United States Patent

Allen

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[54] SHAFT OR STACK FURNACE AND METHOD AND APPARATUS FOR LINING SAME

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Related U.S. Application Data

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[52] **U.S. Cl.** **263/46,** 264/30, 266/43
[51] **Int. Cl.** **F27d 1/16**
[58] **Field of Search** ..... 263/46; 266/43; 264/30; 110/1 A

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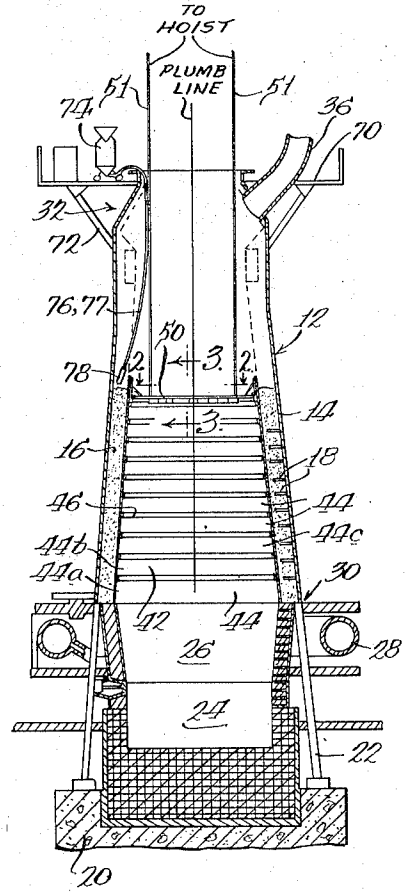
[57] **ABSTRACT**

A stack portion of a furnace having an outer shell is lined with refractory concrete by casting or gunniting the concrete between the stack outer shell and a heat consumable inner form to build up the lining in horizontal layers of stacked integral rings in the absence of appreciable voids or vertical faults. The resulting lining is a monolithic refractory concrete wall capable of withstanding very high temperatures such as in blast furnace use. A suspended and vertically movable platform is provided for supporting ring-shaped form sections spaced inwardly from the furnace shell while the concrete is poured or gunnited from the platform at each pouring level. Laterally or horizontally extensible support members on the platform are used to bridge across the stack interior to provide interior support for the form during pouring.

22 Claims, 5 Drawing Figures



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SHEET 1 OF 2

Fig. 1.

