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Paul

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[54] **PROCESS AND APPARATUS FOR PREHEATING SOLID PARTICULATE MATERIALS**

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[52] **U.S. Cl.** **432/17,** 432/14, 432/98, 34/10

[51] **Int. Cl.** **F27b 1/10**

[58] **Field of Search** ..... 34/10, 57 R, 57 A, 169, 34/175, 167, 79; 432/14, 17, 28, 15, 24, 27, 16, 117, 98, 78

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Assistant Examiner—Henry C. Yuen
Attorney, Agent, or Firm—Frank H. Thomson

[57] **ABSTRACT**

A method and apparatus for preheating solid particulate materials such as limestone and materials used in the process of making sealed surface lightweight aggregate. It includes a vessel having an inlet for solid particulate material and an outlet for solid particulate material, an inlet for hot gases and an outlet for gases. A preheating zone is defined by a bridge, the floor of the vessel and the vessel sidewalls. A valve arrangement is provided for controlling the length of the gas flow path through the preheating zone. When the valve is in one extreme position, the flow path through the gas-solids contact zone is the longest, and when the valve is in the other extreme position, the flow path through the gas-solids zone is at its shortest. The position of the valve may be controlled in response to either the pressure drop across the preheating apparatus or the temperature of the material discharged from the preheater.

13 Claims, 3 Drawing Figures

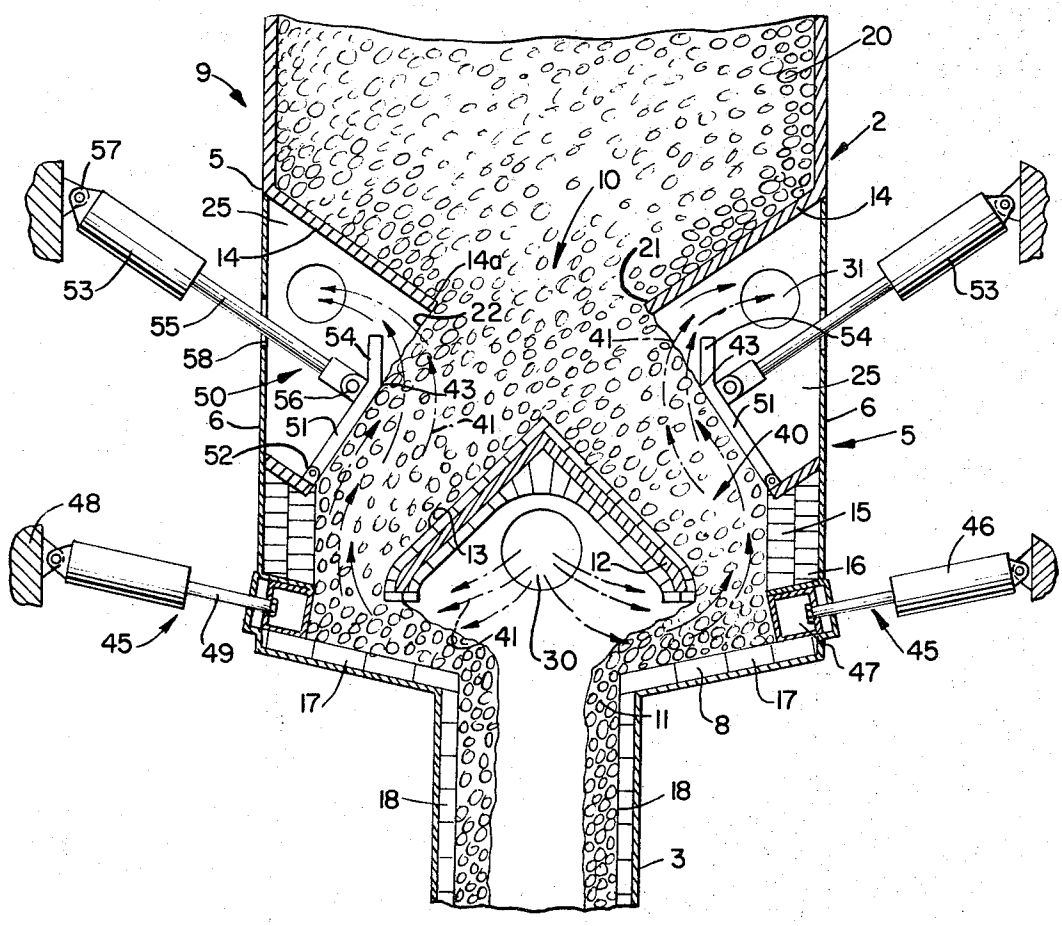


FIG. 1.

