Sept. 22, 1942. S. F. KEENER ET AL 2,296,791

ROTARY FURNACE

Filed June 7, 1941 2 Sheets-Sheet 1

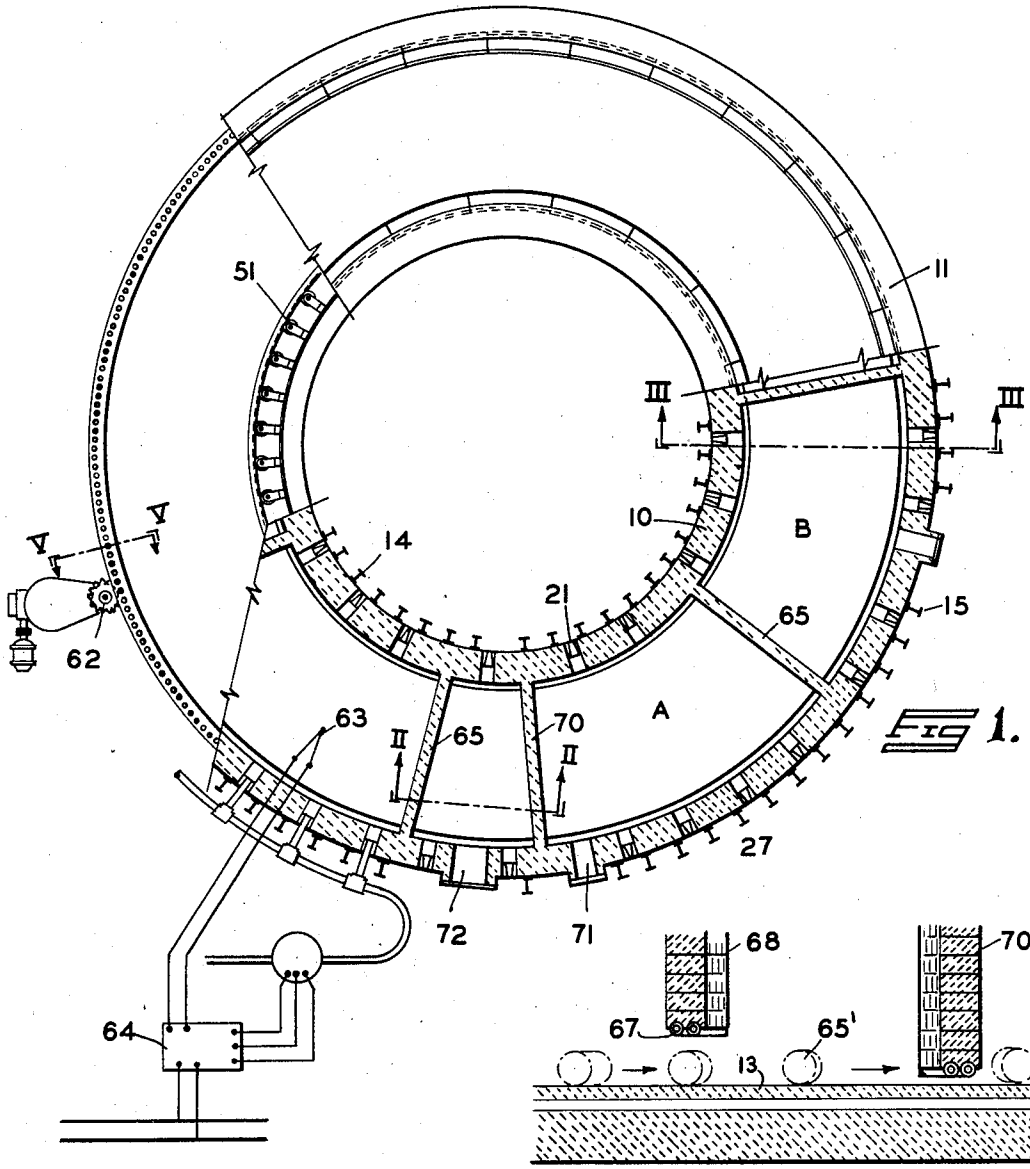

FIG 1.

