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[54] GAS DELIVERY MANIFOLD AND PROCESSED MATERIAL DISCHARGE ASSEMBLY FOR ROTARY KILN

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[52] **U.S. Cl.** ....263/33 R
[51] **Int. Cl.** F27b 7/00
[58] **Field of Search** ....263/32 R, 33 R

[56] **References Cited**

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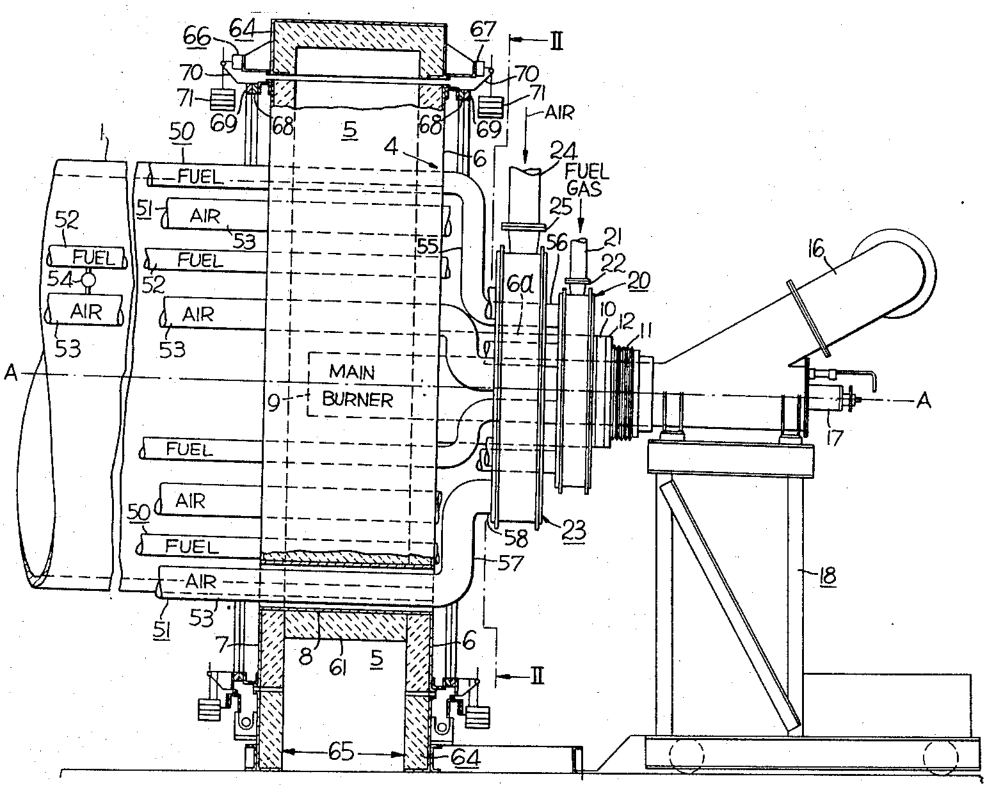
[57] **ABSTRACT**

A rotary kiln is disclosed with a rotary firing hood mounted concentrically over the material discharge end of the kiln to rotate with the kiln. A main burner assembly projects axially through a neck formed by a rear wall of the hood and a plurality of burners project radially through the kiln shell. Fuel gas conducting tubes for supplying the kiln shell burners, are mounted on the outer periphery of the kiln shell and extend axially through the hood and rear wall thereof. The fuel tubes each have portions that project radially inward along an outer surface of the hood rear wall and axially away from the rear wall to an annular fuel gas manifold box mounted close around the hood rear wall neck. The annular manifold box has a pair of axially spaced radial walls connected to rotate with the rotary hood and a nonrotating outer sleeve connected to a stationary fuel gas delivery conduit. An annular air manifold box, similar in construction to the fuel gas manifold box, is mounted close around the axially extending portions of the fuel tubes and between the fuel gas manifold box and the rear wall of the firing hood. Air conducting tubes mounted on the kiln shell also extend axially through the rotary hood and rear wall thereof and have portions which project radially inward and axially away from the rear wall to the annular air manifold box. The kiln is provided with a pair of radial discharge ports, circumferentially spaced 180° apart, for discharging processed material twice each revolution of the kiln. The air and fuel gas tubes are arranged along the kiln shell in two groups, with each group of tubes being on one side of the kiln and between the pair of kiln discharge ports to be spaced away from hot processed material discharged through the ports.

