hearth or reverberatory furnaces which will contribute to the rapidity with which a charge may be heated in the furnace, which will facilitate the charging of the furnace and which will increase the life of the roof and walls.

Another object is the provision of a construction which is particularly effective to maintain tight joints between the furnace walls and the roof and between the component refractories of the roof, and thereby qualify the furnace to be operated with strong inlet blast without exposing the metallic frame members of the furnace or roof to destructive overheating from escaping gas, or the refractories to the rapid destruction occasioned by the leakage of incandescent gases past or between them, or ingress of cold air between heated refractories.

Another object is the provision of a furnace roof construction particularly adapted

for the employment of silica refractories by virtue of its qualifications for accommodating expansion and contraction of the refractories without subjecting them to destructive mechanical stresses, its provisions for diffusion of heat from the refractories and its arrangement for supporting the refractories in a manner such as to best avail of the limited tensile strength of the material of which they are composed.

Another object is the provision of a construction which will permit the refractory roof to be constructed with increased thickness without involving expansion difficulties.

Another object is the provision of a furnace roof construction which admits of standardization of parts and at the same time affords liberal accommodation for variation in size of its component elements, which must have liberal tolerances for practical manufacture.

Yet another object is the provision of a furnace roof construction which admits of localized repairs being made from the exterior of the furnace, even while the furnace is in operation or highly heated, and which permits of such localized repairs being made without requiring the dismantling of parts adjacent the affected area.

Yet another object is the provision of a construction which may be installed rapidly with simple operations over furnaces of extensive area without the necessity for employment of special erecting machinery or forms.

A further object is the provision of a construction which is strong and stable and in which metallic members are effectively safeguarded against destructive overheating.

A further object is the provision of an improved supporting arrangement particularly adapted for the suspension of refractories with portions of the material in tension.

Another object is an improved construction for a refractory as a structural element for a suspended furnace arch.

Other and further objects will be pointed out and indicated hereinafter, or will be apparent to one skilled in the art upon an understanding of the invention and its various features or its employment in practice.

In the drawings forming a part of this specification, are shown a furnace arch construction embodying the invention, and various features thereof, but it is to be understood that these are presented for purpose of illustration only, as the invention is not limited to the particular construction or details herein shown and described, and that the particular example herein disclosed is not to be accorded any interpretation calculated to limit the claims short of the true and most comprehensive scope of the invention in the art.

In the drawings,

Fig. 1 is a sectional elevation of the furnace chamber structure of an open heart furnace, the section being taken from front to rear, with the charging side, or front, at the left hand side of the figure, and the tapping side or back at the right hand side of the figure;

Fig. 2 is a detail in the nature of a sectional elevation, taken on a line transversely of Fig. 1, at one of the ends of an open hearth furnace, showing a portion of the furnace roof or arch, together with parts of the supporting frame work and furnace walls;

Fig. 3 is a top or plan view of an improved form of tile supporting bar employed in the construction illustrated in Figs. 1 and 2;

Fig. 4 is a side elevational view of said tile supporting bar;

Fig. 5 is an end stop attachment adapted to be employed in combination with said bar, same shown in plan or top view;

Fig. 6 is a side elevation of said end stop attachment;

Fig. 7 is a top view of an end tile holder;

Fig. 8 is a side elevational view of same;

Fig. 9 is a side elevational view of a hanger socket member;

Fig. 10 is a top view of same;

Fig. 11 is a side elevation of a hangar jaw member;

Fig. 12 is a bottom view of same; and

Fig. 13 is a detail showing a tile supporting bar in end elevation and the slotted end portion of an improved form of silica tile in elevation.