FIG 2.

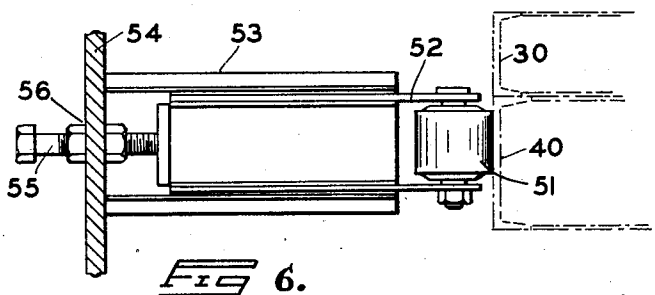

FIG 6.

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FIG 3.

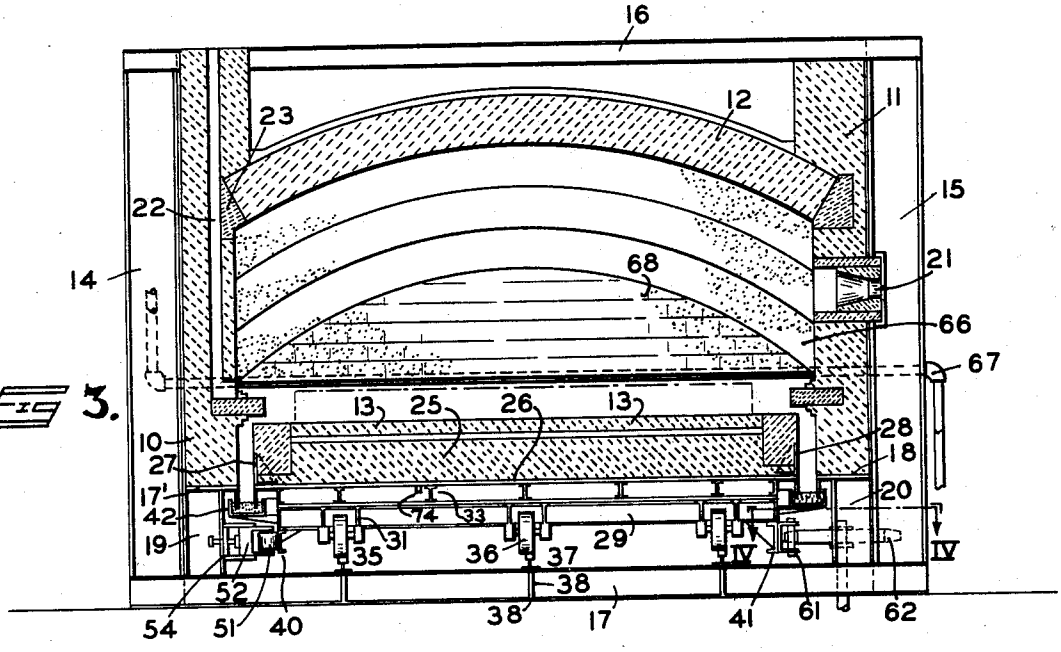
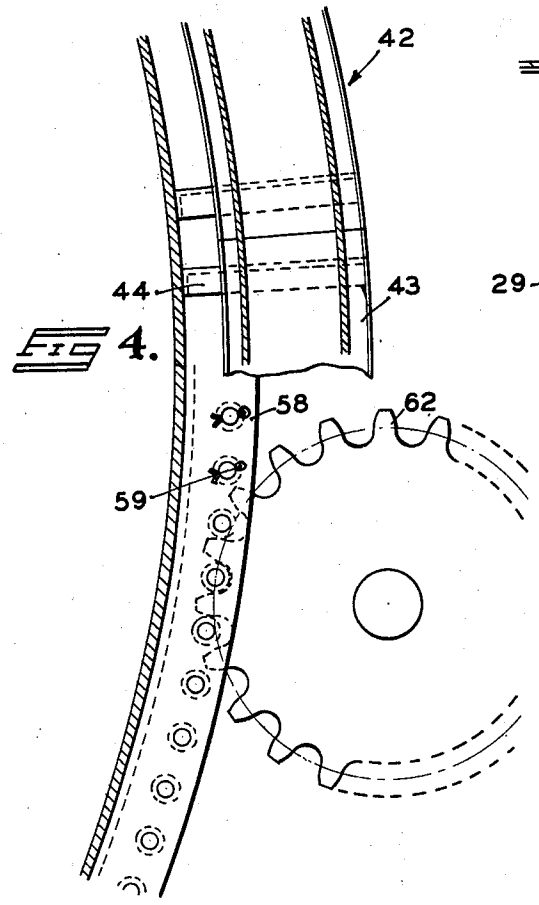


