July 13, 1971 B. R. THOMPSON ET AL 3,592,742

FOUNDATION COOLING SYSTEM SOLE FLUE COKING OVENS

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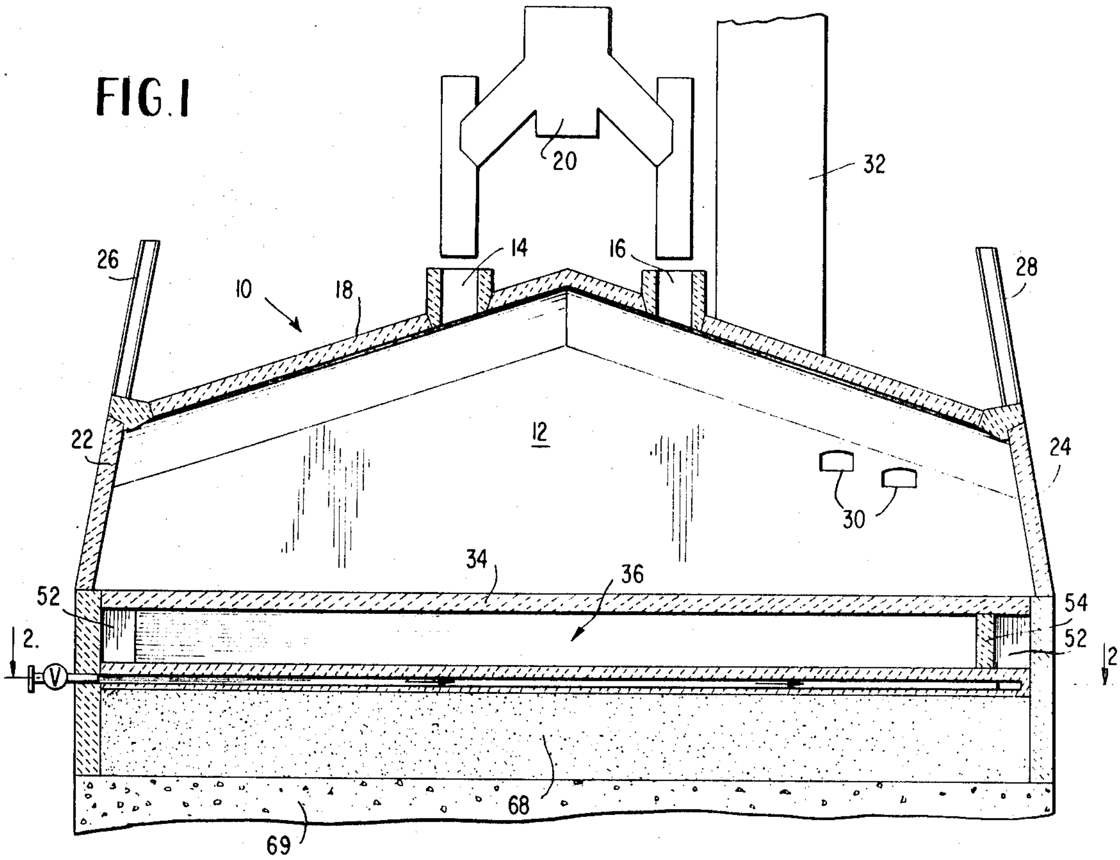
FIG. 1