There are various types of furnaces which require refractory arches or roofs to cover heating chambers or combustion chambers which are quite extensive in area. This is the case with various metallurgical furnaces as, for example, open hearth steel furnaces. In many of such furnaces, particularly in the various types of reverberatory furnaces, the roofs are subjected to very high temperatures, due to their proximity to highly heated molten material in the bath as well as to the rapid firing of the furnace with gas or oil which is burned under the roof. Furthermore, the roofs of such furnaces are subjected to severe erosive and corrosive effects, the former resulting from the rapid and forcible flow of the combustion gases through

the furnace, and the latter from the slugging effects of materials carried in the combustion gases which react with elements in the refractory material under high temperatures. In such furnaces which are worked at high temperatures, the gaseous fuel and air are usually introduced at one end of the furnace under a considerable blast pressure and withdrawn at the other end of the furnace under a negative pressure so that the pressures within the furnace adjacent the inlet end are above atmospheric pressure, while those toward the draft end are below atmospheric pressure. These circumstances make it quite important that the roof itself and the joints between the roof and the walls be maintained very close, in order to prevent the forcing out of incandescent or highly heated gases by the internal pressure, or the drawing in of cold air by the negative pressure. The rapid leakage of highly heated gases between the refractories not only results in their rapid destruction, but may also endanger metallic members employed for the supporting of portions of the furnace walls or roof, while the drawing in of cold air between highly heated refractories is likely to result in their spalling. Since the direction of flow of the combustion gases through the furnace is reversed at comparatively short intervals, it will be appreciated that in the event of leakage the refractories adjacent the leaks will be subjected to sudden and extreme changes in temperature influences.

In charging open hearth steel furnaces and the like, the material of the charge is usually piled up in the bath, so that the space left for passage of combustion gases between it and the roof is materially restricted. This has the effect of increasing both the temperature and erosive influences on the refractories of the roof and the walls. Furthermore, in furnace constructions heretofore employed, in which the roof is of arched or sprung form and is supported by lateral reactions carried by the walls and buckstays, limitations are imposed on the thickness of the refractory roof by the permissible weight and by the ability of the structure as a whole to accommodate its expansion and contraction. Because of the high temperatures to which the roof is subjected, it is necessary that the material exposed to the heat have high refractory quality, and for the attainment of that purpose, and also for metallurgical reasons, it has been customary in this country to use silica refractories, that is, refractories composed of around 94%, or more, of silica. While possessing these desirable refractory qualities, silica brick are very sensitive to temperature changes, in comparison, for example, with fire clay brick, and while they will sustain higher pressures without plastic deformation, they are subject to sudden failure when their load limit under high

temperatures is reached, and they spall very quickly and radically when subjected to sudden cooling effects while heated. They have a poor resistance to abrasion, as compared with fire clay brick, and due to their acid nature, are more prone to rapid slagging when subjected to contact with basic substances at the high temperatures at which they begin to soften. Silica brick sometimes demonstrate a further characteristic which assumes great importance in extensive structures, in that after expansion part of their increase in size is sometimes permanent, upon cooling. Furthermore, upon reheating, they sometimes undergo further expansion and further permanent increase in size, these physical changes in size being attributable to chemical changes in their constitution.

The foregoing considerations, and many others, render the designing of an improved highly refractory furnace roof a quite intricate and difficult problem. By the present invention there is provided a form of furnace construction which permits a substantial increase in the thickness of the refractory roof, reduces the effect upon it of the destructive influences to which it is exposed, minimizes the handicaps or limitations inherent in the refractory materials employed, while permitting their advantageous qualities to be fully availed of, simplifies the operations of installation and repair, and increases the term of serviceability and the productivity of the furnace.

The nature of the invention may be ascertained from the structural example shown in the drawings. In the particular arrangement here shown, the invention is embodied in an open hearth furnace, the bath being designated by the reference character 10, the charging side wall by 11, the tapping side wall by 12, and the end walls 13. The walls are afforded lateral support by buckstays 14, which are connected longitudinally of the furnace by runners 15, and joined across the top of the furnace by transverse beams 16. A charging door opening is designated 11^a. The refractory roof is construed as a suspended structure presenting a flat surface within the furnace chamber over the bath. The refractories of which the roof, or arch, are composed, are designated 17. They have parallel sides arranged in rectangular relationship, and their width is substantially greater than their thickness, and their length greater than their width to an extent determined by the desired thickness of the refractory roof. At the middle of their upper ends they are provided with slots 17^a, which will be described in detail later. These tiles are assembled and supported in roof sections, each section comprising a plurality of tiles, and each section being suspended independently of the other sections with the tiles of each section abutting those of other sections. The