8 Claims, 3 Drawing Figures



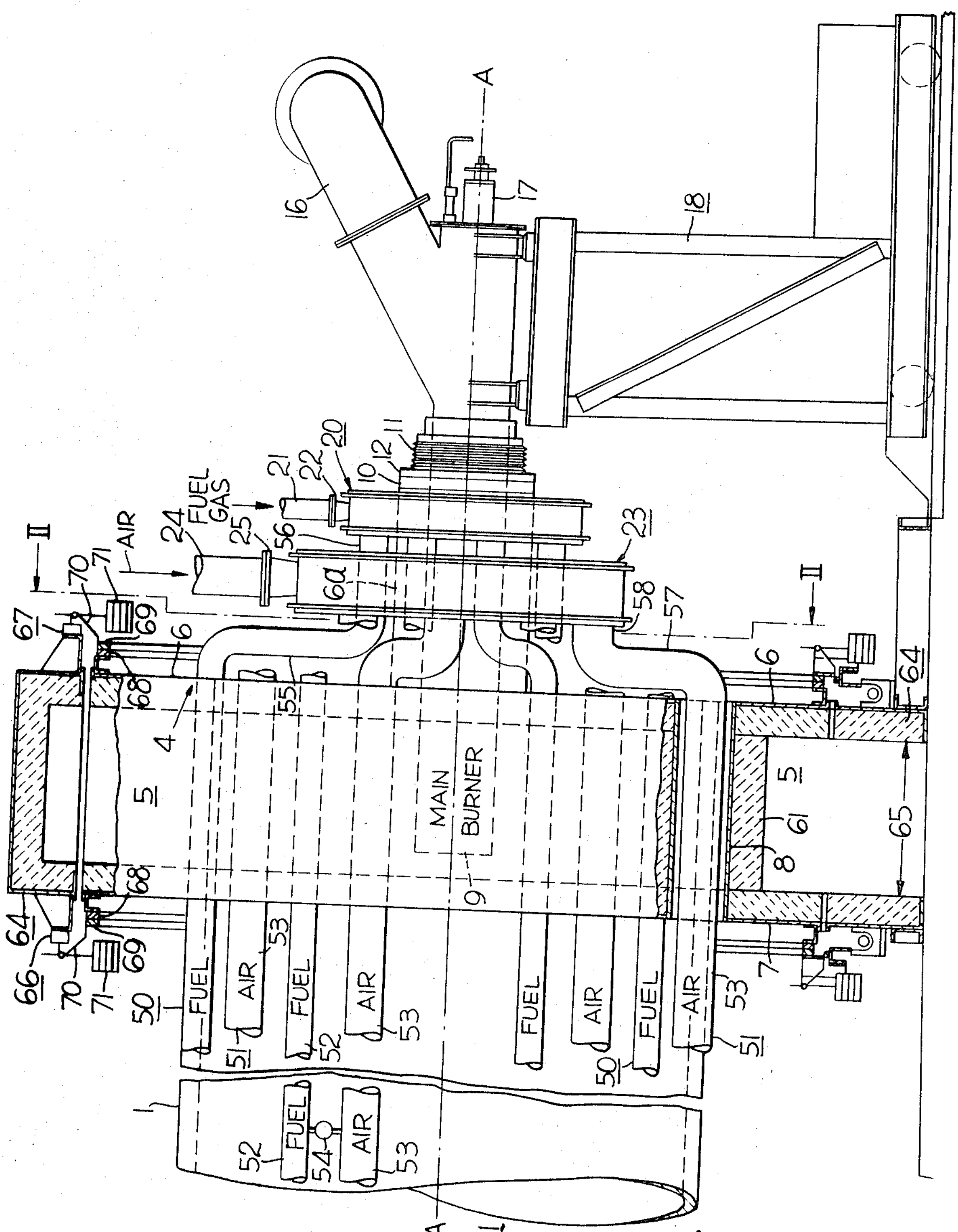


Fig-1

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