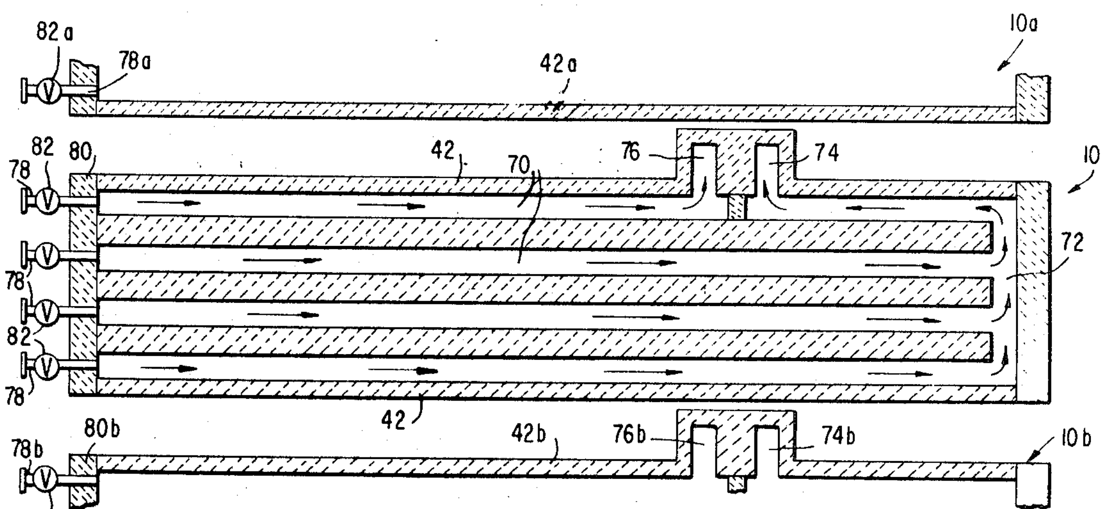


FIG. 2

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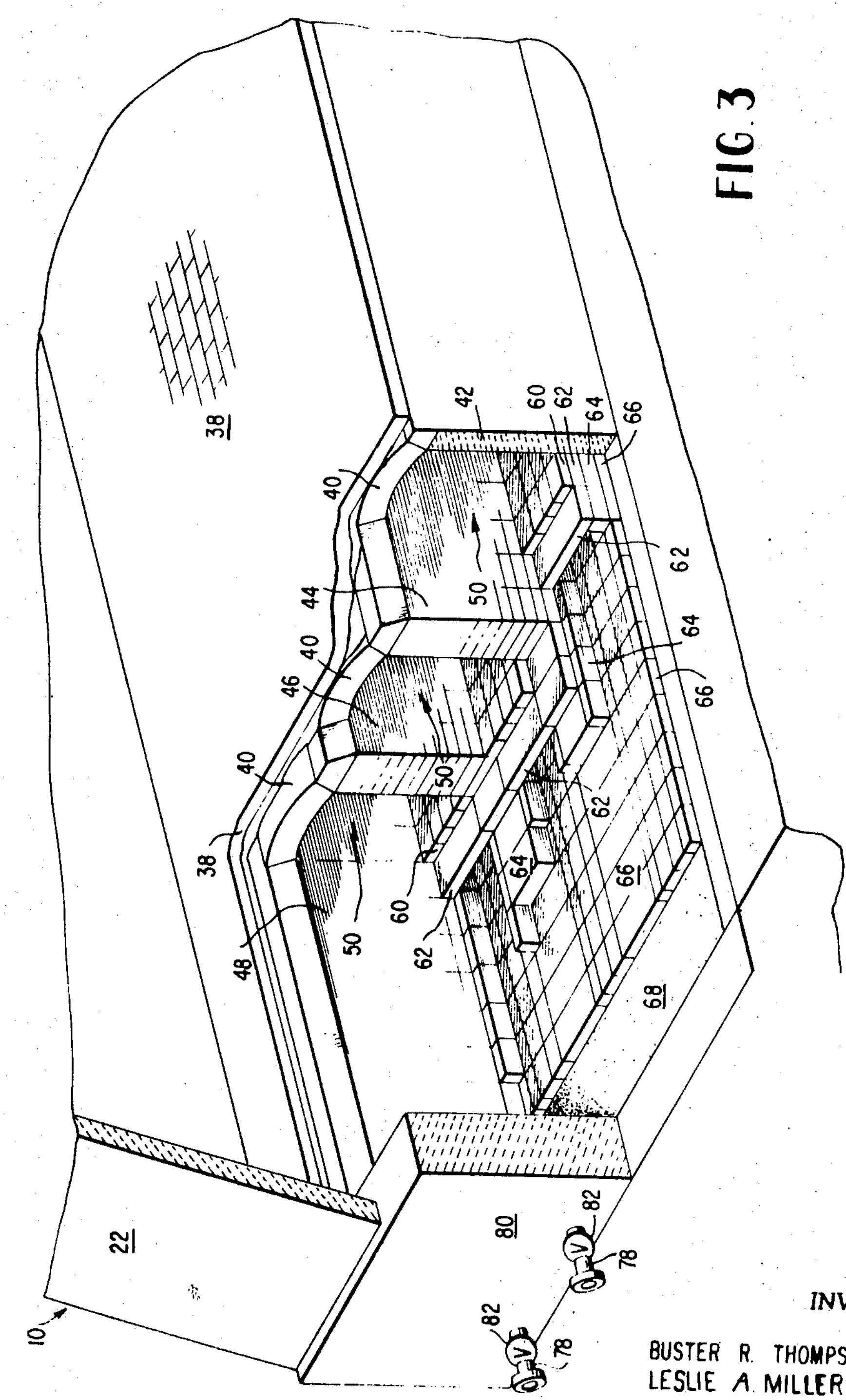