FIG 4.



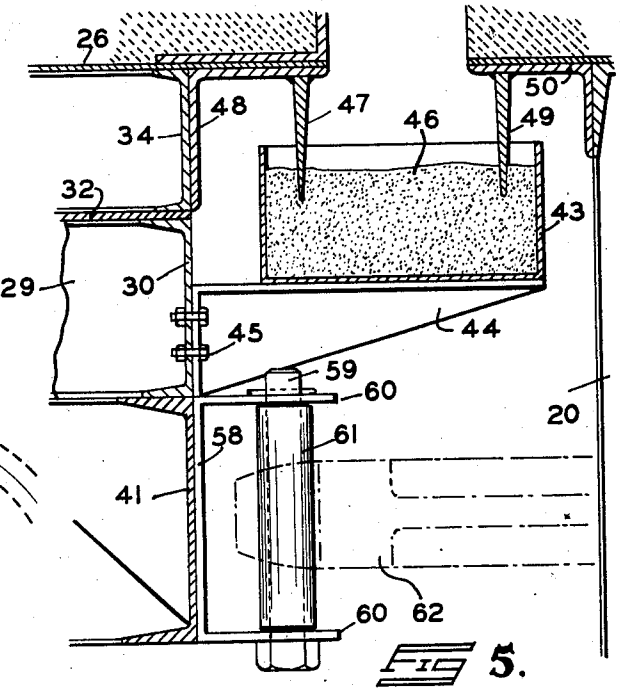


FIG 5.

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2,296,791

ROTARY FURNACE

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18 Claims. (Cl. 263—7)

This invention relates to rotary hearth furnaces and more particularly to improved features of construction of such furnaces, which features are concerned primarily with the support, guiding and driving of the hearth, with the sealing of the movable hearth with respect to the stationary walls of the furnace, and with the construction of baffle or curtain walls which are utilized to divide the furnace chamber into a plurality of zones for control purposes. The primary object of the invention is the provision of such improved features of construction as will enable the furnace to be economically constructed in large sizes and which will permit of the satisfactory operation and maintenance of the furnaces when so constructed.

A further and more specific object of the invention is the provision of an improved arrangement for movably supporting and guiding the rotatable hearth of the structure, which arrangement dispenses with the need of a center guiding post and eliminates the objectionable characteristics attendant the use of flanged and/or tapered rollers or wheels normally employed to support and guide the hearth.

Another object of the invention is the provision of an improved sand seal in a furnace of the rotary hearth type which improvement enables an obstruction to be readily removed from between the relatively movable members of or adjacent the seal without cooling down the furnace or dismantling any substantial part thereof. Heretofore, a principal difficulty encountered in the operation of rotary hearth furnaces, particularly in the larger sizes thereof, has been the accumulation of scale and other debris in the close spaces between the fixed side walls and the edges of the moving hearth at or adjacent the seal therebetween. This accumulation has a tendency to bind the parts, making the continued rotation of the hearth difficult if not impossible, and has the further disadvantage of throwing the hearth out of alignment with respect to its supporting and guiding means thereby making the continued operation and maintenance of the furnace very difficult. These difficulties are overcome by the present invention by providing an arrangement whereby the interstices between the movable hearth and the fixed walls of the furnace at or adjacent the seal may be very readily cleaned of scale and other debris without cooling down the furnace. This is accomplished by making the circular sealing sand trough sectional whereby each short section thereof may be individually removed without disturbing the remainder of the trough and by arranging the space between the hearth and the fixed walls so that when the sand trough therebelow is removed, the space is readily accessible to any simple tool projecting upwardly from below for the purpose of dislodging any material which may be lodged in the space. Upon dislodgment, the material is free to fall downwardly out of the space after which the trough section may be replaced and operation of the furnace continued.