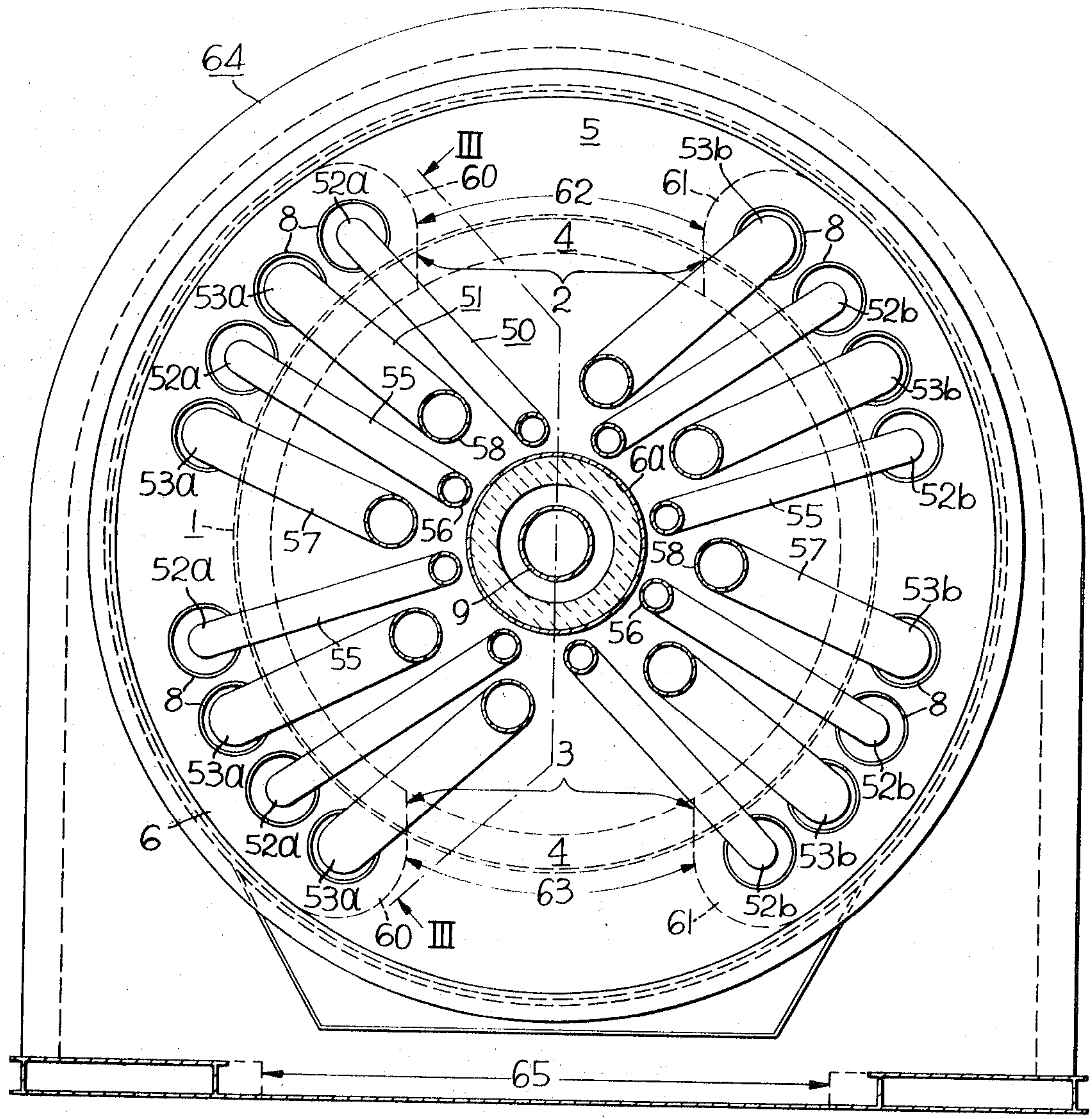

Fig. 2

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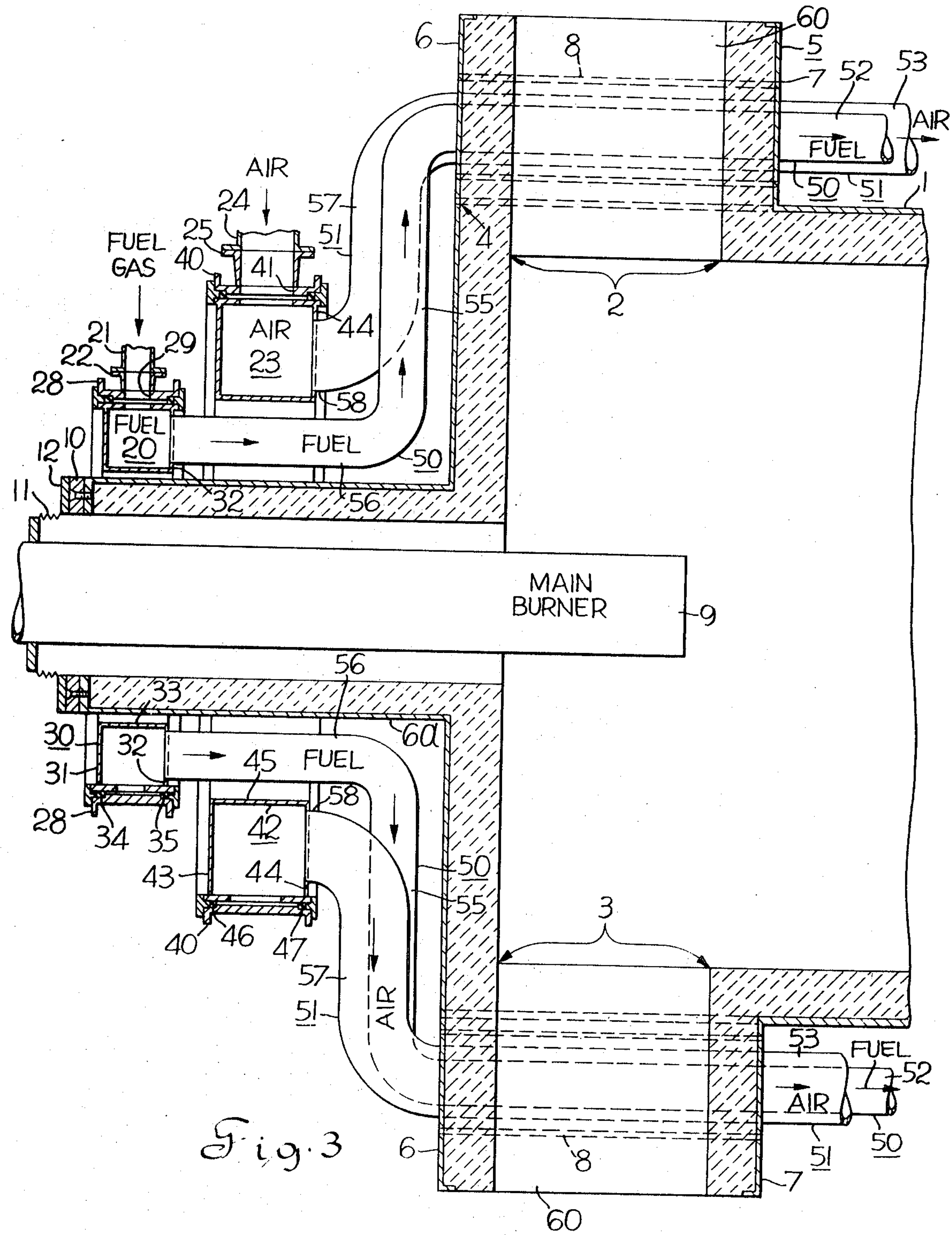