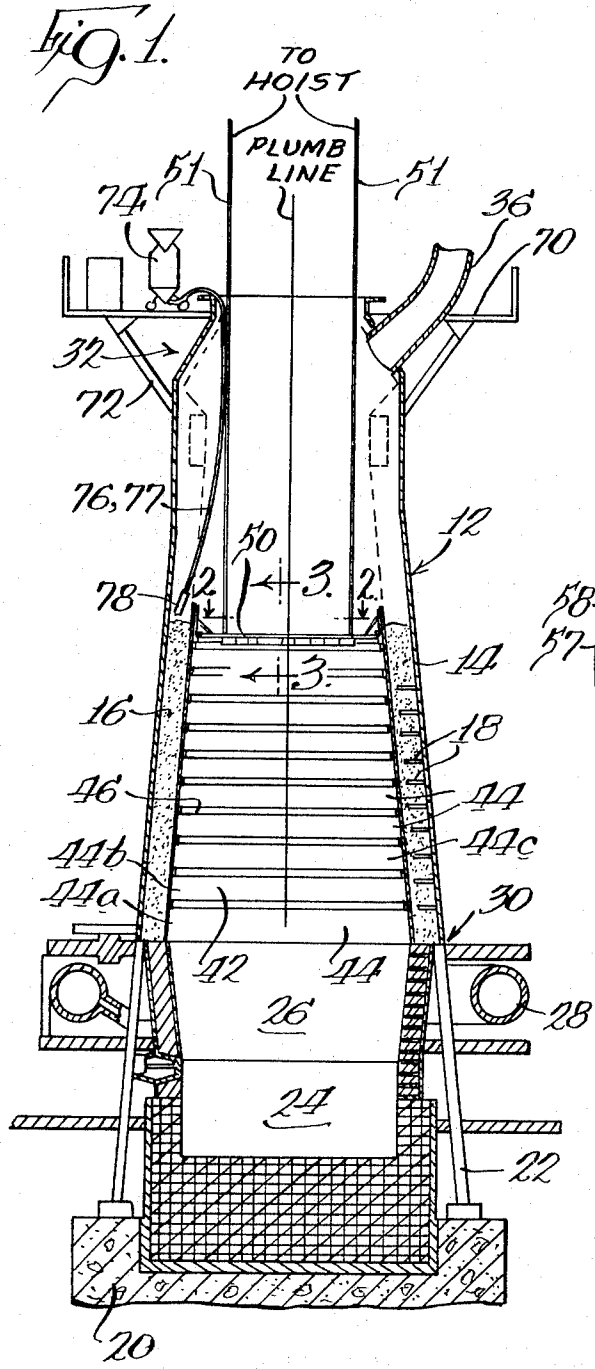

Fig. 2.

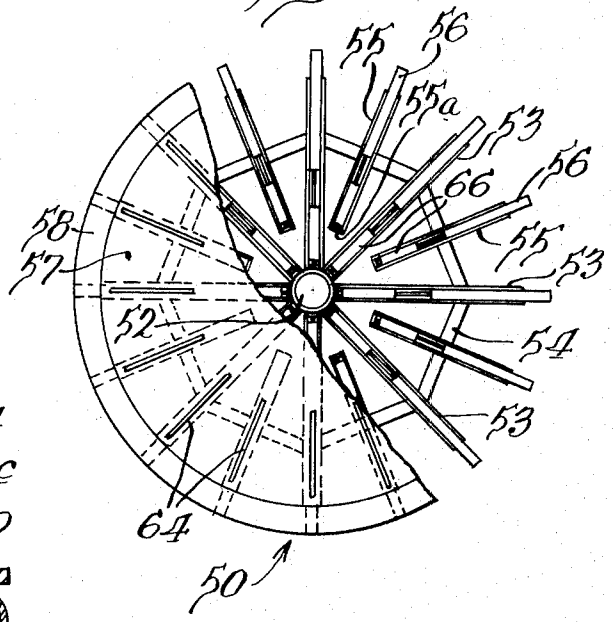

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Fig. 3.