A still further object of the invention is the provision of an improved hearth construction for a furnace of the rotary hearth type and of an improved arrangement for supporting and guiding said hearth whereby the appreciable expansion and contraction which accompanies the operation of such furnaces, particularly in their larger sizes, may be so guided as not to interfere with the continued operation of the furnace and so as to minimize the probability of any damage occurring by reason of the expansion and contraction. Rotary hearth furnaces of the type disclosed herein have been and are being constructed in sizes of one hundred feet or more in diameter and the expansion in diameter of the hearth proper in furnaces of such size has heretofore presented grave problems concerning the maintenance of proper clearances throughout the circumferential extent of the furnace for maintaining continued operation of the furnace. The problem is particularly aggravated if the hearth is unevenly loaded since then that portion of the hearth which bears the heaviest load concentration will tend to move in the direction of slope if tapered supporting rollers are used. If the hearth is guided about a center post, the long length of the struts or spokes extending between the posts and the hearth render difficult the rigid support of the inner side and top walls of the furnace chamber, as is understood in the art. In accordance with the present invention, the hearth assembly consists of a fabricated steel base comprising substantially a ring-like structure which is provided with rollers supported on circular rails or tracks and supported on the base is the refractory hearth proper. The refractory hearth is floatingly mounted on the base structure so that expansion and contraction of the former will not be transmitted to the letter. The hearth base is guided by a multiplicity of circumferentially spaced rollers mounted on vertical axes and arranged to be individually adjusted radially inward and outward.

Yet another object of the invention is the provision of an improved arrangement for driving

the hearth of a rotary hearth furnace which arrangement enables substantial economies to be effected in the construction and maintenance of the furnace. Other objects of the invention include the provision of an improved construction for a curtain or baffle wall employed in a furnace of the rotary hearth type which improved construction reduces the probability of any of the walls failing in service which occurrence would necessitate the shutting down of the furnace and subsequent major repairing. It should now be apparent that the invention seeks to provide such improvements in the construction of a rotary hearth furnace as will enable the furnace to be constructed more economically and will render the furnace more reliable in service.

The above and other objects and advantages of the invention will become apparent from a consideration of the following detailed specification and accompanying drawings wherein there is specifically illustrated a preferred embodiment of the invention.

In the drawings:

Figure 1 is a horizontal section through a furnace constructed in accordance with the teachings of the present invention;

Figure 2 is a fragmentary vertical section taken along the line II—II of Figure 1;

Figure 3 is a vertical section through the furnace along the line III—III of Figure 1;

Figure 4 is a fragmentary horizontal section taken along the line IV—IV of Figure 3;

Figure 5 is an enlarged fragmentary vertical section taken along the line V—V of Figure 1; and

Figure 6 is an enlarged view of a guide roll support and adjusting means.

In accordance with usual practice, the furnace, in its illustrated embodiment, comprises circular inner and outer side walls 10 and 11 and an arched top wall 12 which, together with the movable hearth 13, constitutes the heating chamber of the furnace. A plurality of circumferentially disposed buckstays 14 laterally support the inner wall 10 and the outer wall 11 bears against a series of buckstays 15 which are arranged in a circle, as shown in Figure 1. Interconnecting the top ends of the buckstays 14 and 15 are the struts 16 which, together with the beams 17 interconnecting the lower ends of the buckstays, provide a box-like enclosure for the masonry of the furnace. The side walls 10 and 11 are supported on the circular steel plates 17' and 18, respectively, which plates are in turn supported by the circumferentially spaced colums 19 and 20, respectively. The side walls are each provided with apertures to receive fuel burners 21 which are spaced upwardly of the hearth 13 and are also provided with passages 22 opening into the furnace chamber at points adjacent the hearth 13 to provide for the egress of the products of combustion. The arch of the roof 12 is keyed into the side walls 10 and 11 at 23 and 24, respectively, the time members 16 preventing separation of the walls and collapsing of the roof arch.