supporting means for each section includes a tile supporting bar, suspending hangers, and hanger supports. The latter are beams 18 which are disposed in parallel relationship and secured in fixed positions on beams 16. Two forms of tile supporting bars are shown in Fig. 1, both being designated by the reference numeral 19. These two forms have most features in common, however, and the details of their construction may be ascertained from Figs. 3, 4, 7, 8 and 13. These bars are made of material having the necessary heat resisting qualities, such as cast iron. They comprise a web portion 19^a formed with a bulb or ledge 19^b projecting from both sides at the lower margin. At the top of the web and adjacent its ends are provided hanger seats comprising laterally extending suspension flanges 19^c from which depend stop lugs 19^d. The bars intended to support the marginal roof sections are each provided at one end with means for connection of an end stop attachment. This means comprises short flanges 19^e extending longitudinally of the web from one end thereof, and equally spaced projections 19^f extending in parallel relationship from the top of the web to said flanges 19^e and perpendicular to the latter. The end stop attachment is illustrated in Figs. 5 and 6 and is designated by the reference numeral 20 in Fig. 1. It comprises a web portion 20^a carrying flange extensions 20^b at one side thereof, said extensions being provided on their inner faces with projections 20^c extending in parallel relationship and spaced for intermeshing registration with the projections 19^f, the flange extensions 20^b being spaced apart a proper distance to permit their being slid into dovetail engagement with the web 19^a and projections 19^f, from the top of the former. When so assembled with the bar, the end stop attachment is supported by the flanges 19^e and retained against longitudinal displacement by the interengaging projections 19^f and 20^c. Along the lower margin, which is thus supported in alignment with the lower margin of the bar, the end stop attachment has a bulb or ledge 20^d corresponding in size and cross section to bulb 19^b, and at the outer end of the bulb 20^d is a stop flange 20^e. The bars 19 are also equipped with end tile holders 21. For connection of an end tile holder, the bar is provided at its end with an upstanding lug 19^g, while the end tile holder, which is a small hook shaped casting, is provided with a socket 21^a adapted to seat on the lug 19^g, and a portion 21^b adapted to abut the end of the bar web 19^a. At its lower end the end tile holder carries a bulb or ledge 21^c, similar in cross section to the bulb 19^b, and arranged to align with same when the end tile holder is supported on the end of the bar. The tiles comprising the roof section are suspended on the bulb 19^b of the bar and the bulbs 20^d and 21^c of the end stop

attachment and end tile holder respectively, the tile on the end tile holder being arranged in abutment with an end tile of an adjacent roof section. The tile supporting bar, with the end attachments and the tiles supported thereon are suspended from the section supporting beams 18 by means of flexible hangers. Each of these hangers comprises a socket member 22, a hanger bolt or rod 24 and a hanger jaw member 25. The socket member is illustrated in Figs. 9 and 10. It is a casting having at the top oppositely disposed hook portions 22^a arranged to engage the flanges of one of the beams 18 in such fashion as to retain the socket member thereon, and a body below said hook portions which is shaped to afford a socket or pocket 22^b having a restricted slot opening 22^c through its bottom and one side. This pocket receives loosely a headed end of the bolt or hanger rod 24, which may be introduced laterally into the socket below the beam 18, the shank of the rod passing through the slot opening 22^c with a clearance, so that the bolt may assume various angular positions relative to the socket member. The hanger jaw is carried at the lower end of the rod or bolt, and comprises a yoke portion 25^a having an aperture permitting the passage of the bolt therethrough with a clearance, and oppositely arranged hook portions 25^b depending from the yoke portion and spaced apart a distance permitting the inserting between them of the web 19^a of the tile supporting bar. The hook portions 25^b are adapted to engage under the suspension flanges 19^c, so as to support the bar, the jaw member being retained by the seat lugs 19^d against longitudinal movement on the flanges 19^c, to prevent disengagement of the bar from the hanger. With the roof sections supported in this fashion, they are susceptible individually of swinging movement in any direction without shifting of their point of connection with the section supporting bars 18. Due to the nature of their material and the conditions obtaining in their manufacture, the refractories are not made to exactly uniform size. Consequently, it is desirable to make provision for such variation, which, in the aggregate, since a considerable number of tiles are used in a course, may amount to an appreciable difference in the length of different courses. These variations are accommodated by the adjustment of the end stop attachments 20 relative to the bars, the interlocking members 19^d and 20^e allowing a considerable range of close adjustments.