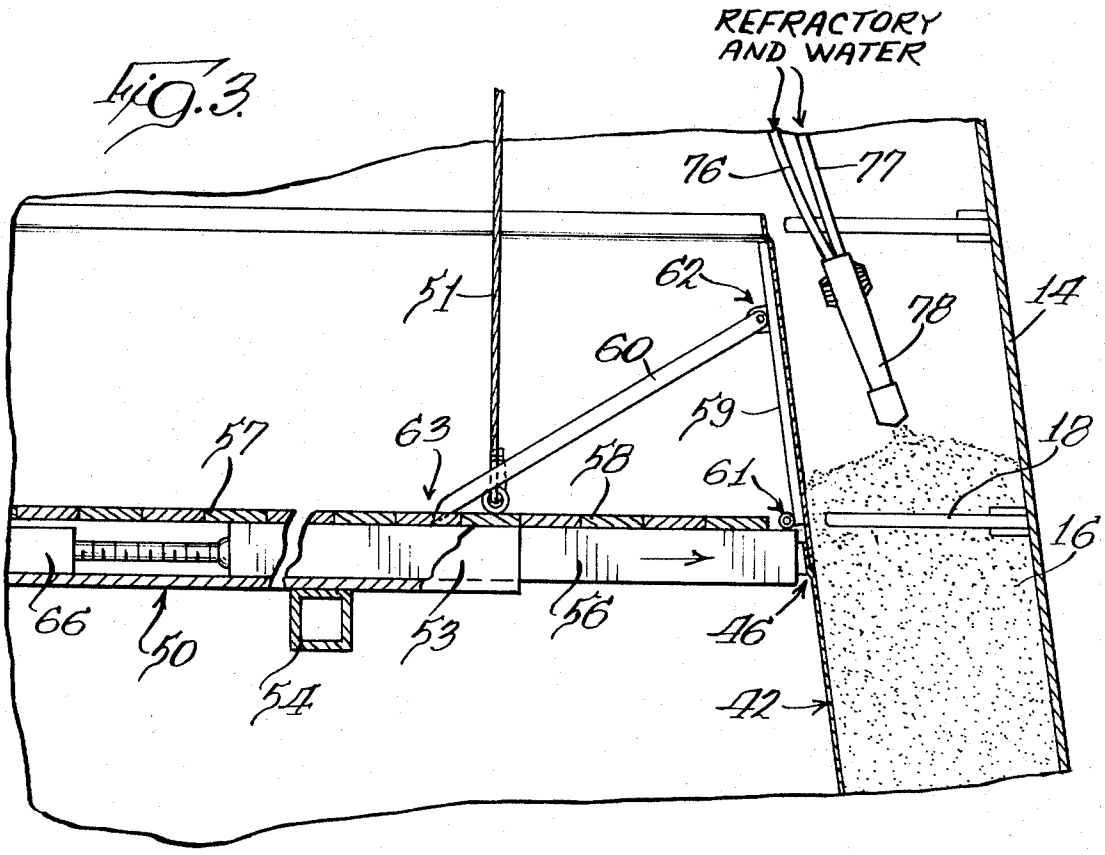


Fig. 4.

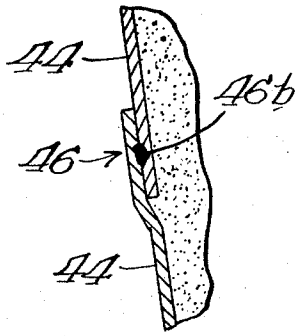
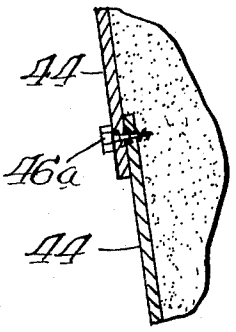


Fig. 5.



SHAFT OR STACK FURNACE AND METHOD AND APPARATUS FOR LINING SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my copending application Ser. No. 13,329, titled "Blast Furnace Stove" and filed Feb. 24, 1970, now U.S. Pat. No. 3,625,494.

BACKGROUND OF THE INVENTION

1.Field of the Invention

This invention relates to furnace stack linings and especially relates to lining of the stack or inwall of a blast furnace.

2.Description of the Prior Art

Pig iron, to be further converted into steel or cast into suitable form for remelting in use in the foundry industry, is conventionally produced in blast furnaces. Such blast furnaces have refractory linings for withstanding the processing heat, abrasion and erosion which are common to iron producing processes. However, such furnaces require periodic relining with refractory materials.

A conventional blast furnace will have a bottom hearth section for holding molten iron and slag and functioning as the bottom or base of the furnace to contain and support all charge material. Just above the hearth area is a bosh zone in which the combustion, melting, refining and final reduction take place. Extending upwardly from the bosh zone is a stack or inwall portion which terminates at its upper end in a dome section. The hearth, bosh and inwall portions of the furnace are lined with refractory which from time to time needs replacement.

Methods of relining blast furnaces are usually by brick laying. The bricklaying techniques have been well developed over the years to include a carefully engineered pattern of standard shapes, formed from various qualities of refractories and fired to specified heats to yield a quality of brick considered best suited for the various sections of the furnace, and laid up in a pattern whereby the joints between each brick are carefully broken and a refractory slurry is used to fill the voids between the brick which are created by the irregularities in size of the brick due to shrinkage and warpage during the firing process. The bricklaying function is a combination of material handling or stocking of the work area and the actual laying of the brick in the prescribed manner by highly skilled tradesmen.

In relining it is common to insert plates or hollow metal coolers in the wall for cooling purposes and to also install the armor or wearing plates. This requires considerable cutting of the brick to accommodate the irregular surfaces of these metal components. The handling of these heavy metal components is normally done by other than bricklaying tradesmen, but in cooperation with the bricklaying crews.