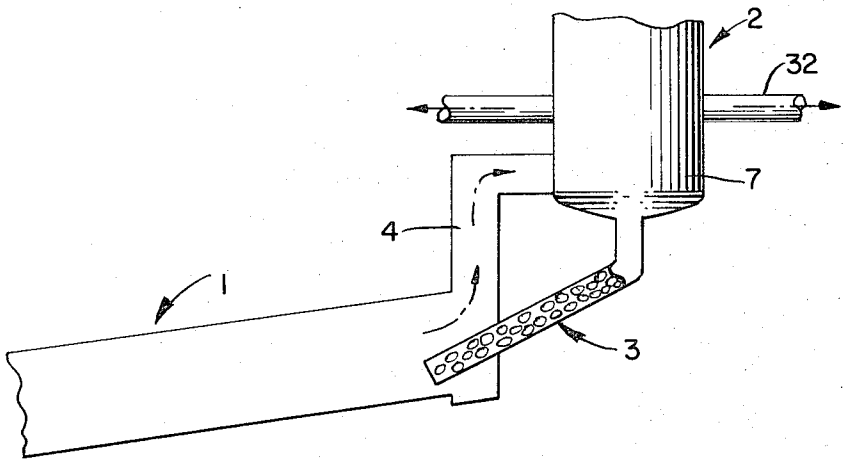

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FIG. 2.