As illustrated in Fig. 13, the side walls of the tile slots 17^a are formed with a double curve or ogee shape having the reentrant or concave curved portions 17^b on a smaller radius than the salient or convex curved portions 17^c, which latter form the boundary walls of overhanging lug portions of the tile which are adapted to rest upon the ledges or

bulbs of the tile supporting bar and its end attachments. The upper faces of the bulb diverge from the web portion of the bar at obtuse angles and are convexly curved to meet the lower face, and the cross section of the bulb and web is considerably smaller than the area of the tile slot, so that the tile may be applied to the bar with freedom, and the convex surfaces of the overhanging lugs of the tile rest upon the sloping upper surfaces of the bulb with a limited area of contact, in the nature of a line contact. Because of the relative size of the tile slot and the bulb, the tile has liberal latitude for swinging movement relative to the bar, and also latitude for movement upwardly toward the bar because of the clearance between the bottom of the bulb and the bottom of the slot. In this fashion, the tiles of a roof section have individual mobility in the structure, so that the section is flexible within itself.

The spacing and positions of the hanger sockets are established with reference to the location of the sections which they are to support. As illustrated in Fig. 1, the locations of the section supporting beams 18 and hanger sockets for the sections in the marginal portions of the roof are arranged so that the flexible hangers of the sections which they support are deflected out of plumb toward the adjacent walls. Consequently, the weight of the sections suspended on these hangers will exert a moment inwardly toward the middle portion of the roof, against the tile in the intervening sections. The outer end tiles of the marginal sections abut end stops 20^e of the end stop attachments 20, preventing outward displacement of the tiles on the bars. As a result, expansion of the tiles in the roof can have the effect of swinging the marginal sections outwardly, which movement they are free to take because of the flexible nature of the hangers and because they are not resisted by the walls or buckstays. The intermediate sections, likewise, are free to accommodate themselves to expansion and contraction of the roof, because of their flexible suspension, while the individual tiles in all of the sections are free to adjust themselves for equalization of the pressures to which they are subjected from different sides. Thus, their supporting lugs, as well as the body portions of the tiles, are relieved of leverage forces and unbalanced pressures which would tend to fracture the material. By virtue of the construction, therefore, all of the tiles in the roof are subjected to constantly acting pressures toward the center of the roof, which are effective to hold them closely together and prevent leakage between them. These pressures may result from the thermal expansion of the tiles as well as from the gravity moment of the marginal sections. However, these pressures are applied in a yielding fashion

to the component tiles of the roof, due to the fact that the free suspension of the sections limits the aggregate pressure to the horizontal component of the gravity moment. For the purpose of accommodating expansion and contraction of the roof and providing an effective seal between the roof and the walls of the furnace, the marginal sections are arranged to overlap the tops of the walls and a seal of loose refractory material 26 is applied over the joint. Plates 27 may be supported on the buckstays along the joint line to retain this loose sealing material in place to seal the joint while accommodating expanding and contracting movements of the roof.

If it is desired to slope any part of the arch, this may be accomplished, as illustrated at the left hand end of Fig. 2, by providing hanger rods of different lengths so that the successively positioned sections are suspended at gradually increased elevations.