The handling and stocking operations for conventional bricklaying also require additional crew members. Bricks which are precisely made at the brick plants are packaged on pallets and shipped in railroad cars or trucks to the furnace location. The railroad cars or trucks are unloaded by mobile equipment, and the pallets stocked in an area adjacent to the furnace. Generally the pallets are then opened and the brick transferred to roller lines where the bricks are dropped into tubs for hoisting to sites adjacent to the bricklaying tradesmen. At this point bricks are inspected again for broken corners and other defects resulting from the handling procedure. Bricks which do not pass inspection are discarded, usually involving loss of 1 percent to 3 percent of the total bricks, although some savings can be realized by reclaiming some of these rejects to be cut when other than a standard shape is required.

In constructing complete furnace linings the above bricklaying techniques re normally used. At other times only partial replacement or patches are needed in existing linings and this can be done either by bricklaying or by other patching techniques. However, the bricklaying of linings and the patching techniques all result in vertical flaws in the wall. In the case of patches these flaws extend the vertical length of each patch and in bricklaying, the brick is layed in a slurry of refractory cement which results in a plane of weakness at all six surfaces of the brick. Additionally, the brick usually must be fitted into a circular pattern and must be broken to fit around metal cooling or armor inserts used in the wall. Where patching is involved the patching materials often contain air and moisture which produces a coarse patch. Where pressure spray techniques normally known as guniting are used to try to rebuild the inner portion of the lining a portion of the sprayed material rebounds often causing loss of as much as 20 to 50 percent of the material.

Further, almost all of the present lining and patching techniques require the construction of multiple tiers of heavy support platforms or scaffolding within the furnace to support a supply of refractory bricks at various positions adjacent the refractory lining where the bricks are needed. Where linings are to be replaced, hoist platforms, mounted from the top of the furnace, are required for removal of the old lining material. The use of heavy wood scaffolding creates fire hazards during the lining procedure and must be removed from the furnace interior after the lining is complete.

SUMMARY OF THE INVENTION

The method of the present invention involves the construction of a refractory concrete lining in a furnace stack between an outer shell and an inner temporary or consumable form in a plurality of successive pouring steps from the bottom to the top of the stack portion. During each pouring the form is braced across the interior of the stack at a position adjacent the pouring site. The lining is thereby formed as a monolithic refractory concrete body throughout the stack portion in the absence of voids and in the absence of appreciable vertical faults.

Also provided for use in the method of the present invention is a platform which can be lowered into the furnace shaft from the top thereof. The platform is vertically movable between pour positions and has horizontally extensible members for bracing the pouring form against falling into the stack interior during the pouring operation and setting of the concrete. The extensible members and platform floor area are adjustable to accommodate any width of the stack so that the platform is especially useful in upwardly tapered stacks.

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic vertical section through one embodiment of a blast furnace being provided with a lining in accordance with the present invention;

FIG. 2 is an enlarged fragmentary top plan view of a platform useful in providing the lining in the furnace of FIG. 1, from along line 2—2 of FIG. 1;

FIG. 3 is an enlarged section along line 3—3 of FIG. 1;

FIG. 4 is a section further enlarged from FIG. 3 showing the furnace wall liner form in greater detail; and

FIG. 5 is a section as in FIG. 4 showing another embodiment of furnace liner form.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be described particularly with reference to lining or relining the inwall or stack portion of a blast furnace although the invention is applicable to other walls of the furnace such as in the hearth and bosh sections. Referring to FIG. 1, the stack or inwall 12 of the blast furnace extends roughly from the mantle 30 up to the dome section 32 and includes a heavy steel outer shell 14 which functions to

contain the refractory material and to withstand pressures of the process within the furnace. Shell **14** also serves as a support structure for the top assembly of the furnace. The refractory lining **16** of shell **14** is a monolithic lining and includes cooling plates **18** through which cooling water is circulated which assists in cooling and prolongs the life of the refractory material.