In accordance with the present invention, the hearth proper, which is built up of refractory brick 13 and 25, is supported on a metal plate 26 having continuous flanges 27 and 28 extending upwardly from the inner and outer edges, respectively, of the plate 26. Plate 26 rests on a structural steel frame work which includes radially extending members 29, circumferentially extending inner and outer channels 30 and intermediate circumferentially extending beams 31. Supported on this framework is a plate 32 and interposed between plates 32 and 26 are a plurality of concentric beams 33 and channels 34 at the inner and outer edges of the plates. There is thus provided closed insulating air spaces between the plates 26 and 32. Secured to the beams 31 are a plurality of circumferentially spaced journal blocks 35 which journal the supporting rollers 36. The latter are arranged to travel on concentric rails 37 which are supported on concentric beams 38 which span the intervals between successive radial beams 17. A continuous channel 40 is rigidly secured to the inner end of each of the radial beams 29, the channel 40 being positioned immediately below the beams 29 and a continuous channel 41 is similarly attached to the outer ends of each of the beams 29.

To provide a seal between the movable hearth and the fixed side walls of the furnace, a sand trough 42 is carried with the hearth adjacent both its inner and outer edges. As indicated in Figure 4, the troughs are each constructed of separable sections 43, each of which is individually mounted on the channels 30 by means of brackets 44 and removable bolts 45. The trough sections 43 are adapted to be substantially filled with sand 46 into which extends a depending continuous flange 47 supported from the channel 34 by a metal section 48. Also extending into the sand 46 is a depending continuous flange 49 which is carried about the columns 19 and 20 by means of the metal sections 50. It should be apparent that during operation of the furnace, the flanges 49 have relative motion with respect to the sand 46 while the flanges 47 are fixed with respect to the sand since both the flanges 47 and the trough sections 43 are carried with the rotatable hearth. By referring to Figures 3 and 5, it will be apparent that the flanges 47 and 49 are substantially flush with the inner surfaces of the side walls 10 and 11 and with the inner and outer edges of the hearth proper so that the space immediately between the side walls of the furnace and the edges of the hearth extends vertically above the troughs 42. When one of the trough sections 43 is removed, the accumulation of scale and other foreign matter which is loosely lodged in the spaces will fall vertically out of the spaces and any debris which may become tightly wedged in the spaces may be readily removed by any suitable tool since the whole of the spaces is readily accessible. It should be observed that the cleaning of the seal and of the spaces between the hearth and the side walls of the furnace may be accomplished from outside of the furnace chamber.

Supporting rollers 36 have cylindrical tires or rail supporting surfaces as indicated, and to provide means to guide the hearth along its rotary path in the furnace, a multiplicity of circumferentially spaced rollers 51 journaled for rotation about vertical axes are employed for engagement with the continuous channel 40. As shown in Figures 3 and 6, each of the rollers 51 are carried by a frame 52 which is guided in members 53 for radial inward and outward movement. Guides 53 are fixed with respect to the columns 19 in any suitable manner as by being attached to plates 54 which span certain of the columns. The positions of the roll supporting frames 52 are determined by adjustment of screws 55 which have screw-threaded engagement with nuts 56 positioned on either side of the plates 54. It

should be apparent that upon proper adjustment of the screws 55 throughout the circumferential extent of the furnace, it is possible to accurately center the hearth with respect to the fixed parts of the furnace and to maintain proper clearances between the inner and outer edges of the rotating hearth and the inner and outer side walls of the furnace. Moreover, since the hearth is guided throughout the entire circumferential extent of the furnace and along a line closely adjacent the space between the hearth and the inner wall of the furnace, any distortion of the shape or form of the hearth by reason of uneven temperature or loading of the hearth will have a minimum effect on the clearances between the hearth and the fixed side walls since such distortion will be immediately opposed by certain of the guide rollers 51 and if the distortion is excessive, the same will be transmitted to some extent to the fixed inner wall of the furnace thereby insuring the maintenance of sufficient clearance between the parts to enable the operation of the furnace to be continued. This feature is considered to be of substantial importance particularly in furnaces of the larger sizes wherein distortion of the hearth may result in substantial out of line movements of certain portions of the outer or inner edges of the hearth. It should also be understood that the guiding arrangement described herein aids in maintaining the circular shape or concentricity of the hearth over long periods of service.