Fig. 3

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GAS DELIVERY MANIFOLD AND PROCESSED MATERIAL DISCHARGE ASSEMBLY FOR ROTARY KILN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to rotary kilns, used for such purposes as reducing iron ore to a lower state of oxidation, and having nozzles mounted on the outer surface of the kiln to project radially through the kiln shell and inject air and fuel into the kiln at axially spaced locations along the length of the kiln. In particular the present invention relates to an assembly for delivering air and gaseous fuel from stationary conduits to conduits mounted on the kiln shell to rotate therewith, and for discharging processed material from the kiln.

2. Description of the Prior Art

Rotary kilns for such as reducing iron ore to a lower state of oxidation and having nozzles projecting through a kiln shell for injecting air into the kiln, are disclosed in prior patents, for example U.S. Pat. No. 1,216,667 of 1917; U.S. Pat. No. 1,760,078 of 1930; and U.S. Pat. No. 2,344,440 of 1944. Such kilns disclose seals between nonrotating conduit structures and rotating conduit structures having a diameter larger than the diameter of the kiln. It has always been difficult to construct good seals of such large diameter because thermal expansion is proportionately greater for larger sizes, and it is more difficult to provide the dimension tolerances and surface finishes needed for effective seals. For conduits and nozzles delivering only air to the kiln, the problem was not serious as there is no danger involved if the seals leak air externally of the kiln and the economic loss from leaking air is not great. Early examples of prior art patents disclose constructions which avoided delivering gaseous fuel through such distribution systems for leaks of combustible gases could involve both danger and significant economic loss.

Early prior art patents disclose other ways for admitting fuel to the kiln. The three previously mentioned prior art patents introduced a reducing atmosphere into the kiln by injecting fuel through the usual axial burner projecting into the material discharge end of the furnace, and the first two of those references also disclose including combustible material with the charge material fed to the furnace.

Other ways have been disclosed by prior art to inject gaseous fuel into such a kiln without creating a need for such large diameter seals. U.S. Pat. No. 1,797,130 of 1931 accomplishes such fuel injection with a single annular tube extending along the central axis of the kiln and having nozzles which project radially outward from the tube. U.S. Pat. Nos. 2,848,198; 3,182,980; and 3,196,938 provide several axially extending fuel conduits inside the kiln shell. U.S. Pat. No. 3,011,772 discloses a double wall kiln with gaseous flue being delivered to the space between the walls. The kiln constructions disclosed in this group of patents all involve seals between stationary and rotating fuel delivery conduits having a diameter smaller than the outer diameter of the assembly but all these constructions have two disadvantages. One disadvantage is that the gaseous fuel conduits are not kept cool by exposure to the atmosphere of surrounding air and a second disadvantage is that such conduits are hidden from view and cannot therefore be inspected while the kiln is in operation.