FIG. 3

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FOUNDATION COOLING SYSTEM SOLE FLUE COKING OVENS

Filed Jan. 2, 1970 4 Sheets-Sheet 3

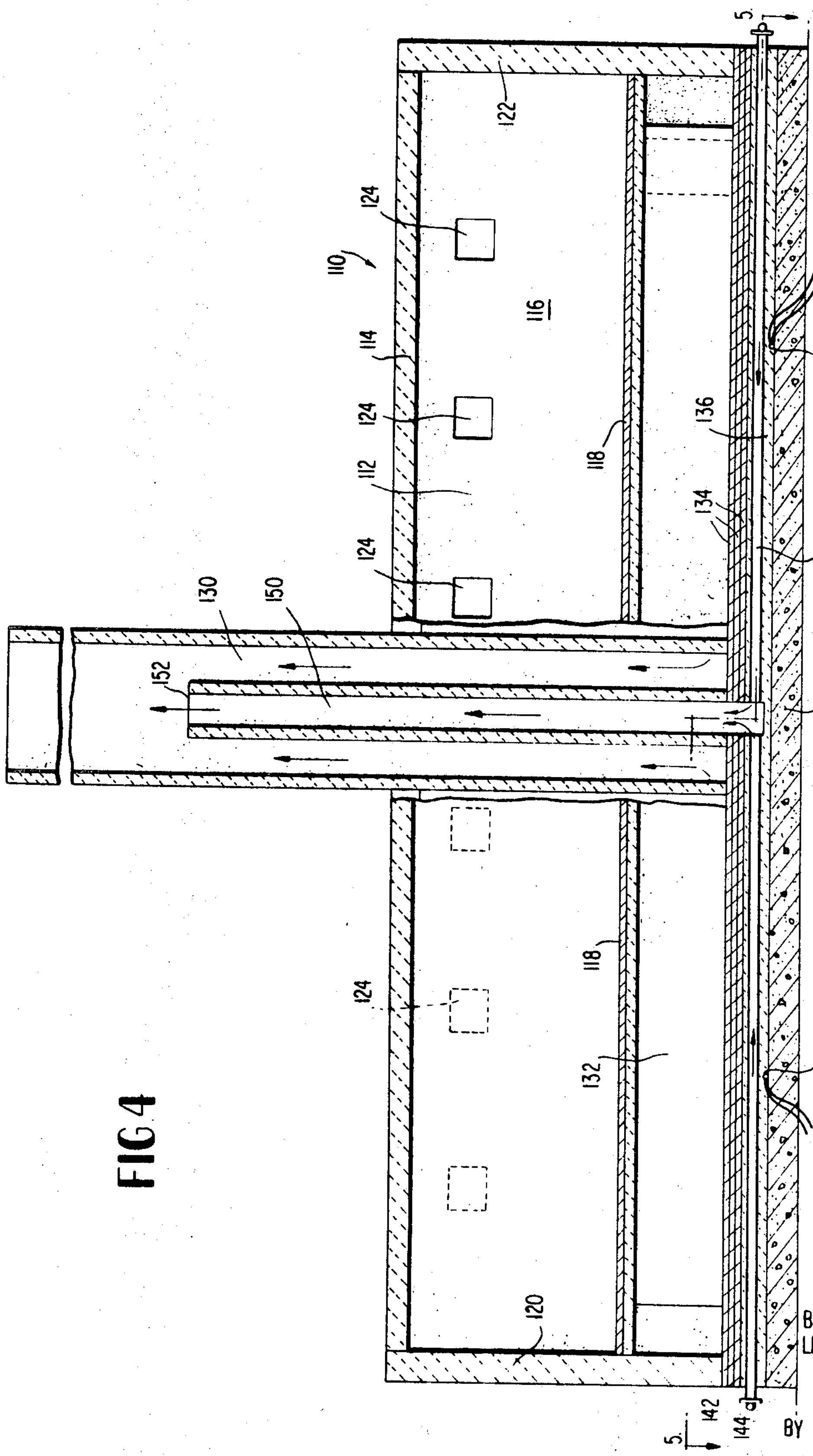

FIG 4

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FOUNDATION COOLING SYSTEM SOLE FLUE COKING OVENS

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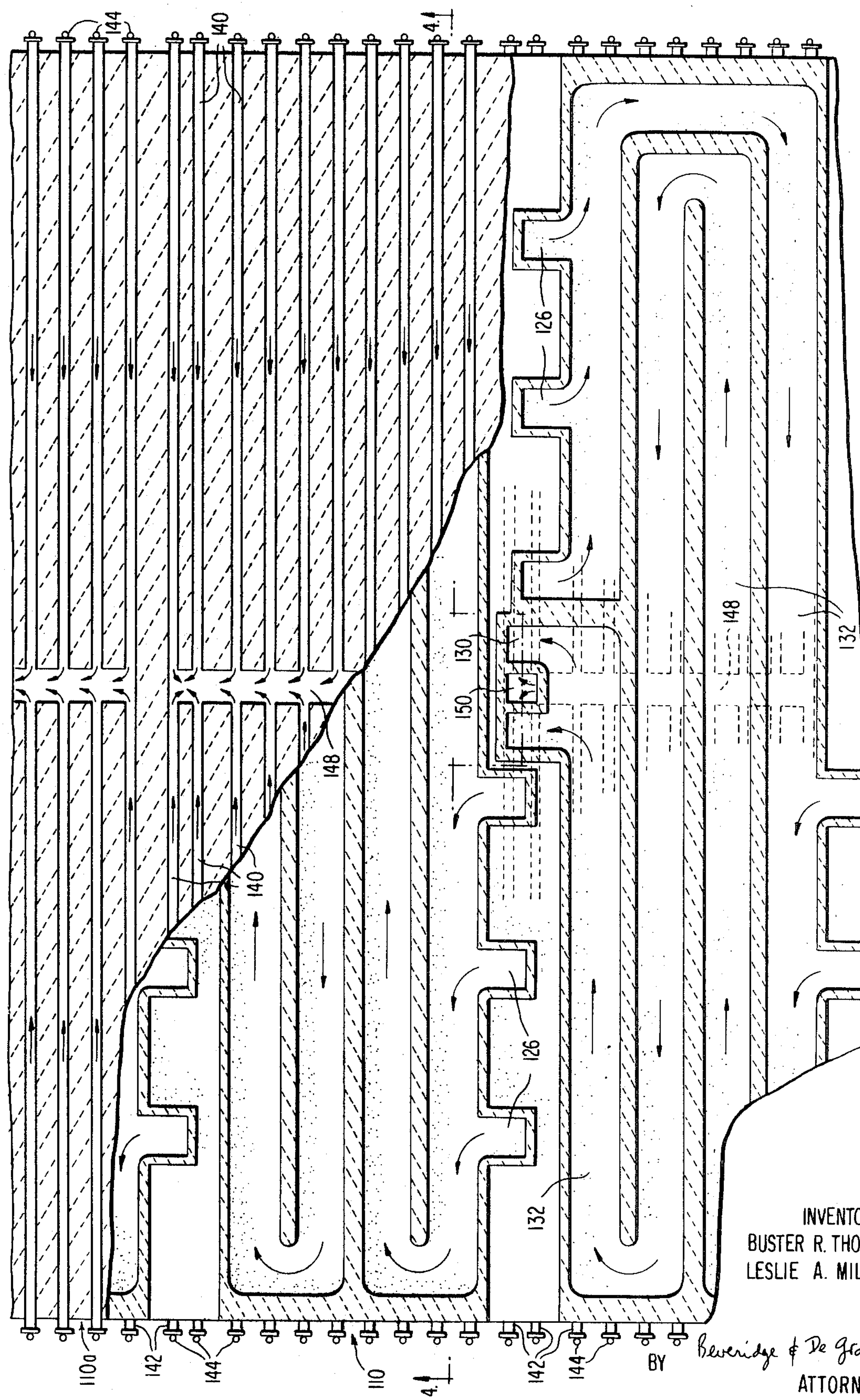

FIG 5

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FOUNDATION COOLING SYSTEM FOR SOLE FLUE COKING OVENS

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Continuation-in-part of application Ser. No. 660,322, Aug. 14, 1967. This application Feb. 6, 1970, Ser. No. 9,333
Int. Cl. C10b 5/06
U.S. Cl. 202—102 15 Claims

ABSTRACT OF THE DISCLOSURE

A cooling system for the support structure of a coking oven having a plurality of heating flues extending beneath the floor to supply heat to the coking chamber. A plurality of air ducts, or tunnels extend beneath the sole flues in the oven support structure and one into the oven stack to draw cooling air through the support structure beneath the sole flues and discharge it directly into the waste gas in the stack to reduce the temperature of the support structure.