In addition to the stack or inwall portion **12**, the illustrated blast furnace includes the normal furnace foundation **20** and supports **22** for supporting shell **14**. Supported on foundation **20** is a mass of bottom refractory brick blocks which form the bottom of the hearth area **24**. Brickwork builds up the sidewalls of the furnace from the bottom blocks through the hearth area **24** and the bosh area **26**. The ring main **28** is provided in its normal location below the mantle **30**. The shell **14** extends from mantle **30** throughout the stack or inwall portion **12** and the dome section **32** where an offtake **36** is provided.

Referring now to FIGS. **1** and **3**, the refractory lining **16** is a monolithic refractory concrete lining contained between the outer shell **14** and an inner skin or pouring form **42** which is of sheet metal, wood fiber, synthetic plastic or other material which can be burned out at the use temperature of the furnace, thereby exposing the refractory concrete **16** as the stack or inwall lining. The form **42** is provided as a series of vertically stacked ring sections **44** (see also FIG. **4**) which have inwardly diverted top edge flanges to telescopically receive the bottom edge of the next higher section **44** as at **46**. Alternatively, the diverted top edge flanges can be omitted as seen in FIG. **5** and the ring sections can be merely facially abutted.

In general, the lining is formed from the bottom up by pouring refractory concrete, e.g., by gunniting, between the shell **14** and the inner pouring form **42**. Accordingly, a first section **44** of the pouring form is positioned spaced inwardly from the shell as indicated at **44***a* (FIG. **1**) and refractory concrete is poured over the lip of the form portion **44***a*. Form **44***a* does not have sufficient strength to retain its shape under the hydrostatic pressure of the concrete so it is braced internally across the stack during pouring of the concrete. Once the concrete has been processed behind form section **44***a* a second form section as at **44***b* is telescopically joined at **46** and secured, e.g., by screws **46***a* (FIG. **5**) or tack welding **46***b* (FIG. **4**) to section **44***b* to provide an additional vertical increment of the form. Similarly form section **44***b* is supported from the interior during pouring of the concrete behind section **44***b*. During pouring, care should be taken to assure that the pour fills all voids, especially around irregular surfaces such as at cooling plates **18**. The cooling plates are preferably supported within and by the poured concrete. This can be accomplished merely by laying the plates in the wall in proper position during or between pours as the wall reaches the proper height where such plates are needed or desired.

Form section **44***c* and the remainder of the form sections are sequentially similarly built up within the stack **12**, followed by a pour of refractory concrete between each section until the wall is complete throughout the vertical extent of stack **12**. It will be noted that stack **12** tapers inwardly through its upward extent and form sections **44** can be prefabricated, e.g., within the stack, to proper configurations to ensure uniform spacing between the shell **14** and the form **44** throughout the vertical extent of stack **12**.

Referring to FIGS. **1** through **3**, a swinging scaffold or support platform **50** is provided for lowering within the furnace from the top thereof, e.g., by hoist driven cables **51**. The support platform **50** is readily adjustable in size from a small diameter capable of passing through the narrowest portion of the lined stack adjacent the dome area to an extended size of sufficiently large diameter to practically equal the diameter of the lined stack at its widest point. In a lining replacement operation, the platform **50** is first lowered into the stack to the top portion for removing the old lining and is incrementally lowered down the stack to various levels for continued removal of old lining and the diameter of the platform can be increased at each level for more convenient access to the work area. Once the fire brick has been removed, the platform is then lowered to the bottom of the stack for use in applying the monolithic refractory concrete lining.

The platform **50** includes a central plumb line hold **52**, for centering around a wire or rigid structural tube, from which a plurality of channel shaped spider arms **53** extend radially. The spider arms **53** have the open side of their channel faced upward. Adjacent the outer ends of spider arms **53** are chordal cross-brace members **54** for supporting the spider arms in proper radial disposition and for additionally supporting intermediate shorter channel arms **55** having inner closed ends **55***a*. Within each of channel arms **53** and **55** is a telescoped sliding beam **56**.