U.S. Pat. Nos. 3,132,023 of 1964 and 3,235,375 do disclose constructions in which both air and fuel conduits carried to rotate with the kiln are external to the kiln and a joint between the rotating and nonrotating conduits does not require seals having a diameter larger than the kiln. The constructions disclosed in these two patents however (and U.S. Pat. Nos. 2,848,198; 3,196,938; and 3,011,772 of the previous group) discharge processed material from the kiln through an opening central of the seal and therefore necessarily smaller than the diameter of the kiln. With such a construction the kiln must either contain a relatively large charge in order for material to flow over a dam formed by the discharge header (as with U.S. Pat. No. 3,235,375); or be provided with internal

lifters (as with U.S. Pat. Nos. 3,848,198; 3,011,772 and 3,196,938); or a double shell kiln and lifters for moving processed material back to the feed end of the kiln for discharge (as with U.S. Pat. No. 3,132,023).

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new and improved gas delivery manifold and processed material discharge assembly in which gases from stationary sources of supply are delivered to tubes mounted on the outer periphery of a kiln to rotate with kiln, through sealed annular manifolds of diameter smaller than the kiln and mounted in spaced axial alignment relative to the discharge end of the kiln, and having provision for discharging processed material radially outward from the inner periphery of the kiln without direct exposure of the tubes to the hot processed material discharging from the kiln.

According to a preferred embodiment of the present invention a rotary kiln is provided with a rotary firing hood mounted concentrically over the material discharge end of the kiln to rotate with the kiln. A main burner projects axially through a neck formed by a rear wall of the hood and a plurality of burners project radially through the kiln shell. Fuel gas conducting tubes for supplying the burners projecting through the kiln shell, are mounted on the outer periphery of the kiln shell and extend axially through the rotary hood and rear wall thereof. The fuel tubes each have portions that project radially inward along an outer surface of the hood rear wall and axially away from the rear wall in proximity to the burner assembly, to an annular fuel gas manifold box mounted around the burner assembly. The annular manifold box has a pair of axially spaced radial walls attached to rotate with the burner assembly and a nonrotating outer sleeve connected to a stationary fuel gas delivery conduit. An annular air manifold box, similar in construction to the fuel gas manifold box, is mounted around the axially extending portions of the fuel tubes and between the fuel gas manifold box and the rear wall of the firing hood. Air conducting tubes mounted on the kiln shell also extend axially through the hood and rear wall thereof. The air tubes have portions which project radially inward along the outer surface of the hood rear wall and axially away from the rear wall to the annular air manifold box. The kiln is provided with a pair of radial discharge ports, circumferentially spaced 180° apart, for discharging processed material twice each revolution of the kiln. The air and fuel gas tubes are arranged along the kiln shell in two groups, with each group of tubes being on one side of the kiln and between the pair of discharge ports. A stationary hood defining a single downward discharge passage, encloses the outer periphery of the rotary firing hood. Processed material therefore discharges from the kiln radially downward between the groups of tubes and down through the single discharge passage of the stationary hood, twice each revolution of the kiln, with the tubes being spaced away from the hot processed material discharged through the kiln ports.

Other features and objects of the invention that have been attained will appear from the more detailed description to follow with reference to an embodiment of the present invention shown in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 of the accompanying drawing is a fragmentary side elevation, partly in section, of a rotary kiln with a gas delivery manifold and processed material discharge assembly according to the present invention;

FIG. 2 is an end view taken along line II—II in FIG. 1 and viewing the structure in the direction indicated by arrows; and

FIG. 3 is a fragmentary side elevation in section, taken along line III—III in FIG. 2, viewing the structure in the direction indicated by arrows and with a stationary hood, shown in FIGS. 1 and 2, eliminated from this view.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawings, a rotary kiln having a cylindrical shell **1** is supported in a conventional manner (not shown) to rotate about a central axis A—A. As shown in FIG. 3, the shell **1** is refractory lined and provided with a pair of radial discharge ports **2, 3** adjacent the end **4** of kiln shell **1** and (see FIGS. 2, 3) the ports **2, 3** are circumferentially spaced apart 180°, for discharging processed material downwardly therethrough; i.e., gravity discharge, twice each revolution of the kiln shell **1**.

Referring to FIGS. 1 and 3, a rotary firing hood **5** is mounted concentrically about the discharge end **4** of the kiln shell **1** and connected thereto to rotate with the kiln shell **1** about the central axis A—A. Hood **5** is provided with a rear wall **6** at the end **4** of kiln shell **1**, and a forward wall **7** axially spaced along the kiln shell **1** from the rear wall **6**. The walls **6, 7** are axially spaced apart by axially extending tubular elements **8** arranged radially outward of kiln shell **1**. The rear wall **6** is provided with a neck **6*a*** through which a conventional main kiln burner **9** projects concentrically to axis A—A into firing hood **5**. Rear wall **6** therefore encloses the discharge end **4** of kiln shell **1** about the burner **9**. The rear wall neck **6*a*** is provided with a flange **10** attached thereto which therefore rotates with rear wall **6**. The flange **10** is sealed relative to the stationary burner **9** by a bellows seal **11**. The bellows seal **11** has a flange **12** which does not rotate, and which engages the rotating flange **10**, to provide a friction seal between the stationary burner **9** and the rotating neck **6*a*** of rear wall **6**.