This is a continuation-in-part of copending application Ser. No. 660,322, filed Aug. 14, 1967, now abandoned.

This invention relates to sole flue coking oven, and more particularly to an improved sole flue coking oven having means for inducing a flow of cooling air through a system of tunnels, or ducts, formed in the flue support structure to limit the extent to which the intense heat of the sole flues penetrate the oven foundation.

It is known in the art to construct coking ovens with a system of heating flues, commonly referred to as sole flues, extending beneath the floor of the coking chamber, or oven, to supply the heat necessary to operate the oven. It is also known to construct regeneration coking ovens with sole flues and to preheat the air necessary for combustion by passing the air through twyers along the sides of the flues to thereby increase the temperature in the flues. In the coking of coal and other carbonaceous material in such ovens, whether regenerative or nonregenerative, it may be necessary to maintain the temperature in the sole flues as high as 3000° F. for prolonged periods of time. This intense heat, necessary to the coking process, is highly deleterious to the oven structure and particularly to the structure beneath the flues because of its great capacity for the retention of heat absorbed from the sole flues. This heat quickly penetrates the foundation and earth beneath the flues to substantial depths and, although efforts have been made to minimize the adverse effect of this heat penetration, it has, nevertheless, frequently resulted in premature over failure. This failure may be in the form of cracking or disintergration of concrete foundations or other support structure as a direct result of the heat absorbed, or may merely be a result of the drying and consequent cracking and shrinking of the earth beneath the oven support structure with the result that the entire oven structure may be destroped. Since the construction of a single layer modern coking oven costs many thousands of dollars, the magnitude of this problem of foundation failure becomes apparent, particularly, when it is considered that such oven which may all have to be replaced at once.

Applicant has found that the adverse effect of the high flue temperature on the supporting structure can be substantially eliminated by controlling the amount of heat which is permitted to penetrate the layers of heat-resistant ceramic tile, brick, or other refractory material (sometimes referred to hereinafter collectively as refractory brick) normally employed in the foundation structure beneath the sole flues. This is accomplished by providing a system of ducts or tunnels extending through the refractory structure of the foundation, and by providing fluid communication between the tunnels and the oven stack so that the stack applies a draft, or sub-atmospheric pressure to the tunnels. Ambient cooling air is admitted into each of the tunnels and permitted to flow therethrough and be discharged into the waste gas in the stack. Thus, there is a continuous flow of cooling air through the tunnels to carry off excess heat from the foundation structure during operation of the oven.

It has been found that a relatively low velocity flow of cooling air through the tunnels will greatly reduce the intensity of the heat which penetrates beneath the refractory material. By providing a plurality of relatively closely spaced tunnels, sufficient volume of this low velocity air will be drawn through the system to absorb and carry off the excess heat from the foundation structure. Draft control regulators, or valves, may be employed to control or vary the volume of air admitted into the individual tunnels, and thermocouples may be employed in the foundation structure to indicate the temperature of the structure. Thus, the primary object of the present invention is to provide an efficient and economical means for controlling the temperature of the structure beneath the flues of a sole flue coking oven.

Another object is to provide an improved sole flue coking oven including a cooling system for its foundation which will protect the foundation from the adverse effects of heat adsorption and penetration, and thereby prolong the life of the oven.

Another object is to provide such a cooling system which makes practical the construction and operation of substantially larger coking ovens than those previously employed.

Other objects and advantages of the present invention will become obvious from the following specification, taken with the drawings, in which:

FIG. 1 is a fragmentary sectional view, in elevation, of a sole flue coking oven embodying the present invention;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a fragmentary perspective view of the coking oven shown in FIG. 1, with parts of the oven broken away to more clearly illustrate other parts;

FIG. 4 is a sectional view, in elevation, taken along lines 4—4 of FIG. 5, and illustrating one of a series of large ovens embodying the invention; and

FIG. 5 is a fragmentary sectional view taken along lines 5—5 of FIG. 4.

Referring first to the embodiment of the invention illustrated in FIGS. 1–3, a coking chamber **12** having charging ports **14, 16** in its roof **18** for receiving a charge of coal or other carbonaceous material from a filling mechanism **20**. Opposed ends of the coking chamber are closed by doors **22**, **24**, which may be moved vertically on tracks **26**, **28**, respectively, to permit a charge of coke to be pushed from the oven **12**. A pair of ports, illustrated at **30**, provide passage from the oven for gasses produced during the coking process, which gasses are then led into the sole flues where they are burned to provide heat for the coking process.