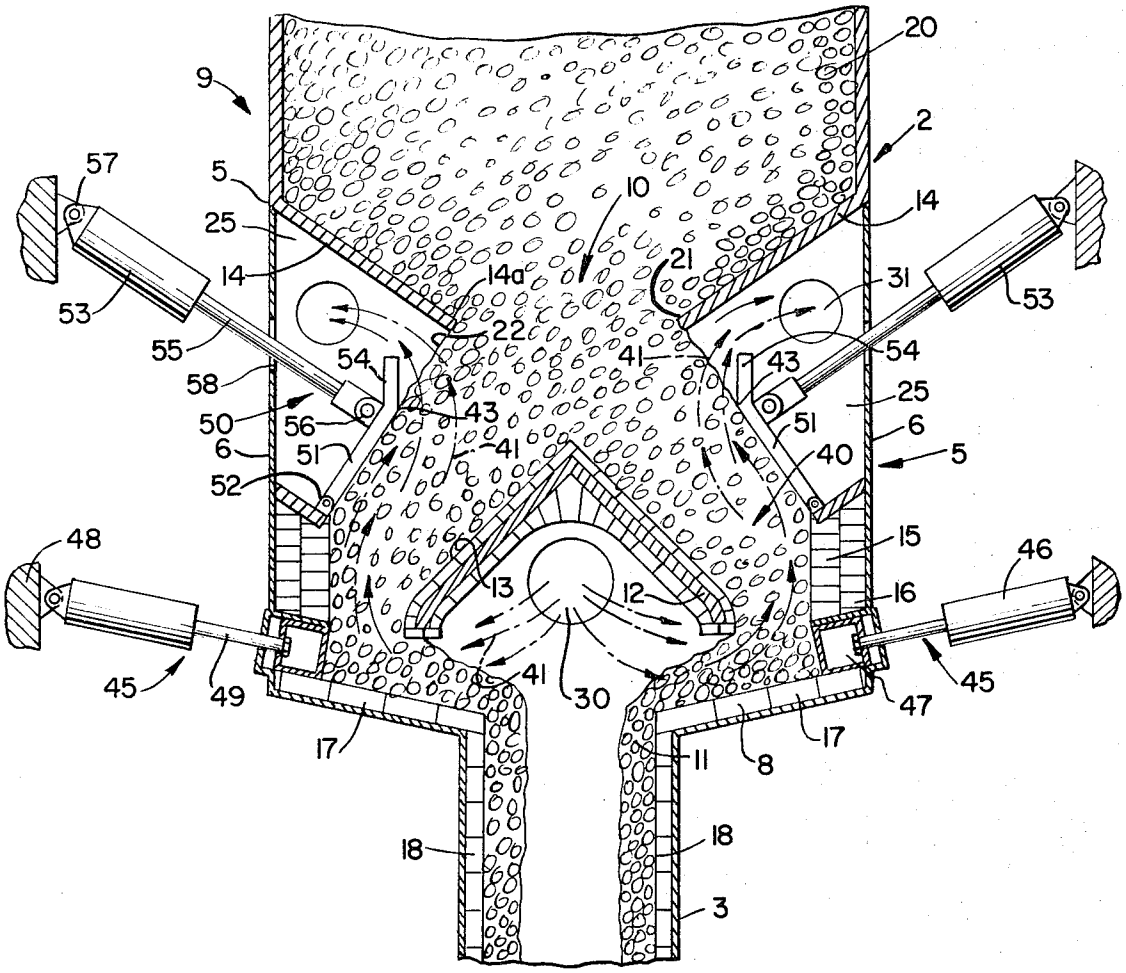
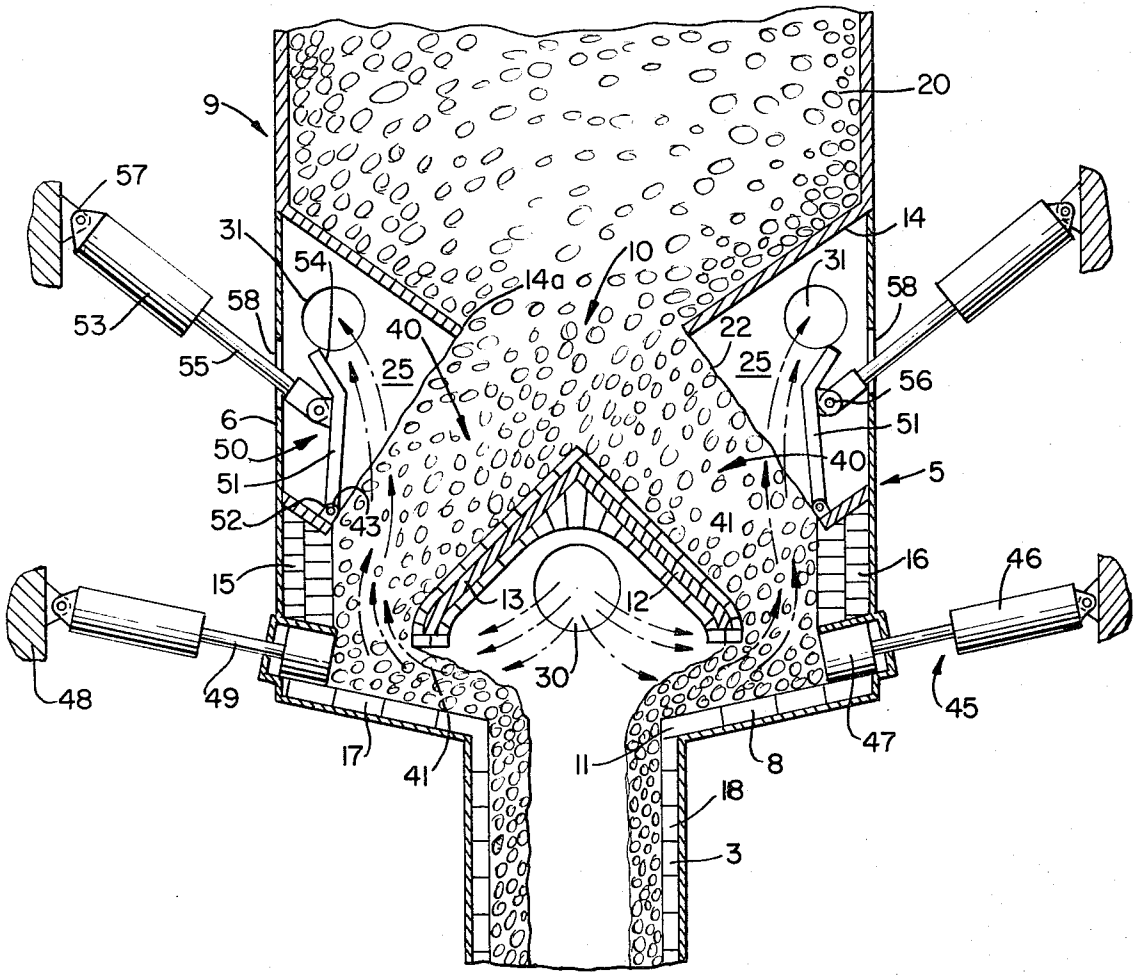

