May 1, 1973 V. D. ALLRED 3,730,849

INTEGRAL CALCINED COKE COOLER

Filed Nov. 13, 1970 3 Sheets-Sheet 1

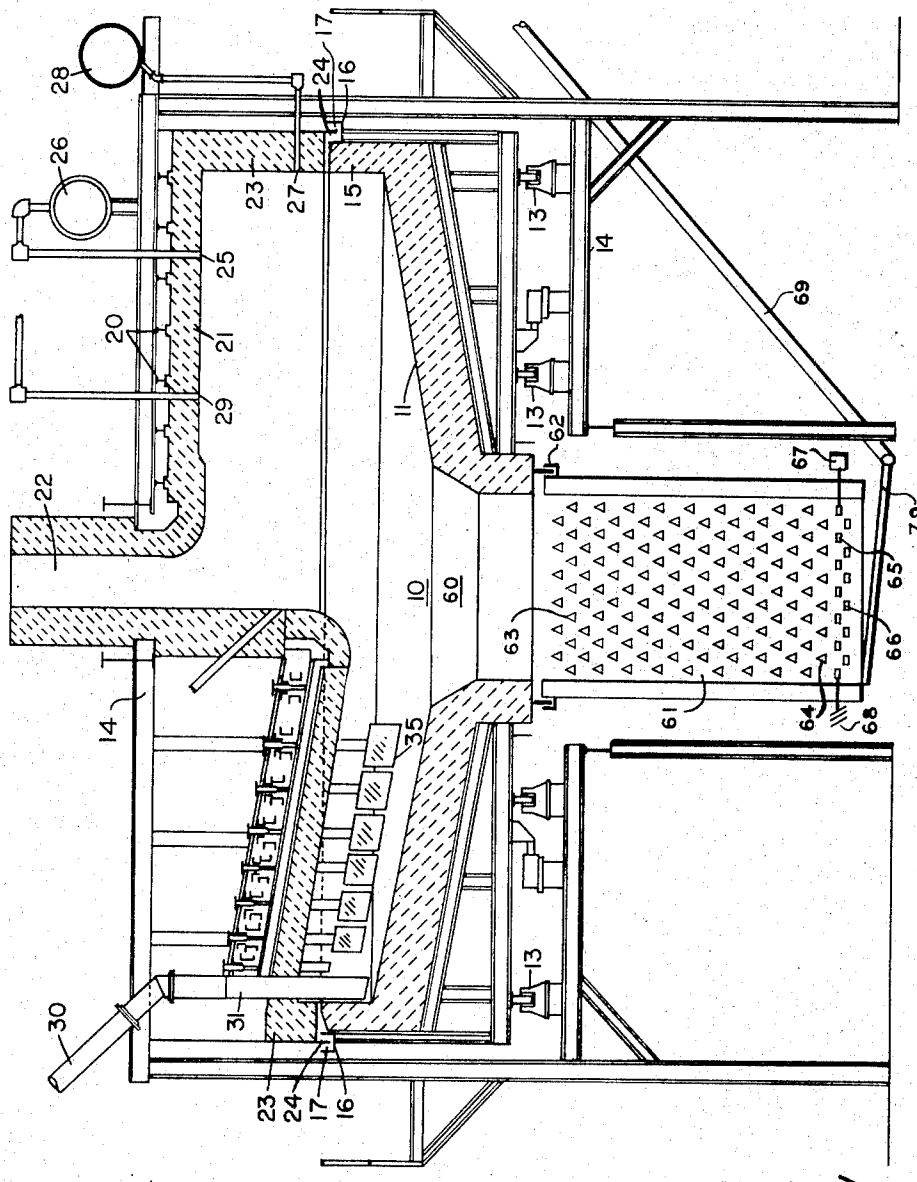


FIG. 1

WITNESS

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INTEGRAL CALCINED COKE COOLER