A plurality of coking ovens of this general type are normally constructed simultaneously, with the individual ovens being joined in a row in side-by-side relation, as indicated schematically by ovens **10**, **10*a*** and **10*b*** in FIG. 2. A stack **32**, constructed between adjacent ovens, provides a draft for the sole flues to convey the waste hot flue gasses therefrom in the conventional manner.

The floor **34** separates the coking chamber **12** from the sole flues, indicate generally at **36**. The upper surface of the floors **34** is made up of a layer of heat resistant ceramic or refractory brick **38** supported on the refractory block ceiling **40** of the sole flue.

As best seen in FIG. 3, the floor **34** is supported along its side edges by the oven walls **42**, and at spaced intervals intermediate its side edges by a plurality of refractory bricks walls **44**, **46**, **48**. The oven walls **42** cooperate with the walls **44**, **46** and **48** to define a plurality of parallel, generally rectangular tunnels **50** extending longitudinally of the oven beneath the floor **34**. The tunnels **50** are interconnected at opposed ends of the oven structure, as by openings **52** and transverse walls **54** (see FIG. 1), to define the sole flue of the furnace. This sole flue extends back and forth longitudinally of the oven beneath the floor **34** to provide a continuous path in which the fuel, including gasses produced in the oven, is burned to heat the oven. The flue terminates in an opening (not shown) near the base of the stack **32** so that the waste hot flue gasses pass directly into the base of the stack and are discharged into the atmosphere at a point high above the top of the oven.

Referring again to FIG. 3, the support structure beneath the sole flue comprises a plurality of layers of refractory brick including a top layer **60**, an upper intermediate layer **62**, a lower intermediate layer **64** and a bottom layer **66**. The bottom layer **66** is supported on the top surface of a bed **68** of sand, which, in turn, may be supported either directly on the earth or on a suitable concrete foundation structure **69** as illustrated in FIG. 1. The layer **68** of sand is preferably approximately one foot thick, and its primary function is to act as a heat insulator. Alternatively, the bottom layer may be supported directly on a concrete foundation without the insulating layer of sand.

Still referring to FIG. 3, it is seen that the layer of refractory brick **60** forms the bottom surface or floor of the sole flue while the upper intermediate layer **62** acts both as a support for the layer **60** and as a heat barrier between the sole flue and the structure therebelow. The refractory brick of lower intermediate layer **64** are arranged to provide a series of tunnels **70** extending longitudinally of the oven, with a tunnel **70** being positioned directly beneath each tunnel or channel **50** of the sole flue. A cross channel **72** is provided at one end of the oven to interconnect each of the tunnels **70**, and a pair of openings **74**, **76** (see FIG. 2) are provided in one of the walls **42** of the oven to provide communication between the base of the stack **32** and one of the tunnels **70** so that the draft in the stack, acting through the openings **74**, **76** in communication with the channels **70** provides a subatmospheric pressure within the channels **70**.

At the end of the oven opposite the channels **72**, a plurality of pipe segments **78** are mounted in and extend through the end foundation wall **80** of the oven. The pipes **78** are arranged in the wall **80** so that a pipe segment **78** has its inner end in communication with each of the cooling air tunnels **70**. A valve or draft control regulator **82** is provided in each of the pipe segments **78** to provide means to control the flow of air through the pipe segments **78** into the respective tunnels **70**.

As illustrated in FIG. 2, the high vacuum present in the base of the stack **32** during operation of the coking oven will apply a subatmospheric pressure through the channel **74** and **76** and cause a flow of air through the individual pipes **78** from outside the coking oven to cool the refractory brick sub-structure of the oven and be discharged directly into the oven stack. The volume, and consequently the velocity, of air flowing through the respective tunnels **70** may readily be controlled by the valves **82** to provide the desired degree of cooling of the sub-structure while, at the same time, limiting the amount of air flowing into the base of stack. By maintaining the cross-sectional area of the tunnels **70** relatively large, the velocity of air flowing through the tunnels may be kept relatively low to thereby minimize erosion of the refractory brick.

The above described system has been found capable of maintaining the temperature in the structure beneath the tunnels **70** as low as 800° to 1000° F., even after operating the oven for prolonged periods with temperatures in the sole flues ranging up to 3000° F. The system is automatic in operation, is substantially trouble free, and requires no forced air system. Tests of ovens incorporating this cooling system for more than three years have shown that sub-structure failures resulting from heat penetration may be virtually eliminated by this relatively simple cooling system. During this period, no oven failures resulting from heat penetration has occurred in ovens having the cooling system, while ovens of similar construction and on similar terrain in the same geographical location, but without the cooling system, have failed.