Referring to FIG. 1, burner **9** has two branches **16, 17** with branch **16** being adapted for connection to a source of primary air (not shown) and branch **17** being adapted for connection to a source of primary fuel gas (not shown). The burner **9** with its branches **16, 17**, is mounted on a retractable burner support assembly **18**. A first annular gas manifold box **20** is provided around the rear wall neck **6*a*** and between rear wall **6** and flange **10**. The box **20** is adapted for connection to a second stationary source of fuel gas, conduit **21**, at a coupling **22**. A second annular gas manifold box **23** is provided between the manifold box **20** and rear wall **6**, and box **23** is adapted for connection to a second stationary source of air, conduit **24**, at a coupling **25**. The construction of the manifold boxes **20** and **23** will be described with reference to FIG. 3.

As shown in FIG. 3, the first annular gas manifold box **20** has a first portion which is a cylindrical sleeve **28** with a port **29** in registry with the coupling **22**, and sleeve **28** is fitted over and encloses a second portion of box **20** which is an annular channel **30**. The channel **30** comprises a pair of axially spaced annular walls **31, 32** attached to a cylindrical collar **33** fitted around a neck portion **6*a*** of rear wall **6**, through which the burner **9** projects. As will appear from the description to follow, the second portion; i.e., the channel **30**, rotates with the end wall **6**. Channel **30** therefore rotates within the inner periphery of the nonrotating sleeve **28**. Annular seals **34, 35** are provided between the channel **30** (which rotates) and the sleeve **28** (which does not rotate). The second annular gas manifold box **23** is constructed in a manner similar to the box **20** but the annular configuration of box **23** is of larger diameter than box **20**, for reasons that shall appear as the description of the apparatus proceeds, and box **23** is proportionately larger than box **20** to accommodate air in larger volumes than the fuel gas delivered to box **20**. The box **23** has a first portion which is a cylindrical sleeve **40** with a port **41** in registry with the coupling **25** and sleeve **40** is fitted over and encloses a second portion which is an annular channel **42**. The channel **42** comprises a pair of axially spaced annular walls **43, 44** attached to a cylindrical collar **45** radially spaced around the neck portion **6*a*** of rear wall **6**. As will appear from the description to follow, the second portion of box **23**, i.e., the channel **42**, also rotates with end wall **6**. Channel **42** therefore rotates within the inner periphery of the nonrotating sleeve **40**. Annular seals **46, 47** are provided between the channel **42** (which rotates) and the sleeve **40** (which does not rotate).

Referring to FIGS. 1 and 3, a first plurality of tubes **50** and a second plurality of tubes **51** are provided which each have a first section **52, 53** respectively, mounted on the outer periphery of kiln shell **1** parallel to the central axis A—A. The tubes **50** are provided to deliver fuel gas and tubes **51** are provided to deliver air, to kiln shell burners **54**, only one of which is shown (see FIG. 1) and which may be such as are disclosed in U.S. Pat. No. 3,029,141. The first sections **52, 53** of tubes **50, 51** project through the tubular elements **8** which extend between the walls **6, 7** of rotary hood **5**. The tubes **50** have a second section **55** projecting radially inward along the outer surface of rear wall **6** and a third section **56** projecting axially away from rear wall **6**. The third section **56** of tubes **50** extends parallel to axis A—A radially outward of neck **6*a*** of rear wall **6** and radially inward of the second annular gas manifold box **23**, and into gas communicating connection with the first annular gas manifold box **20**. As shown in FIG. 3 section **56** extends axially along the outer periphery of the neck **6*a*** and inward of the cylindrical collar **45**, and is connected to the annular wall **32** of the second portion of box **20**, i.e., channel **30**, to discharge gas into the box **20**. The tubes **51** have a second section **57** projecting radially inward and along the outer surface of rear wall **6** and a third section **58** projecting axially away from rear wall **6**. The third section **58** of tubes **51** extends parallel to axis A—A radially outward of the third sections **56** of tubes **50** and into air communicating connection with the second annular gas manifold box **23**. The sections **58** are connected to the annular wall **44** of the second portion of box **23**, i.e., channel **42**, to discharge air from the box **23**. Since the tubes **50, 51** are mounted on kiln shell **1** to rotate therewith and the annular channels **30, 42**, are connected to the tubes **50, 51**, the channels **30, 42** are carried by the tubes to rotate relative to the sleeves **28, 40** which are connected to stationary supply conduits **21, 24** and therefore carried in a position fixed in space.