Secured in back to back relation to the continuous channel 41 is a channel 58 having a multiplicity of readily removable pins 59 spanning its flanges 60. Extending over each of the pins 59 and intermediate the flanges 60 is a wear sleeve 61 which provides teeth to cooperate with a driven sprocket wheel 62 to provide an economical and rugged arrangement for rotating the hearth of the furnace. Pins 59 are readily removable, as indicated, to facilitate replacement of damaged or worn pins and sleeves. Also, by positioning the drive at the outer edge of the hearth, the forces required to be withstood by the driving elements are substantially reduced thereby further contributing to the durability and reliability of the drive.

To provide further accurate control of the heating of the metal objects within the furnace, the furnace chamber is divided into a plurality, for example—seven, of zones A, B, etc., each of which is provided with a thermocouple 63 or other temperature responsive device which through controller 64 controls the supply of gas or other fuel furnished to the burners in the respective zones. In most heating operations, it is usually desirable to begin the heating at lower temperatures and progressively increase the temperature as the metal objects approach the exit door of the furnace. This progressive control is facilitated by dividing the furnace chamber into zones, as explained, by means of baffle or curtain walls 65 which, as shown in Figures 2 and 3, extend downwardly from the roof 12 of the chamber toward the hearth 13 but terminates short thereof, a sufficient interval to allow passage of the objects 65' being heated. In accordance with the present invention, the baffle walls 65 are constructed of a series of superimposed arches 66 each of which is keyed into the side walls 10 and 11 in the same manner as is the arch of the roof 12. The base of the lowermost arch 66 determines the position of the lower end of the baffle wall and spanning the walls 10 and 11 at this point are a pair of spaced parallel water tubes 67. These tubes are provided to support conventional refractory brick work 68 which is filled in between the water tubes 67 and the lowermost arch 66. It has been found that when the baffle or dividing walls of the furnace are constructed in the manner disclosed herein, the same are extremely rugged and durable in service and have no tendency to collapse and interrupt the operation of the furnace, even after long periods of use. The principal weight of the walls is borne by the arches, the expansive forces of which are opposed by the box-like structure provided by the metal sections 14—17. The water tubes carry only the weight of the brick work 68. A similarly constructed wall 70 is positioned between the inlet door 71 and the outlet door 72 of the furnace. Wall 70, however, extends further down toward the hearth 13, as indicated in Figure 2.

To provide for the expansion and contraction of the hearth proper without such expansion and contraction being transmitted to the metal framework of the hearth support, the plate 26 which immediately supports the refractory floor of the hearth is floatingly supported on the beams 33 and channels 34. Thus the hearth floor and its supporting plate 26 is free to expand and contract without affecting the alignment of any of the members of the supporting framework. Plate 26 is provided with a multiplicity of downwardly extending projections 74 which are positioned immediately inward of the inner flange of the innermost beam 33 and thus serve to restrain any undue shifting of the hearth proper with respect to its supporting structure. It should be apparent, however, that the hearth is free to expand in an outward direction without carrying its supporting frame along and without therefore disturbing the relative position of the sand troughs with respect to the fixed walls of the furnace and without altering the clearance between the sleeve 61 and sprocket 62. Thus the furnace is maintained in operating condition regardless of the extent of unevenness in the heating of the hearth or of the extent of expansion or contraction of the hearth.

It should now be apparent that we have provided an improved construction for a metal heating furnace of the rotary hearth type which accomplishes the objects initially set out. By the employment of the principles of the invention, it is possible to economically construct a durable and reliable furnace of the rotary hearth type without limit as to its size or capacity. By enabling the sand troughs to be removed and replaced in sections, the maintenance of the furnace is substantially facilitated. This together with the features of the floating hearth as well as the improvements in the drive and the construction of the zoning walls results in the furnace of better economy and of better operating characteristics than those heretofore devised and constructed.