The coking ovens illustrated in FIGS. 4 and 5 are believed to be the largest in the world. These ovens, as constructed, have an overall length of 53 feet and a width of 14 feet, measured cold. The coking chamber, cold, measures 50 feet in length and 11 feet in width. The weight of this structure, when combined with a full charge of coal, is such that, if the substantial shrinkage of earth beneath the foundation incident to the operation of a conventional sole flue oven were encountered, the foundation would surely fail.

The structure illustrated in FIGS. 4 and 5 is quite similar in function and operation to that of the somewhat smaller ovens shown in FIGS. 1–3. The large oven, indicated generally in FIG. 4 by the reference numeral **110**, includes a coking chamber **112** defined by a top wall **114**, opposed vertically extending side walls **116** and a floor **118**. Chamber **112** is adapted to be charged and emptied through end doors **120**, **122** by use of an external charging and leveling mechanism, not shown. The hydrocarbon and other gasses produced during the coking process pass from chamber **112** through a plurality of ports **124** and vertical conduits in walls **116** to the sole flues where the gas is burned to provide heat for the coking process.

As is conventional, a plurality of ovens **110** are normally constructed simultaneously, with the individual ovens joined in a row in side-by-side relation, as indicated schematically in FIG. 5 by ovens **110**, **110*a*** and **110*b***. A stack **130** constructed between adjacent ovens provides a draft for the sole flue to convey the waste hot flue gasses therefrom in the conventional manner. The floor **118** separates the coking chamber **112** from the sole flues **132** as indicated in FIG. 4.

Still referring to FIG. 4, it is seen that the foundation structure beneath the sole flue comprises a plurality of layers including a first layer consisting of three courses of refractory brick **134** supported on the top surface of a poured slab or layer of castable refractory material **136**. The poured refractory slab **136** is, in turn, supported on a continuous reinforced concrete slab **138** which, in turn, may be supported by a course of gravel or sand over earth fill, not shown. In the large ovens, which have been constructed, the three courses **134** of refractory brick are each approximately three inches thick, so that collectively they provide a nine-inch replaceable floor for the sole flues. The layer **136** of castable refractory material is 12 inches thick and the reinforced concrete slab **138** is 10 inches thick.

To cool the foundation structure, a plurality of parallel conduits **140** are cast in the castable layer **136** of refractory material. These conduits **140** extend the length of the oven and project outwardly therefrom at each end, as indicated at **142**. A draft control regulator **144** is mounted on the projecting end of each conduit to control the amount of air which is permitted to flow through the cooling system. It is contemplated that the draft control regulators **144** may be manually operated, either individually or in small groups, or automatically controlled in response to signals from thermocouples indicated schematically at **146** cast in the layer of castable refractory material **136**. In the existing ovens, the conduits **140** have six-inch inside diameters, and there are ten conduits beneath each oven.

A tunnel **148** is formed in the layer **136**, and extends transversely of the oven foundation joining the midsections of each of the conduits **140**. Tunnel **148** extends into the base of the stack **130** and is connected to a vent tube, or uptake **150** which extends upwardly within stack **130** to terminate in an open end **152** positioned within the stack at a point above the top of the coking chamber **112**. Thus, during operation of the oven, the reduced pressure within the stack **130**, in combination with the venturi effect of the hot flue gasses moving upwardly in the stack past the open end **152** of uptake **150**, applies a partial vacuum within the uptake which, in turn, causes a flow of air through tunnel **148** and the individual cooling conduits **140**. Further, the height of the uptake **150**, which in the case of the existing 50-foot ovens is approximately 23 feet, is sufficient to provide a chimney effect for the heated air within the conduits **140** to provide a flow of cooling air through the foundation structure for a substantial period after the oven is shut-down.

During operation of the oven, the addition of a substantial volume of preheated air into the stack gasses at a point substantially above the sole flues assures an adequate supply of oxygen to complete combustion of any hydrocarbon material in the flue gasses which are not completely consumed in the flues, thereby reducing pollution in the air in the vicinity of the coking oven. However, the substantial volume of the flue gasses, in comparison with the cooling air discharged from the uptake, in combination with the preheating of the cooling air before it is discharged into the stack, avoids any substantial quenching effect in the stack so that the draft is not materially affected by the discharge of the cooling air into the stack.