Filed Nov. 13, 1970 3 Sheets-Sheet 2

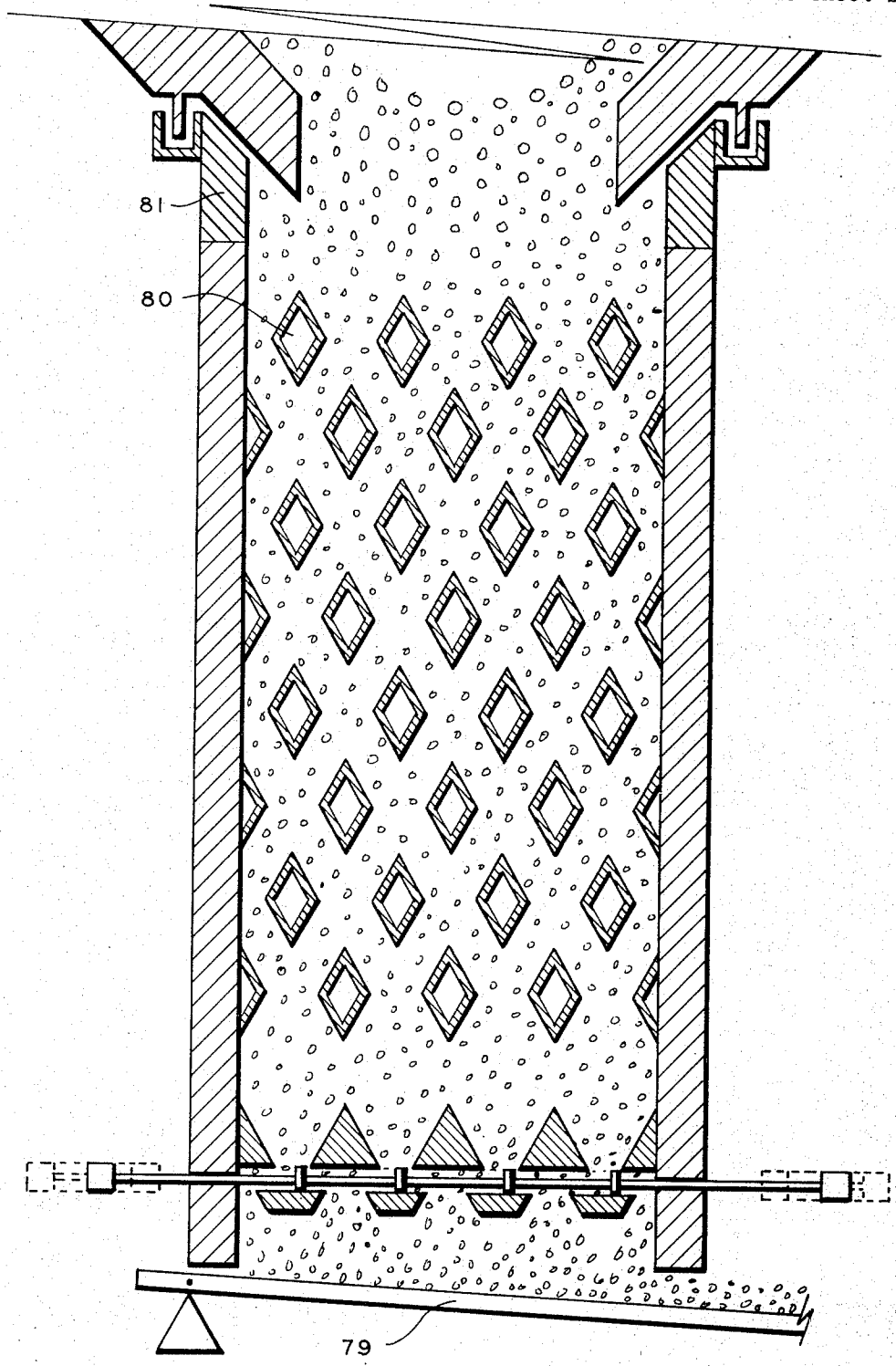


FIG. 2

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INTEGRAL CALCINED COKE COOLER