The above specifically described embodiment of the invention should be considered as illustrative only as obviously many changes may be made therein without departing from the spirit or scope of the invention. Reference should therefore be had to the appended claims in determining the scope of the invention.

Having thus fully described our invention, what we claim as new and desire to protect by Letters Patent is:

1. A metal heating furnace of the rotary hearth type comprising concentric inner and

outer side walls and an annular roof spanning said side walls, an annular hearth intermediate said side walls and guided for rotation about its geometric center, means to seal the spaces between the inner and outer edges of the hearth and the inner and outer walls respectively comprising a continuous flange depending downwardly substantially from the inner face of each of said side walls, a continuous flange depending downwardly from each edge of said hearth, annular sand troughs carried with said hearth adjacent either edge thereof and adapted to receive said continuous flanges, said sand troughs being each constructed of individually removable and replaceable sections, and means to secure said sections to the rotary hearth structure whereby the sections of the troughs may be readily removed and replaced from outside of the furnace chamber.

2. A metal heating furnace of the rotary hearth type having concentric inner and outer side walls and an annular roof spanning the side walls, an annular hearth intermediate said side walls and guided for rotation about its geometric center, the inner and outer side edges of said hearth being cylindrical, the inner portions of said side walls opposite the hearth edges being cylindrical whereby the spaces between the hearth edges and said side walls are substantially uniform in width throughout their vertical extent, a gas seal comprising a sand trough positioned below each of said spaces, said troughs being each constructed of a plurality of individually removable and replaceable sections.

3. A metal heating furnace of the rotary hearth type having concentric inner and outer side walls and an annular roof spanning said side walls, an annular hearth intermediate said side walls and guided for rotation about its geometric center, the inner and outer edges of said hearth being spaced inwardly from the inner surfaces of said side walls to allow for rotation of said hearth, a gas seal comprising a continuous sand trough positioned below each of said surfaces, said troughs being each constructed of individually removable and replaceable sections carried with said hearth, and means readily accessible from outside of the furnace chamber to attach said sections to said hearth.

4. A metal heating furnace comprising concentric inner and outer side walls and an annular roof spanning said walls, an annular hearth intermediate said side walls and guided for rotation about its geometric center, said hearth comprising a supporting framework having continuous superimposed members about both its inner and outer edges, a sectional sand trough detachably secured to the upper of said members at both said inner and outer edges, a plurality of circumferentially disposed vertically journaled guide rolls adapted to engage one of the lower of said continuous members, and a drive rack carried by the other of said lower continuous members.

5. Apparatus according to claim 4 further including means to adjust the position of said guiding rolls radially inward and outward.

6. A metal heating furnace comprising in combination an annular support, upwardly extending buckstays carried by said support and arranged in two concentric circles, a circular wall carried by said support and adapted to abut the inner circle of buckstays, a circular wall concentric with the first mentioned wall and adapted to abut the outer circle of said buckstays, said walls being intermediate the two circles of buckstays, radially extending tie members interconnecting the upper ends of said buckstays, an annular arched roof spanning said concentric walls, an annular hearth intermediate said walls, a plurality of circumferentially disposed vertically journaled guide rolls normally fixed in relation to said inner concentric wall and being adjacent thereto, said annular hearth being provided with a continuous member adapted to engage said rolls whereby said hearth is guided for rotation about its geometric center and its path of movement substantially fixed with respect to said inner and outer concentric side walls.

7. Apparatus according to claim 6 further including means to adjust the positions of said rolls radially inward and outward.

8. Apparatus according to claim 6 further including means to adjust the positions of said rolls individually radially inward and outward.

9. Apparatus according to claim 4 further characterized in that said rack comprises a continuous channel with the legs thereof extending outwardly of the hearth, a plurality of circumferentially spaced vertically disposed pins spanning the two legs of said channel, and a wear sleeve about each pin intermediate said legs.