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FIG. 3.


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PROCESS AND APPARATUS FOR PREHEATING SOLID PARTICULATE MATERIALS

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for preheating solid particulate material such as limestone or lightweight aggregate raw material which is to be processed in a furnace such as a rotary kiln.

In the processing of raw material in a furnace such as a rotary kiln, exhaust gases from the furnace contain substantial heat value. With the increasing awareness of fuel costs, it is desired by many mineral processors to employ this waste heat for preheating the raw material supplied to the furnace. By employing this waste heat for preheating raw material, the material which is supplied to the furnace will be at a higher temperature than if material at ambient temperature is supplied to the furnace. Since thermal processing must be carried out at a particular temperature, with higher temperature feed, less heat needs to be added to the furnace to process the raw material and thus less fuel needs to be used.

In the calcining of limestone and the processing of lightweight aggregate as well as other thermal processes, it is generally known to use a preheater. A preheater of one configuration is shown in U.S. Pat. No. 3,601,376 issued Aug. 24, 1971. In this preheating apparatus, an arrangement is provided for controlling the preheating operation by controlling the volume of gas which passes through the full preheating zone of the apparatus. Some of the preheating gases pass through the entire length of the preheating zone and provision is made for by-passing some of the preheating gases so that they only pass through a portion of the preheating zone. By the present invention, all of the preheating gases pass through the preheating zone, but the effective length of the preheating zone is changed by controlling the direction of gas flow through the preheating zone.

Control of a preheater is important because of variations in the density and porosity of a bed of bulk material moving through the preheater. Although with some materials, it is desirable to obtain as high a temperature of the discharged material as is possible, with some materials it is not desirable to heat the raw material to too high a temperature in the preheater in order to avoid chemical reaction in the preheater. The present invention provides the control needed for temperature control.

SUMMARY

It is the principal object of this invention to provide a method and apparatus for preheating bulk material which provides a novel means of control over the preheating process.

It is a further object of this invention to provide a method and apparatus for preheating solid particulate material which can be used to provide a control for the temperature of the material discharged from the preheater.

It is a further object of this invention to provide a gas-solids heat exchange apparatus which provides a control which may be responsive to the pressure drop across the preheater.

In general, the foregoing and other objects will be carried out by providing a gas-solids heat exchange apparatus comprising a vessel having an inlet for solid particulate material, an outlet for solid particulate material, an inlet for gaseous fluid and an outlet for gaseous fluid; means defining a gas-solids contact zone intermediate said inlet and said outlet for gaseous fluid and intermediate said inlet and said outlet for solid particulate material whereby solid particulate material which moves from said inlet for solid particulate material to said outlet for solid particulate material passes through the gas-solids contact zone; means for directing substantially all of the gaseous fluid through the gas-solids contact zone for heat exchange contact with the solid particulate material; and means for varying the length of the gas-solids contact zone through which substantially all of gaseous fluid is directed.