Referring to FIG. 2, the first sections **52, 53** of the tubes **50, 51**, are arranged in two groups. The tube sections **52, 53** of a first of the groups are identified in FIG. 2 as tube sections **52*a*** and **53*a***, and tube sections **52, 53** of a second of the groups are identified in FIG. 2 as tube sections **52*b*** and **53*b***. The tube sections **52*a*** and **53*a*** are arranged, alternately, along one side of the periphery of kiln shell **1**. The individual tube sections **52*a*** and **53*a*** are circumferentially spaced apart from each other and the sections **52*a*, 53*a*** are grouped relative to the circumference of kiln shell **1** to be circumferentially between the discharge ports **2, 3** in kiln shell **1**. Likewise, the tube sections **52*b*** and **53*b*** are arranged, alternately, along the side of kiln shell **1** opposite to tube sections **52*a*** and **53*a***, and the tube sections **52*b*, 53*b*** are also grouped to be circumferentially between the discharge ports **2, 3**. Thus none of the tube sections **52*a*, 53*a*** or **52*b*, 53*b*** pass axially over the ports **2, 3** in kiln shell **1**.

Referring to FIGS. 2 and 3, the tubular elements **8** through which the tube sections **52*a*, 53*a*** pass, are surrounded by a cast refractory shroud **60**. As shown in FIG. 2, the tubular elements through which the tube sections **52*b*, 53*b*** pass are also surrounded by a cast shroud **61** similar to shroud **60**. The shrouds **60, 61** may be formed in place from a thick mud of refractory cement poured into suitable removable forms (not shown), after which the mud is permitted to dry and harden to a solid body. The shrouds **60, 61** protect the tubular elements **8** from hot gases and processed material emitted from kiln shell ports **2** and **3**, and the shrouds **60, 61** define therebetween a pair of radial discharge passages **62, 63** in registry with the kiln shell ports **2** and **3**.

Referring to FIGS. 1 and 2, the apparatus is provided with a stationary hood **64** encircling the outer circumference of rotary hood **5** and stationary hood **64** defines a single downward discharge passage **65**.

Referring to FIG. 1, annular seals **66, 67** are provided between the stationary hood **64** and the rotary hood **5**. Each of the seals 66, 67 is provided with an annular ring 68 connected to the rotary hood 5 to rotate therewith, and an annular ring 69 pivotally connected by an actuating arm 70 to the stationary hood 64. The pivotal actuating arm 70 is actuated by a weight 71 to bias ring 69 toward frictional engagement with ring 68 to provide a friction seal between rings 68, 69.

The apparatus that has been described may be operated to process material according to a variety of operations and processes, such as are disclosed for example in U.S. Pat. No. 1,797,130, U.S. Pat. No. 3,029,141, and U.S. Pat. No. 3,182,980. In operation with the described apparatus material to be processed by heat and gases supplied by burners 9 and 54, moves axially through the kiln shell 1 toward the discharge end 4, because of the usual slight downward sloping alignment of kiln shell 1 toward the discharge end 4. Air and fuel for the primary burner 9 is supplied through the branches 16, 17 of the burner 9. Fuel for the kiln shell burners 54 is supplied through the stationary conduit 21 to the first portion of box 20, i.e., nonrotating sleeve 28 of box 20, and to the second portion of box 20, i.e., annular channel 30 which rotates with kiln shell 1. From channel 30 the fuel gas passes through the sections 56, 55 and 52 of the first plurality of tubes 50. Air for the kiln shell burner 54 is supplied through the stationary conduit 24 to the first portion of box 23, i.e., nonrotating sleeve 40 of box 23, and to the second portion of box 23, i.e., channel 42 which rotates with kiln shell 1. From channel 42 the air passes through the sections 58, 57 and 53 of the second plurality of tubes 51. After the material in kiln shell 1 has been processed and arrives at the discharge end 4 of kiln shell 1, the material is discharged from the kiln twice each revolution of kiln shell 1 and rotary hood 5, through ports 2 and 3 and between the shrouds 60, 61 enclosing the two groups of tube sections 52*a*, 53*a* and 52*b*, 53*b*, to fall downwardly through the stationary hood discharge passage 65.

With the described apparatus the foregoing operation is achieved with sealed annular gas manifold boxes 20, 23 being of smaller diameter than the kiln shell 1. In fact, the annular seals 34, 35 for the fuel box 20 are only slightly larger in diameter than the neck 6*a* of rear wall 6 and therefore can be constructed to effectively seal against loss of costly combustible fuel gases utilized in such as the described operations. Furthermore, the tube sections 52 and 53 in tubular elements 8 that pass through the rotary firing hood 5 are not directly exposed to the atmosphere within the kiln or the hot and usually abrasive processed material discharging from the kiln.