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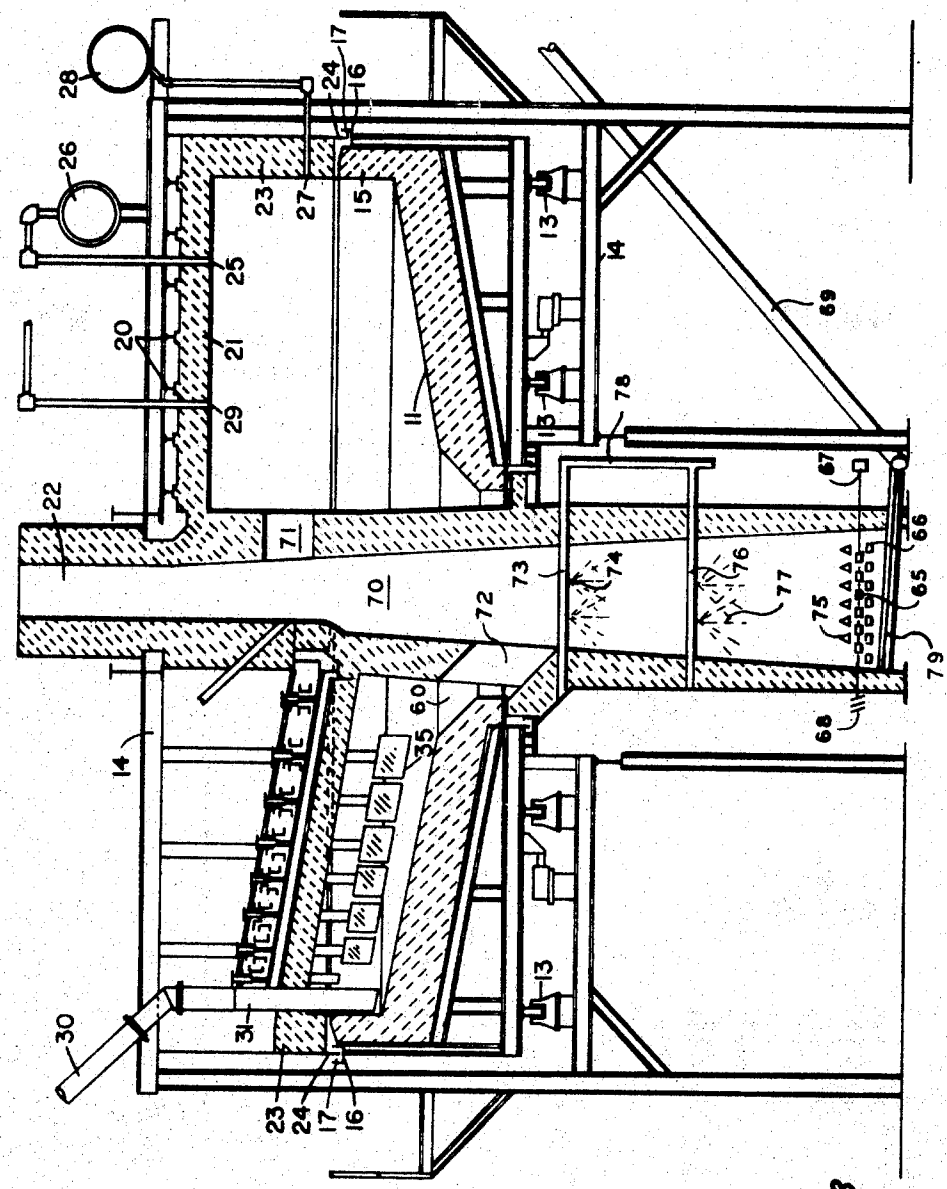


FIG. 3

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United States Patent Office 3,730,849 Patented May 1, 1973

3,730,849

INTEGRAL CALCINED COKE COOLER

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Filed Nov. 13, 1970, Ser. No. 89,320
Int. Cl. C10b 7/00, 49/06, 39/00
U.S. Cl. 202—103 5 Claims

ABSTRACT OF THE DISCLOSURE

A heat exchanger, e.g., a series of transverse heat-conductive conduits through which fluid circulates, or a conventional waste heat boiler, or a water spray can be incorporated into a soaking pit in a rotary hearth calcining furnace. The soaking pit can also be made integral with the flue.