A permanent floor **57** generally circular in shape is secured to and closes the tops of channel arms **53** and **55** and covers the circular area defined by the outer extremities of arms **53** and **55**. A removable or temporary floor **58**, which may be built up of arcuate segments or planks, is provided for covering the sliding beams **56** as they are extended various amounts from the outer ends of arms **53** and **55**.

At the outer end of each beam **56** there is provided an upstanding and inwardly inclined supporting arm **59**, at a proper angle and of a proper length for supporting the ring-like form sections **44**, a brace **60** extends from adjacent the upper end of each arm **59** and is secured to or anchored on the corresponding sliding beam **56** for holding each arm **59** in its properly inclined position. Although in the normal construction the arm **59** and brace **60** will be rigidly secured to each other and to beam **56**, arm **59** can be hingedly connected to beam **56** at **61**, brace **60** can be pivotally connected to arm **59** at **62** and a suitable adjustable abutment such as a toothed surface can be provided on the upper surface of beam **56** at **63** so that the angular disposition of arm **59** can be adjusted.

It will be noted that permanent floor **57** has a central opening forming a portion of the central plumb line hole and also has radial slots **64** for accommodating braces **60** as each beam **56** is extended or contracted from arms **53** and **55**. Each beam **56** is driven inwardly and outwardly within its channel arm **53** or **55** by a jack **66** having one end secured through a ball socket working end of the jack to the beam **56** and the other end secured to and grounded against either the arm end **55***a* or the structural tube **52**. Although mechanical jacks having their operating mechanisms accessible at the top of platform **50**, e.g., through openings in permanent floor **57**, can be used, it is anticipated that hydraulic jacks may be preferable.

In operation of the device, after the old refractory lining has been removed, the platform is lowered to a position about level with the mantle **30** with the beams **56** in their contracted position. The platform is preferably centered within the stack and this can be done by dropping a plumb line down the center of the stack from the top and adjusting the position of platform **50** until the plumb line passes through the center of the central plumb line hold in the platform, i.e., at about the axis of structural tube **52**. The form section **44***a* is placed in proper position and the jacks **66** are operated to extend beams **56** until arms **59** engage against the inner diameter of the form section **44***a* and hold the form section in place. Care should be taken in operating jacks **66** so as not to deform form section **44***a* by an undue outward pressure. Once the beams **56** are extended to support section **44***a*, temporary flooring **58** is laid on the beams to extend the permanent floor **57** radially approximately to the inner surface of section **44***a*.

A top platform **70** is mounted on and suitably braced from the outer shell wall as at **72**. Supported on top platform **70** is a supply **74** of mixed refractory concrete suitable for use in gunniting. The fluid refractory concrete and water are supplied via pressurized lines **76** and **77** to a gunniting nozzle **78** which can be operated from platform **50**. The gunniting nozzle **78** is used to gunnite the concrete behind the form section **44***a* and after the concrete is in place, the next form section **44***b* is placed in its proper position and welded to form section **44***a*. The beams **56** and arms **59** are then pulled away from section **44***a* by operation of jacks **66** and the platform **50** is raised to

position arms 59 for engagement with form section 44b. The arms 59 are again driven out by jacks 66, again controlling the extension of beams 56 a proper amount to facially engage and support form section 44b by arms 59 without deforming it. Because the form sections used in making up form 44 are of a relatively weak material, excessive pressure by jacks 66 should be avoided. Refractory concrete is then gunnited behind section 44b using nozzle 78. The entire operation is then repeated for form 44c and for the remainder of the form sections throughout the upward extent of the stack or inwall 12 to form the monolithic lining 16.

At the top portion of the inwall 12 and in the dome an "armor" or more highly abrasion-resistant section is usually provided to withstand the abrasion and impact of the material charged to the furnace and to resist abrasion of gas-borne solid particles. This can be done by including wearing or abrasion plates in the top portion of the monolithic wall and in the dome. Such plates can be held in the wall structure by the concrete, filling all voids, as in the case of the cooling plates described above. Once the refractory concrete body 16 is complete, and adequate drying performed, the blast furnace is ready for use. The form 44 will burn out from the blast furnace interior during its operation.