From the above, it should be apparent that the primary function of the cooling system of this invention is to absorb excess heat which penetrates into the foundation structure beneath the sole flues, and to carry this heat from the structure. The cooling system operates completely independently of the flues except that the stack which carries off the waste gasses and products of combustion from the flues also is employed to induce a flow of cooling air through the system.

We claim:

1. A cooling system for the foundation of a non-regenerative coking oven having a system of sole flues extending beneath the floor of the oven for supplying heat to the floor for coking carbonaceous material in the oven, a stack communicating with said sole flues for conveying waste hot flue gases therefrom, and a foundation beneath said flues, said foundation including a base consisting of a plurality of layers of heat-resistant refractory material, said cooling system comprising at least one elongated cooling tunnel formed in one of said layers, means independent of said sole flues providing fluid communication between said stack and said at least one tunnel providing a subatmospheric pressure in said tunnels during operation of said coking oven, and inlet means for admitting ambient air into each of said tunnels, said sub-atmospheric pressure causing a flow of air through said at least one tunnel from said inlet means into said stack during operation of said oven to cool said foundation.

2. A cooling system as defined in claim **1** wherein said inlet means comprise regulating means for controlling the volume of air admitted to said tunnels.

3. A cooling system as defined in claim **2** wherein said system of sole flues comprises a plurality of generally parallel flue passages extending longitudinally of said coking oven and wherein said cooling system includes a plurality of tunnels with at least one tunnel positioned beneath each of said flue passages.

4. A cooling system as defined in claim **3** wherein said foundation comprises top and bottom layers and at least two intermediate layers of heat-resistant brick, with at least one of said intermediate layers overlying and covering said cooling tunnels.

5. A cooling system as defined in claim **4** wherein said inlet means comprises separate regulating means for controlling the volume of air admitted to said tunnels individually.

6. A cooling system as defined in claim **5** wherein said foundation further comprises a bed of sand beneath said layers of refractory brick, said bottom layer being supported on the upper surface of said bed of sand.

7. A cooling system as defined in claim **1**, wherein said cooling system includes a plurality of cooling tunnels extending longitudinally of said oven in substantially parallel spaced relation to one another, and wherein said means providing fluid communication between said tunnels and said stack includes a duct extending substantially perpendicular to said tunnels in one of said layers and terminating in an open end in said stack.

8. A cooling system as defined in claim **7** wherein said means providing fluid communication between said tunnels and said stack includes an uptake connected with said duct and extending upwardly in said stack to terminate in an open end spaced above said sole flues.

9. A cooling system as defined in claim **8** wherein at least selected ones of said tunnels extend substantially the full length of said oven, and said inlet means includes valve means at each end of said selected tunnels for admitting ambient air into each end thereof simultaneously.

10. A cooling system as defined in claim **9**, wherein said duct intersects each of said tunnels substantially at the transverse centerline of said foundation.

11. In a coking oven including a system of sole flues extending beneath the floor of a coking chamber, a stack having a central opening communicating with said sole flues system for conveying waste hot flue gasses therefrom, and a foundation beneath said flues consisting of a plurality of layers of heat-resistant refractory materials, the improvement comprising, in combination, a cooling system for said foundation including a plurality of tunnels formed in one of said layers and extending longitudinally of said oven in substantially parallel spaced relation to one another, inlet means for admitting ambient air into each of said tunnels, duct means formed in said foundation in fluid communication with said tunnels and extending into the base of said stack, uptake means formed in said stack within said central opening and extending upwardly from said base of said stack, said uptake means terminating in an open top end within said central opening at a point spaced above said sole flues and being connected at its lower end to said duct means, said stack and said uptake cooperating to cause a flow of cooling air through said tunnels from said inlet means to be discharged from said open end within said stack.

12. The coking oven as defined in claim **11**, wherein said inlet means includes a means at each end of said foundation connected to said tunnels for admitting ambient air into each end of said tunnels simultaneously.

13. The coking oven defined in claim 12, wherein said inlet means includes valve means for regulating the volume of air admitted into said tunnels.

14. The coking oven defined in claim 11, wherein said foundation comprises a top layer consisting of a plurality of courses of refractory brick, an intermediate layer of castable refractory material cast in situ, and a lower layer of reinforced concrete material, said cooling tunnels being formed in said intermediate layer.

15. The coking oven defined in claim 14, wherein said cooling tunnels comprise a plurality of cylindrical conduits cast within said intermediate layer, said duct means

providing fluid communication between each of said cylindrical conduits and said uptake means.

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202—145