CROSS-REFERENCES TO RELATED APPLICATIONS

United States patent application Ser. No. 887,449, filed Dec. 22, 1969, now U.S. Pat. 3,594,287, Ser. No. 866,790, filed Oct. 6, 1969, now U.S. Pat. 3,652,426, and Ser. No. 888,698 filed Dec. 29, 1969, now U.S. Pat. 3,652,404, and Ser. No. 887,450, filed Dec. 22, 1969, now U.S. Pat. 3,612,497, relate to the general field of the present invention.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to the calcining and cooling of solid materials generally classified in subclasses 201–33, 201–34, 202–102, 202–103, 202–117, 202–120, 202–136, 202–218, 202–319, 110–13, 110–24, 110–36, and 110–171 of United States Patent Office Classification System.

Description of the prior art

U.S. 3,020,209 to Culbertson discloses a heat exchanger (element 50 in his drawing) through which discharged hot ashes and gases pass from an oil shale retort. While this patent utilizes a rotating pyrolysis drum, this drum rotates about a horizontal, not vertical, axis and this heat exchanger is not usable with or within the pyrolysis drum. The heat exchanger does depend from the outlet of the housing **39** which contains a rotating grate **42**.

Rotary hearth furnaces of the "pancake" or "turntable" variety have been described previously, e.g., in U.S. Pats. 3,475,286 and 3,470,068, both to John L. Kemmerer, Jr. and Edward G. Buschow, in U.S. 3,448,012 to V. Dean Allred and in copending U.S. patent application Ser. No. 887,449 filed Dec. 22, 1969, now U.S. Pat. 3,594,287, by V. Dean Allred and Ser. No. 888,698, filed Dec. 29, 1969, now U.S. Pat. 3,652,404, by Robert E. Schilson.

SUMMARY

General statement of the invention

The present invention is adaptable to each of the prior patents and applications mentioned above which concern rotary hearth furnaces. Most of the above prior art patents teach the use of a soaking pit concentric with the rotary hearth and depending downward from the hearth to form a conduit for conveying the calcined coke from the hearth to the rotary discharge table. The rotary discharge table and/or other conveying apparatus delivers the hot calcined coke to a cooler which is generally a rotating horizontal cylinder with water cooled walls for cooling the coke to ambient temperatures.

According to the present invention, a cooler for the coker of the solid materials is placed substantially concentrically with the rotary hearth and is positioned in

the center outlet of the rotary hearth so that coke falls from the hearth (through the action of rabbles, as described in the aforementioned rotary hearth patents, into the cooler of the present invention). A detaining device located at the discharge end of the cooler controls the rate of flow of coke through the cooler and permits the cooler to operate more or less full of coke. This provides adequate time for heat transfer to occur between the coke or the solid material and the cooling fluids employed in the cooler.

These cooling fluids for use in the cooler may be gases, e.g., air but are preferably liquids, most preferably water. Water may be either caused to flow through heat transfer members, e.g., horizontal tubes or conduits preferably having a diamond or triangular cross sectional shape with the vertexes pointed upward to facilitate the flow of coke, or may be sprays which directly contact the coke with water or other liquid. Where cooling by direct contact with liquid is utilized, conduits must be provided to carry off the steam or other vapors.

A particular advantage of the invention is the elimination of external coolers which have generally tended to have higher maintenance than the relatively low-maintenance rotary hearth furnaces. While the tubular cooler of the present invention (as shown in FIG. 1) may be made integral with the rotary hearth and cooling fluids supplied through suitable rotary liquid seals, it will generally be preferable to connect the cooler to the rotary hearth by means of a sand or water-seal so that the cooler can remain stationary while the hearth rotates. The present invention is particularly useful where it is important that the hot coke or the solid material not be exposed to an oxidizing atmosphere, e.g., where the air would tend to oxidize a portion of the coke and reduce the yield of fixed-carbon product.

The cooling chamber can be constructed of any suitable conventional material adequate to withstand the environment, e.g., steel, titanium, castable refractories or prestressed brick work, preferably jacketed with steel. Water cooling, e.g., by circulating through the walls or through a jacket can be provided to the chamber walls.

Where direct cooling is employed, the water sprays or other liquid sprays can be of conventional design with nozzles giving the desired degree of fineness of droplets. They can be connected to a suitable source of water under pressure by piping of steel or suitable conventional materials. The liquid coolant will, in most cases, be water and may be water which has been previosuly used for cooling either the walls of the cooling chamber, or the rabbles or other portions of the furnace.