The refractory concrete wall may be cast or poured using simple pouring procedures, but it is preferably cast or poured under pressure, by gunniting, and using a drier or low moisture content in the concrete to minimize formation of voids. Because the gunniting technique provides the lower moisture content refractory mixture and in addition develops the denser lining of the two methods, plus provides the most accessible means for conveying the refractory ingredients into the furnace relining work area, it is the preferred procedure. The gunniting method can be practically continuous. As soon as one layer of wall is produced behind a mold form portion, another mold form portion can be positioned and welded or otherwise secured in place and braced and the gunniting can then be continued. The setting of the metal cooling and wearing plates is accomplished by the continual filling in with the gunned or cast refractory both under and above, to form a monolithic wall. Further, the composition of refractory can be varied according to the specific requirement at the various levels in a manner similar to the quality of refractory as specified for brick.

A different concrete composition may be used for the dome lining for greater abrasion resistance if the dome lining is to be gunnited. Alternatively, precast or preformed sections of special refractories or other abrasion-resistant materials may be designed for rapid installation.

Although the refractory concrete can be mixed at the site, it may be advantageous to mix at a remote location or to use a premixed bulk refractory material supplied in containers by a manufacturer of such material. The containers can readily be hoisted to an elevated level, e.g., service platform 70, and charged to the gunniting nozzle or nozzles in use within the stack.

The present method provides the exact configuration designed for that specific blast furnace into which is cast or gunned the refractories. Moreover, spillage or rebound losses of 20 to 50 percent are not experienced since the application or filling of the mold form is in a downward direction. At the same time any planes created by minor changes in material or moisture content or interruption of the continuous application are in a horizontal plane rather than a vertical plane. Further, castable or gunniting types of refractories properly containerized do not become damaged as occurs with fire bonded brick, which are subject to chipping and corner cracks. Another advantage is that handling costs for the materials used are substantially less. The purchase price of castable or gunniting types of refractories is far less costly than conventional fire bonded brick providing equal quality of refractory mass and the installation of castable or gunniting refractories requires less skilled labor for the same mass of refractory material installed. This is significant as both the cost and availability of bricklaying tradesmen are a serious factor with each advancing year.

Castable or gunniting types of refractories are chemically bonded to form a monolithic construction of the blast furnace lining while brick creates a succession of joints and voids filled with a refractory slurry. The fit around the cooling plates and wearing plates is solid and free of voids when refractory concrete is used while hand cut pieces of brick and refractory slurry do not provide a monolithic void-free mass. The time required to install a blast furnace lining in the manner described herein is approximately one-half the time required for brick laying. This factor permits less off time and greater utilization of the productive potential of the furnace.

I claim:

1. A method of lining a vertically extending portion of the stack of a furnace such as a shaft furnace having an outer structural shell, which method comprises constructing within said stack a concrete pouring form spaced inwardly and generally parallel with said shell, bracing said form across the interior of said stack at a plurality of vertically spaced positions between the top and bottom of the stack, and pouring at each of said plurality of positions a complete vertical extent of the liner within said stack portion extending circumferentially of the form filling all voids between the form and shell to provide a monolithic refractory concrete body throughout said portion of the stack and in the absence of appreciable vertical faults, said constructing, bracing and pouring steps each comprising a plurality of sequential operations involving constructing a first vertical extent of the form at the bottom of the stack portion, bracing the first vertical extent of the form, constructing a second vertical extent of the form contiguous with said first vertical extent at the top thereof, bracing the second vertical extent and pouring over the lip of the second vertical extent and repeating the constructing, bracing and pouring steps to form sequential contiguous vertical extents of the firm upwardly alternating with the forming of horizontal layers of the line between these extents and the shell during separate pouring steps until the concrete lining is formed as a contiguous incremental vertical lining throughout said vertically extending portion of the stack, and each pouring step comprises delivering the concrete under pressure to form each horizontal layer.