From the foregoing detailed description of the present invention it has been shown how the objects of the present invention have been attained in a preferred manner. However, modification and equivalents of the disclosed concepts such as readily occur to those skilled in the art are intended to be included in the scope of this invention. Thus, the scope of the invention is intended to be limited only by the scope of the claims such as are or may hereafter be, appended hereto.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus comprising:

a. a cylindrical rotary kiln shell having a plurality of kiln shell mounted burners each projecting radially inward through the kiln shell, and the kiln shell having a radial discharge port through the shell thereof adjacent one end of the kiln shell for discharging processed material from the kiln shell;

b. a rotary firing hood mounted concentrically about the end of the kiln shell and connected thereto to rotate with the kiln shell about a central axis through the kiln shell, with the rotary firing hood having a rear wall closing the adjacent end of the kiln shell;

c. a first annular gas manifold box concentric to the central axis and axially spaced away from the kiln shell and hood rear wall adapted for connecting a stationary gas source to the plurality of kiln shell mounted burners, and said annular box having an outer circumference of a diameter smaller than the diameter of the kiln shell; and

d. a first plurality of gas conducting tubes each having a first section mounted on the outer periphery of the kiln shell with each said tube first section connected on one end to at least one of said kiln shell mounted burners and each of the first sections being parallel to the central axis and circumferentially spaced away from the radial discharge port in the rotary kiln shell, with the first section of each tube extending through the rotary hood and rear wall thereof, and each tube having a second section projecting radially inward along the outer surface of the rear wall and a third section projecting axially away from the rear wall into connection with the annular gas manifold box for conducting gas from the annular gas manifold box into the gas conducting tubes to the shell mounted burners, and with the gas conducting tubes spaced away from exposure to processed material discharged from the kiln shell through the radial discharge port.

2. An apparatus according to claim 1 having a stationary hood encircling the outer circumference of the rotary hood and defining a downward discharge passage through which processed material from the rotary kiln shell is discharged upon rotation of the kiln shell to bring the kiln shell radial discharge port in registry with the stationary hood discharge passage.

3. An apparatus according to claim 1 having a second annular gas manifold box with an outer diameter smaller than the diameter of the kiln shell but larger than the outer diameter of the first annular box, said second annular box being between the first gas manifold box and the rear wall of the rotary hood, concentric about the central axis and with an inner periphery radially outward of the third sections of the first plurality of gas tubes, and a second plurality of gas conducting tubes each having a first section mounted on the periphery of the kiln shell with each said tube first section connected on one end to at least one of the kiln shell mounted burners and each of the tube first sections being parallel to the central axis and circumferentially spaced away from the discharge port in the rotary kiln shell, with the first section of each tube of the second plurality extending through the rotary hood and rear wall thereof, and each tube of the second plurality having a second section projecting radially inward along the outer surface of the rear wall and a third section projecting axially away from the rear wall into connection with the second annular gas manifold box.

4. An apparatus according to claim 3 having a main burner concentric to the central axis of the kiln and projecting through a central opening defined by the first and second annular gas manifold boxes, through the rear wall of the rotary hood, and into the adjacent end of the rotary kiln shell.

5. In an apparatus according to claim 1, the rotary kiln shell having a pair of radial discharge ports circumferentially spaced 180° apart, and the first sections of the gas conducting tubes being circumferentially arranged in two groups with both groups arranged circumferentially spaced from both discharge ports, to discharge processed material between the groups of tubes twice each revolution of the rotary kiln.

6. In an apparatus according to claim 3, the tubes of the first and second pluralities thereof being arranged with each tube of the first plurality being circumferentially located between a pair of tubes of the second plurality.

7. In an apparatus according to claim 1, the first annular gas manifold box having a first portion comprising a cylindrical sleeve with a port adapted to be connected to a stationary gas source, and the first annular gas manifold box having a second portion comprising an annular channel defined by a cylindrical collar with a pair of axially spaced radially extending annular walls, the cylindrical sleeve being arranged to engage the outer periphery of the annular walls to enclose the annular channel of the said first annular gas manifold box and the third section of each gas conducting tube being connected to the annular channel for receiving gas there-from.

8. In an apparatus according to claim 3, each annular gas manifold box having a first portion comprising a cylindrical

sleeve with a port adapted to be connected to a stationary gas source, and each annular gas manifold box having a second portion comprising an annular channel defined by a cylindrical collar with a pair of axially spaced radially extending annular walls, the cylindrical sleeve of each said box being arranged to engage the outer periphery of the annular walls of each said box to enclose the annular channel of each said an-

nular gas manifold box, and the third section of each tube of the first plurality of tubes being connected to the annular channel of the first manifold box and the third section of each tube of the second plurality of tubes being connected to the annular channel of the second manifold box.

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