Where liquid conduits are used for indirect cooling, the conduits will be preferably so shaped as to provide a flow of the solid materials past their exterior. For example, square, diamond shaped, eliptical, triangular or similar cross sections having vertexes oriented upward can be employed. Though less desirable, circular cross section conduits may, of course, be employed. Because of its high thermal conductivity, and therefore low wall temperature, plain carbon steel can be employed for the cooling conduits. Other metals and even graphite and ceramics can be employed in specialized instances. In cases where it is desired to have the inner chamber rotate with the hearth, a conventional high-temperature service rotating seal can be provided in the piping delivering liquid to the cooling conduits.

Utility of the Invention

The present invention is useful for a cooling of a wide variety of calcined solid materials exiting from the hearth or rotary hearth furnace. These include coke, e.g., delayed petroleum coke, fluid petroleum coke, coal, coke, e.g., from bituminous or anthracite coal, limestone, calcined garbage

residues, or any other material which it is desirable to calcine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section view of the rotary hearth furnace showing the cooling chamber of the present invention which utilizes conduits through which cooling liquids flow.

FIG. 2 is a detailed schematic cross section of the cooling chamber of FIG. 1.

FIG. 3 is a section view of a rotary hearth furnace showing the direct cooling chamber of the present invention in which cooling is accomplished by water sprays.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Starting materials

The starting materials utilized in the invention can be any of the aforementioned materials and any other materials capable of being calcined within a rotary hearth furnace and which, in the case of direct cooling, are not deleteriously affected by contact with limited amounts of water. The cooling liquid is generally water, but can be any non-flammable liquid including, where desired, liquids which will react with the hot solid materials to form a desired chemical product.

The amount of liquid injected per pound of solid material processed by the furnace will vary with the temperature of the material exiting from the hearth, the latent heat of vaporization of the liquid (where the liquid is permitted to vaporize) and the desired temperature of the solid material when it exits from the cooling chamber. As an approximate example, when processing delayed petroleum coke having a particle size roughly in the range below about 2" in average diameter, from 0.1 to about 1.0, more preferably from 0.4 to about 1.0, and most preferably from 0.6 to about 0.8 pound of cooling water will be sprayed on each pound of coke and the direct cooling embodiments of the invention.

In using cooling conduits, the cooling liquid may be permitted to vaporize but better heat transfer will in most cases be obtained by merely heating the water, under pressure if necessary, without permitting it to vaporize. The economics of the individual installation, including especially the relative value of hot water to steam or other processes, will determine which mode of cooling is employed.

Examples

FIG. 1 illustrates a furnace having a rotary hearth **10** with inner hearth surface **11** sloping from the outer periphery downwardly to a beveled surface **60** which conveys the coke into a concentric cooling chamber **61** located below the surface of the hearth. The rotary hearth **10** is supported on suitable rollers **13** and furnace frame **14** and is driven by a motor and drive in conventional manner for rotary hearth furnaces. A curb **15** extends vertically above the hearth surface **11** at its outer periphery and carries a trough **16** with sand **17**. A second sand seal **62** serves to connect the cooling chamber **61** with the rotating hearth **11**. In each of these sand seals, a flange attached to the upper member extends downwardly into sand which is confined in a trough attached to the lower member. Other conventional sealing means may be substituted.

Roof beams **20** support a refractory roof **21** having a central stack or flue **22**. The roof **21** has a depending wall **23** carrying flange **24** which extends into the sand **17** and trough **16** forming the rotary sand seal between the hearth **10** and the roof **21**. The roof **21** is provided with air ports **25** and heating air from duct **26** mounted on the furnace frame **14**. Conventional gas burners **29** are provided to heat the furnace in cases where oxidation of volatile matter driven off from the material being calcined does not provide sufficient heat, and during start up operations. A feed chute **30** passes through the roof **21** and has a vertically adjustable delivery end **31** to deliver a selected thickness of feed onto the hearth. A radially extending U-shaped rabble pit shown at the left side of the cross sectional view of FIG. 1, is formed in the roof from the stack **22** to the roof wall **23**. The bottom of the pit is provided with slots (not shown) adapted to slidably receive rabbles **35** which may be solid or hollow plate-like structures and which may be water or air cooled. The rabbles are positioned to dispose the solid material on the hearth **11** into a series of windrows and furrows which radiate spirally from the feed chute **31** toward the outlet point **60**. Material is thus gradually conveyed across the hearth from the feed chute **31** to the outlet, progressing inwardly one windrow per revolution of the rotary hearth **11**.