As will be apparent from the foregoing description, the weight of the roof is carried as a vertical load by the buckstays, which act as supporting columns, the walls being entirely relieved of the weight of the roof and of outward pressures from the same, and the buckstays likewise being relieved of outward pressures. As a result, the refractory roof may be made quite thick, which is an advantageous feature, both from the standpoint of heat conservation and longevity. The form of the tiles, and the manner in which they are supported on the bars, also contribute to the feasibility of a thick roof. By the provision of sloping faces on the supporting lugs of the tile, the reactions from the weight of the tile when suspended on the bar, are distributed laterally through the material in the supporting lugs. Consequently, there is not the tendency for the breaking off of the lugs by the concentration of the load in portions where the material is scanty. Furthermore, since the tile is free to shift to quite an extent about the bar as an axis, there is not the opportunity for the development of a leverage action on the supporting lugs of the tile. As a result of this strength in its supporting portion, the tile may be long, so as to extend below the bottom of the slot considerably in excess of the width of the tile. By proper attention to the molding of the tile in the process of manufacture, the density of the material in the supporting lugs may be made greater than that requisite for the body of the refractory, and the tensile strength of the supporting portions of the tile thereby further increased.

The present invention improves the performance of a melting furnace as it provides a tight flat roof above the bath. In regenerative furnaces it is customary to inject preheated air and the fuel gas through different ports, and these are sometimes arranged in

such relationship that the air is injected above the gas. The relative volume of air and gas is determined on a basis calculated to obtain the most effective combustion, and it is important that they be mixed within the furnace chamber in as nearly as possible the proper proportions. A flat arch contributes to the uniform mixing of air and gas, as they may be more uniformly distributed under a flat roof than under one which is arched. Furthermore, the form of the combustion chamber contributed by a flat arch tends to reduce the erosive and slagging effects on the walls and roof. This is particularly true when the furnace has been freshly charged and the metal is heaped up in the bath, as more space is afforded under the sides of the arch for the passage of the burning gases past the piles of metal. Not only does this tend to lessen the destructive effects on the walls and roof, but it also contributes to the rapid heating of the charge due to the fact that the burning gases may be passed through the furnace in greater volume. The flat roof also produces a more uniform distribution of heat onto the material in the bath than does a roof of arched form.

Localized repairs may be made in the roof while the furnace is heated. By drawing out one of the end tile holders, a space is afforded through which new tiles may be inserted and slid on to the tile supporting bar, the space being filled finally by a tile supported on the removed end tile holder when the latter is restored to position. The entire roof may be installed without necessity for employment of a form or false work for supporting the refractories, as it is built up section by section, each section having its individual suspension support.

It is desirable to form the tile supporting bars with liberally sized webs projecting above the upper ends of the tiles, where they are exposed to air circulation. This provision decreases the likelihood of overheating of the bars and also increases the diffusion of heat from the supporting lugs of the tiles, thereby lessening the possibility of their being heated to a temperature at which their tensile strength is seriously affected. By the cooling of the bars through their heat diffusing webs, the likelihood of overheating the hangers, to a point seriously affecting their strength, is materially lessened.

While the use of a flat roof has certain advantages, as pointed out above, and the present invention renders feasible the use of a flat roof over a reverberatory furnace, many advantages may be attained by the use of the invention in a suspended roof of arched form. By appropriately shaping the tile supporting bars and varying the lengths of the hangers, a suspended roof of arched contour may be provided, supported in roof sections as in the particular embodiment, here-

in illustrated, with the sections suspended so that their weight exerts pressures toward the middle of the arch so as to hold the refractories closely together, in the manner above described. In such a construction, moreover, the roof may be likewise free of lateral support, and have the desirable freedom for expansion and contraction without imposing weight on the walls or outward pressures on them or on the buckstays.

10 What I claim is:

1. In furnace construction, a furnace roof comprising a plurality of refractories assembled in roof sections, hangers supporting
15 respective sections individually for swinging movement, stop members supported by the hangers of marginal roof sections for limiting outward movement of the refractories therein, said marginal roof sections being
20 maintained out of gravitational equilibrium by interior roof sections and the stabilizing gravity moments of said marginal sections being exerted upon the refractories of the interior roof sections.