The objects will also be carried out by providing in a process of preheating solid particulate material by direct contact with hot gases as the solid particulate material moves through a preheating zone and discharging the gases from the preheating zone by passing them into a space overlying the preheating zone, controlling the preheating operation by passing all of the hot gases completely through the preheating zone and varying the length of the preheating zone.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in connection with the annexed drawings wherein:

FIG. 1 is a diagrammatic view of a rotary kiln and preheater as employed by the present invention;

FIG. 2 is a sectional view of the preheater of the present invention with the control mechanism in one operative position; and

FIG. 3 is a view similar to FIG. 2 with the control mechanism in another operative position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, there is shown in FIG. 1 a preheater-kiln combination wherein the kiln is generally indicated at 1 and the preheating apparatus generally indicated at 2. The preheater 2 communicates with the rotary kiln 1 by means of a bulk material conveying conduit 3 and a hot gas conveying conduit 4. Material to be processed is supplied to the preheater 2 where it is treated with hot exhaust gases discharged from the rotary kiln 1 through conduit 4, and the material is conveyed from the preheater 2 through conduit 3 into the kiln 1 for further processing.

Referring to FIGS. 2 and 3, the preheating apparatus 2 includes a vessel 5 having sidewalls 6, end walls 7 (FIG. 1) and a floor 8. The vessel includes an inlet 10 for solid particulate material and an outlet 11 for solid particulate material which communicates with the conduit 3 and is in the floor 8 of the vessel 5.

A raw material hopper generally indicated at 9 may be coextensive with the vessel 5 for supplying material to the vessel. The vessel also includes a bridge 12 which extends between the end walls 7 of the vessel 5 but is spaced from the sidewalls 6 as clearly shown in FIG. 2. The bridge 12 may be of steel construction covered with refractory material. The bridge 12 defines a pair of downwardly and outwardly sloping walls 13.

Also mounted in the vessel are a pair of downwardly and inwardly sloping wall means 14 each extending from one of the sidewalls 6 towards the bridge 12 but spaced therefrom. The area immediately above the wall

means 14 and the opening 21 between the ends of the wall means 14 can be considered to be the solid particulate material inlet 10 of the preheating vessel.

The lower portion 15 of the sidewalls 6 should be covered with refractory brick 16 for heat protection. In addition, the floor 8 and the conduit 3 should be lined with refractory material 17 and 18, respectively. Bulk material 20 which is to be preheated fills the hopper 11 and passes through the material inlet 10 and the opening 21 between the wall means 14 to fill the area above the bridge 12. Between the end 14*a* of the wall means 14 and the lower portion 15 of the sidewalls, the material assumes a slope 22 which is at the material angle of repose to define an open space 25 between the material slope 22, the underside of the downwardly and inwardly sloping wall means 14 and the vessel sidewalls 6.

An inlet 30 for hot gases is positioned below the bridge 12 and communicates with the conduit 4. An outlet 31 for gases is positioned in each of the spaces 25 below each of the wall means 14 and above the slope 22 and each communicates with one of the discharge conduits 32 (FIG. 1).

The wall means 14, the lower portion 15 of the sidewalls 6, the downwardly and outwardly sloping wall means 13 of bridge 12 and the floor 8 define a gas-solids contact or preheating zone generally indicated at 40. Thus, the gas-solids contact zone 40 is intermediate the inlet 10 and outlet 11 for solid particulate material and intermediate the inlet 30 and outlet 31 for gases. Hot gases which flow from outlet 30 pass upwardly through the material in the preheating zone 40 and exit from the preheating zone and material through slope 22 to the outlet 31 as shown by the arrows 41 in a direction generally countercurrent to the direction of material flow through the preheater.

A pusher means 45 having a piston-cylinder arrangement 46 pivotally connected at one end to an external support 48 and having a piston rod 49 for moving a pusher 47 is provided for advancing material from the material inlet 10 to the material outlet 11. When the pusher 47 is advanced along the floor 8 toward the outlet 11, material in front of the pusher is moved along the floor 8 from the sidewall 15 to the outlet 11. When the pusher 47 is retracted by the cylinder 46, material in the preheating zone 40 falls down and material in the hopper 9 moves into the preheating zone 40 through material inlet 10. As the pusher 47 is continuously reciprocated, material continuously flows through the preheater from the inlet to the outlet. With a pair of conveyors 45, the two may be coordinated so that when one is being retracted, the other is being advanced to thus provide a continuous material flow to the kiln.