Staggered rows of triangular cross section conduits **63** are arranged so as to facilitate flow of coke downward through this array of conduits. Lquid inlet and outlet manifolds (not shown) of conventional design provide water flow through these cooling conduits. To provide reasonably uniform temperature differential between the coke and the water in each row of conduits, water flows first through the lowest row then through a row part way up the cooling chamber, then through a row still further up the cooling chamber and finally through the topmost row of the cooling chamber. Similar streams of water flow through the remaining rows of conduits. This provides substantially countercurrent cooling with efficient heat transfer. The water is under pressure by means of a pressure regulating valve installed on the manifold and is not allowed to vaporize substantially in the conduits. This provides water-to-conduit contact without bubbling which would otherwise reduce the heat transfer through the walls of the conduits.

Beneath the lowest row of conduits **64** is located a detention mechanism (see e.g., U.S. 3,375,982 and U.S. 3,401,922) which controls the rate of flow of the coke through the cooling chamber **61**. This detection mechanism consists of a first grate **65** which is composed of a series of rectangular-cross section parallel bars arranged horizontally and spaced apart to permit flow of coke between them. The upper grate **65** is in wiping contact with a lower grate **66** composed of similar spaced, parallel bars. The upper grate **65** is caused to reciprocate by an air-driven motor **67** acting against an opposed spring **68**. The grate **65** reciprocates in a horizontal plane back and forth over a distance which is approximately the width of one of the individual bars of the grate. The upper row of tube **64** is staggered so that the tubes or conduits are substantially aligned with the bars in the lower grate **66**. Coke then flows between tubes **64** into the space between the bars of grate **65** and is then blocked by the bars of lower grate **66**. Grate **65** then reciprocates permitting the coke to fall through the spaces between the bars in lower grate **66**. The coke then exits from the cooling chamber, falling onto vibratory conveyor **68** which moves the coke to a belt conveyor **69**. Belt conveyor **69** delivers the cooled coke to storage.

For greater clarity, FIG. 2 shows a portion of the cooling chamber and detention mechanism, employing diamond-shaped conduits **80**, and showing the discharge grate mechanism schematically, but otherwise similar to the cooling system shown in FIG. 1.

FIG. 3 shows the direct cooling embodiment of the present invention. All the numerals below **70** denote elements which are as described above with respect to FIG. 1. Element **70** is a vertically extending ceramic cylinder which defines a chamber **70** having an inlet **71** which connects the chamber to the interior of the heating chamber of the furnace and an inlet **72** which connects the chamber **70** with the beveled portion **60** of the rotating hearth **11**. Inlet **72** is oriented in line with the row of rabbles **35** so that coke or other solid material is moved gradually across the hearth **11** by the rabbles **35** and then slides down incline **60** through inlet **72** to enter chamber **70** just above spray manifold **73** which provides cooling

water to sprays 74 directed downwardly to cool the coke. Elements 64–68 form a detention mechanism similar to that described above with respect to FIG. 1 except that solid triangular bar 75 replaced the lower level of tubes 64 shown in FIG. 1. A second row of pipes 76 delivers liquid to a second series of cooling sprays 77. A manifold 78 provides water to liquid delivery pipes 73 and 76.

In operation, coke is moved from feed chute 31 across the hearth 11 by the action of rabbles 35. The innermost rabble plows the coke from the surface of earth 11 onto the beveled surface 60 which conveys it through inlet 72 into chamber 70. The action of discharge mechanism 64–68 causes the chamber to be full of coke up to the bottom of inlet 72. The water sprays 74 cause water to contact the hot coke forming steam which exits through flue 22. Volatile gases are burned within the furnace chamber and the products of combustion exit from the furnace chamber through inlet 71 into chamber 70 and out through flue 22. Vibratory conveyor 79 and belt conveyor 69 operate conventionally as described with reference to FIG. 1.