25 2. In a furnace roof, a course of refractories assembled in a series of abutting sections, hangers suspending said sections individually for swinging movement, a stop member suspended with an end section and limiting
30 outward movement of the refractories in said section, said end section being maintained out of gravitational equilibrium by the other sections with its stabilizing gravity moment supported by refractories in said other sections.
35

3. In furnace arch construction, an arch supporting bar having tile retaining members along its lower portion, and an end stop attachment for connection to said bar, a stop
40 member carried by said end stop attachment, said bar and end stop attachment having interengaging portions for retaining the end stop attachment on the bar, said interengaging members being engageable in different
45 relationships to vary the spacing of the stop member relative to the bar.

4. A furnace arch portion comprising a tile supporting bar and an end stop attachment for connection thereto, said bar and end
50 stop attachment having connecting portion engageable in different relationships to maintain the end stop attachment in different positions on the bar.

55 5. In furnace arch construction, in combination, a tile supporting bar provided with tile retaining ledges and a refractory tile formed with suspension lugs having convex
60 surfaces engaging said ledges to support the tile thereon.

6. In furnace arch construction, in combination, a tile supporting bar having tile retaining ledges with divergently sloping faces, and a refractory tile formed with oppositely
65 disposed suspension lugs presenting convex

surfaces for engagement with said faces to retain the tile in suspension on the ledge.

7. In furnace arch construction, in combination, a tile supporting bar having ledges with divergently sloping upper faces, and a
70 refractory tile formed with a slot to receive said ledges, said slot being formed with convex opposite side surfaces for engagement with the sloping faces of the ledges and the
75 slot being of a size to permit shifting of the tile to different angular positions relative to the bar.

8. A furnace arch refractory consisting of a tile formed with a medial slot at one end, the sides of said slot being of ogee contour
80 with a salient curve at the top and a reentrant curve at the bottom, the salient curve having a longer radius than the reentrant curve, the distance between the bottom of the slot and the opposite end of the tile exceeding the
85 width of the tile.

9. A furnace arch refractory consisting of a silica tile formed at one end with suspension lugs, the suspension lugs having convex surfaces arranged in facing relationship to each
90 other to afford an intervening hanger slot, said convex faces constituting the major portion of the slot side walls and diverging toward the bottom of the slot.

10. In furnace arch construction the combination with a flanged beam, of a socket member having a hook portion for engaging the flange of the beam and a socket portion having a restricted laterally opening slot, a
100 hanger rod insertable through said slot and having an enlarged portion for reception in the socket portion, a jaw member for connection to an end of the rod, and a tile supporting member having a seat portion for engagement by the jaw member, whereby said tile supporting member may be suspended from the beam.

11. In furnace arch construction, in combination, a socket member having a hook portion and a socket portion below the hook portion, said socket portion having a laterally opening restricted slot, and a hanger rod insertable laterally through said slot, said rod having a head portion engageable in the
110 socket portion to prevent retraction of the rod through the slot.

12. In furnace construction, a furnace roof comprising a plurality of roof sections, each section including a tile supporting member, a plurality of tile suspended thereon and susceptible of movement to different angular positions relative thereto, and means suspending the tile supporting member to permit swinging movement of the section; the tile of different sections being arranged in lateral abutment with some of the sections maintained out of gravitational equilibrium by other sections.

13. A furnace roof construction comprising, in combination, a plurality of tile sup-

porting bars, a plurality of refractories independently supported in abutment with one another on each of said bars to form a roof section, the refractories being movable to different angular positions with respect to their supporting bars, said sections being arranged with refractories of respective sections in abutment with those of juxtaposed sections, suspension means suspending each section independently for swinging movement in directions inwardly and outwardly of the roof area to accommodate expansion and contraction of the roof, and marginal sections being maintained out of gravitational equilibrium by abutment of their refractories with those of interior sections.

In testimony whereof I have hereunto subscribed my name.

LOUIS ELLMAN.