10. In a metal heating furnace of the rotary annular hearth type means to guide the rotation of the hearth with respect to the concentric inner and outer walls of the furnace chamber comprising a continuous member having a concentric vertically disposed guiding surface carried by said hearth and positioned in close proximity thereto, and a plurality of circumferentially spaced vertically journaled guide rolls normally fixed in relation to said walls and adapted to engage said guiding surfaces.

11. Apparatus according to claim 10 further including means to adjust the positions of said rolls radially inward and outward.

12. A metal heating furnace of the rotary hearth type comprising in combination concentric inner and outer side walls, circumferentially spaced columns supporting said side walls, a circular hearth supporting track intermediate the inner and outer circular groups of said columns, a hearth supporting framework mounted for rotation on said track, means to guide said rotation comprising a continuous member having a concentric vertically disposed guiding surface carried with said hearth, and a plurality of circumferentially disposed vertically journaled guiding rolls adapted to engage said guiding surface and carried by certain of said columns.

13. In a metal heating furnace of the rotary annular hearth type, means to guide the rotation of the hearth with respect to the concentric inner and outer walls of the furnace chamber comprising a continuous member having a vertically disposed guiding surface concentric with said walls and positioned in close proximity thereto, and a plurality of circumferentially spaced vertically journaled guide rolls adapted to engage said guiding surfaces, the guide rolls being carried by one of the relatively movable portions of the furnace, and said continuous member being carried by the other of the relatively movable parts of the furnace.

14. In a metal heating furnace of the rotary annular hearth type, means to guide the rotation of the hearth with respect to the concentric inner and outer walls of the furnace chamber, means to rotate said hearth comprising a continuous

channel member secured to said hearth, a plurality of circumferentially spaced pins spanning the two flanges of said channel, a wear sleeve about each pin intermediate said flanges, and a power driven sprocket wheel adapted to mesh with said wear sleeve.

15. A metal heating furnace of the rotary hearth type comprising in combination concentric inner and outer side walls and an annular roof spanning said walls, a circular hearth supporting track intermediate and below said walls, a supporting framework mounted on said track for rotational movement along a path concentric with said side walls, means to guide said framework for rotation about its geometric center, an annular hearth supporting plate floatingly mounted on said framework, a refractory hearth carried on said plate, and means to maintain the position of the inner portion of said plate with respect to said framework, said means allowing the outer portion of said plate and hearth to expand independently of the framework.

16. A metal heating furnace of the rotary hearth type comprising in combination concentric inner and outer side walls, an annular arched roof spanning said side walls, an annular hearth intermediate said side walls and guided for rotation along a path concentric with said side walls, a baffle wall extending downwardly from said roof but terminating short of the upper surface of said hearth, said baffle wall being constructed of a plurality of superimposed refractory arches positioned immediately below the arch of the roof, a water tube spanning said concentric side walls at the base of the lowermost of said superimposed arches, and refractory brick work interposed between said water tube and the lowermost of said superimposed arches.

17. A metal heating furnace of the rotary hearth type having concentric inner and outer side walls, a roof, and an annular hearth intermediate said side walls and guided for rotation about its geometric center; annular horizontally extending shoulders on said side walls projecting into the furnace chamber above the adjacent edges of said hearth, the inner and outer side edges of said hearth being substantially vertical and depending from the general object supporting plane of the hearth, said side edges being spaced from the surfaces of said walls below said shoulders, and means at the lower ends of the spaces between said walls and hearth edges to seal said spaces against the entrance of outside air.

18. A metal heating furnace of the rotary hearth type comprising in combination concentric inner and outer side walls, an annular roof spanning said side walls, an annular hearth rotatably mounted intermediate said side walls, a plurality of circumferentially spaced baffle walls spanning said side walls and extending downwardly from said roof but terminating short of the upper surface of said hearth thereby dividing the annular furnace chamber into a plurality of controllable zones, means to independently control the temperature in each of said zones, said baffle walls being constructed of a plurality of superimposed refractory arches positioned immediately below said roof, a water tube spanning said side walls at the base of the lowermost of said arches, and refractory brick work interposed between said water tube and the lower surface of the lowermost of said arches.

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