2. The method of claim 1 wherein the bracing steps comprise providing a vertically movable support platform suspended from the top of the stack within the stack bracing each vertical extent of the form outwardly from said platform while pouring the concrete over the lip of the form portion from the platform and thereafter moving the platform upwardly and bracing each additional vertical extent of the form while pouring over the lip of each vertical extent from the platform.

3. The method of claim 2 including the step of removing old refractory lining within the stack prior to the constructing step.

4. The method of claim 2 wherein said bracing step comprises extending a plurality of bracing means at positions spaced around said platform and in a direction peripherally of said platform.

5. The method of claim 1 wherein said stack portion is generally cylindrical and where each pouring step provides a horizontal ring of refractory concrete thereby producing a lining of vertically stacked horizontal rings.

6. The method of claim 5 wherein said form comprises a series of stacked cylindrical sections, one for each of said rings.

7. The method of claim 1 wherein the processing step is by gunniting.

8. The method of claim 1 wherein said form is of a material consumable by burning and including the step after setting of the concrete of burning out the form to expose the refractory concrete lining.

9. A shaft furnace having a stack with an open center including a hearth area, a bosh area and a portion extending upwardly therefrom to a dome section, comprising: a foundation,

an erect outer structural shell, a base of refractory material covering the foundation beneath the hearth area, a refractory lining for said shell defining the stack lining from the foundation to the dome section including a monolithic refractory concrete body circumscribing at least a portion of the open stack center and defining a vertical extent of the stack lining in the absence of appreciable vertical faults in said body, an inner skin layer defining a pouring form for the concrete, a support platform supported from the top of the shaft and provided with means for holding the inner skin against movement inwardly within the stack during pouring and setting of the concrete, and means for moving the platform through a plurality of vertically spaced positions with the stack, said skin holding means comprising a plurality of radially adjustable means extending peripherally from the platform.

10. The shaft furnace of claim **9** wherein said concrete is pressure poured and fills all voids between the shell and inner skin form.

11. The shaft furnace of claim **9** wherein said skin is nonstructural and is supported by braces internally of the stack during pouring and setting of the concrete.

12. The shaft furnace of claim **11** wherein said inner skin is consumable by burning at the use temperature of the furnace.

13. The shaft furnace of claim **9** wherein said skin defines a tube of varying diameter along the length of said concrete body, said skin holding means comprises a plurality of radially movable adjustable members mounted on the platform for supporting the skin at the various skin tube diameters, and said moving means comprises hoist driven cables, and including a top platform mounted on the outer shell wall exteriorly of the stack, a supply of mixed refractory concrete on said top of platform and means for delivering the mixed concrete from said top platform to said support platform.

14. The shaft furnace of claim **9** wherein said refractory concrete body is in the absence of voids.

15. The shaft furnace of claim **9** including cooling plates extending into the concrete body.

16. The shaft furnace of claim **9** wherein said refractory concrete body comprises a plurality of stacked horizontal ring pours.

17. A device for use in supporting personnel and equipment in a stack during the construction or replacement of a lining with poured refractory concrete in a stack furnace such as a blast furnace or an air heater for a blast furnace having an outer shell to be lined with poured concrete, said device comprising a support platform, means for supporting, lowering and raising the support platform within the stack from the top thereof, and adjustable means extending peripherally from the platform for holding and bracing concrete pouring forms from inward movement at positions spaced inwardly from the furnace shell during pouring of concrete between the forms and the shell.

18. The device of claim **17** wherein said adjustable means includes removable floor means for extending the platform area.

19. The device of claim **17** for lining a stack furnace with a lining having a varying cross-section throughout its vertical extent, wherein the support platform is of an appropriate size for bypassing the most restricted area of the pouring forms and wherein said adjustable means comprises means extensible from the support platform periphery to various positions for supporting the forms at each vertical position of different cross-section.

20. The device of claim **17** wherein said adjustable means comprises a plurality of radially movable members.

21. The device of claim **17** wherein said supporting, lowering and raising means comprises hoist driven cables.

22. The device of claim **17** including a top platform secured to the outer shell wall, means defining a supply of mixed refractory concrete on said top platform and means for delivering said mixed concrete from the platform to the support platform.

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