Modifications of the Invention

It should be understood that the invention is capable of a variety of modifications and variations which will be made apparent to those skilled in the art by a reading of the specification and which are to be included within the spirit of the claims appended hereto. For example, the shape of the cooling chamber while preferably square, can be circular or of other horizontal cross sectional shape; the hearth of the rotating hearth furnace need not rotate but the coke may be transferred across a stationary hearth by means of vibration or by rabbles which rotate radially or by other suitable means; the detention means which detains the solid material for sufficient contact with the heat transfer liquid can be merely a constriction at the bottom of the cooling chambers 61 and 70.

In a further modification of the invention, the embodiments of FIGS. 1 and 3 can be combined to some extent by removing the bottom portion of the diamond-cross section conduits shown in FIG. 1 and installing within the resulting angles direct water sprays, e.g., perforated tubes, which are directed downward so as to spray through the open bottom of the angles to provide direct contact with the coke. The resulting steam may be swept out through a header attached to the end of each open-bottom angle and causing transverse flow of steam. Another modification of the invention is to space the top-most row of the conduits, e.g., 63 in FIG. 1, somewhat closer together than are the conduits in the lower rows. Should refractory break loose from the interior of the furnace, the closely spaced upper row of conduits will prevent the refractory lumps from clogging the lower rows of conduits.

What is claimed is:

1. In apparatus for treating solid materials which apparatus comprises a heated chamber and a rotating hearth in said chamber, a material outlet located substantially centrally on said hearth, means for delivering material to the hearth some distance from said material outlet to form a bed of material on the hearth, stationary rabble means for moving said material across said hearth to the material outlet, the improvement comprising:

(a) a vertical chamber extending through the center of said hearth, at least a portion of said vertical chamber extending downward below the surface of said hearth, the vertical axis of said vertical chamber being located substantially at the vertical axis of said rotary hearth.

(b) means for conveying material from said material outlet to said vertical chamber, comprising a funnel-like element concentric with said rotary hearth and said vertical chamber, wherein said funnel-like member is integral with said rotary hearth and rotates with said rotary hearth and wherein a sealing means seals a portion of said vertical chamber to said funnel-like element while permitting said vertical chamber to remain stationary,

(c) cooling means within said vertical chamber for cooling calcined solid materials within said chamber,

(d) detention means for detaining said solid materials for a controlled length of time, within at least the lower portion of said vertical chamber, said detention means comprising a first series of substantially horizontal spaced elements which extend across said chamber, a second series of spaced elements in a plane parallel to and spaced above said first elements, said second elements overlying the spaces between said first elements a third series of spaced elements substantially parallel to said first set of spaced elements, and located between said first and said second element and being in substantially wiping contact with said first set of spaced elements, and means for causing said third elements to alternately wipe across said first elements and then substantially close the spaces between said first and said second elements, then wipe across said first elements in the reverse direction, and to repeat the described motions.

2. Apparatus according to claim 1 wherein said cooling means within said vertical chamber comprise an array of spaced, substantially horizontal thermally-conductive conduits through which fluid is circulated to remove heat from calcined solid materials moving external to said conduits downwardly through said vertical chamber.

3. Apparatus according to claim 2 wherein said substantially horizontal conduits are arranged in staggered substantially horizontal rows and wherein each said conduits has a substantially polyhedral cross section with a vertex arranged uppermost.

4. Apparatus according to claim 1 wherein said cooling means comprises liquid spray means for directly distributing an evaporatable liquid onto the surface of said calcined coke within said vertical chamber, and wherein there are further provided exhaust means for exhausting vaporized products resulting from the direct contact between said vaporizable liquid and said calcined coke.

5. Apparatus according to claim 1 wherein said heated vertical chamber is formed by walls which extend through said chamber to form a flue having walls integral with said walls of said heated vertical chamber and wherein said heated vertical chamber has inlets communicating with said hearth to admit calcined coke and further communicating with said chamber to admit gases from said chamber and convey them to said flue.

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U.S. Cl. X.R.

202—136, 218, 227, 253; 263—32