By the present invention, an arrangement has been provided for controlling the length of the gas-solids contact zone. This means includes a valve means generally indicated at 50 and including a valve member 51 pivotally connected at 52 to the lower portion 15 of the sidewall and extending upwardly therefrom in the area 25 above the slope 22. The valve member 51 is such that in one extreme position as shown in FIG. 2, it lays along the slope 22 which is the material angle of repose of the bulk material. The valve member 51 includes a turned-up portion 53 in order to prevent material from flowing over valve member 51 into space 25. In the embodiment shown in the drawings, a piston-cylinder arrangement 54 is provided for moving the valve member 51. The piston-cylinder 54 is pivotally connected at 57 to an external support and includes a piston rod 55 extending through an opening 58 in the sidewall 6 and pivotally connected to valve member 51 as at 56. A suitable seal (not shown) must be provided in the opening 58 around the piston rod 55 to prevent ambient air from leaking into the vessel through that passage. The piston-cylinder arrangement 53 can be used to move the valve member 51 away from the slope 22 any desired amount to the opposite extreme position shown in FIG. 3.

The means 50 for varying the length of the gas-solids contact zone 40 is such that when the valve member 51 is in the position shown in FIG. 2, all of the hot gases must flow through the gas-solids contact zone 40 up to the point 43 which is the effective end of the valve member 51. As the valve member 51 is moved away from the slope 22 such as shown in FIG. 3, the exhaust point for the gases from the gas-solids contact zone 40 will move down the slope 22 towards the floor 8. In the position of FIG. 3, the exit point 43 for the gases is at its lowest point. Of course, the valve member can be positioned at any intermediate point between the positions of FIGS. 2 and 3, and the point 43 will be intermediate the location shown in FIGS. 2 and 3. Since the gas will follow the easiest flow path, this will also be the shortest path through the material and the gases will be discharged from the preheating zone 40 at the earliest possible point. This point is controlled by the valve member 51, and thus, the valve member 51 serves to control the flow path of gases through the preheating zone 40 and the length of the gas-solids contact zone 40.

The control of the preheating zone is important because variation can occur in the density of the bed of material in the preheating apparatus which will result in a variation in the pressure drop across the preheater. By controlling the gas flow path and the length of the gas-solids contact zone, if the bed of material becomes more dense resulting in an increase in pressure drop across the gas-solids contact zone, the length of the flow path through the zone 40 can be decreased to compensate for the increase in density. In addition, with some materials, it is desirable not to overheat the material in the preheater so that chemical reaction will not take place in the preheater. If the material discharged through the outlet 11 is too hot, the valve means 50 will be opened to shorten the length of the gas-solids contact zone and thus the amount of time the hot gases contact the raw material and thereby result in a lower temperature of material being discharged from the preheater. Conversely, if the temperature of the discharged material through outlet 11 decreases, the valve means 50 can be moved toward the position of FIG. 2 to increase the time in which the solid particulate material is contacted by hot gases to thereby increase the heat exchange between the hot gases and the raw material. Temperature equilibrium between the gases and the material will be more closely approached. If desired, suitable controls may be provided for automatically adjusting valves 50 in response to material discharge temperature or gas pressure drop.

In view of the function and position of the valve member 51, it can be considered that the valve member aids in defining the gas-solids contact zone.

The present invention provides that all of the gases pass through the entire effective length of the gas-solids

contact zone rather than having some of the gases pass through all of the gas-solids contact zone and some of the gases pass through only a portion of the gas-solids contact zone as in U.S. Pat. No. 3,601,376. Control is achieved by controlling the length of the gas-solids contact zone and thus the length of time the solid particulate material is contacted by hot gases.

The process of the present invention should be apparent from the foregoing description. The process provides for preheating solid particulate material by exhaust gases from a mineral processing furnace whereby the solid particulate material moves through a preheating zone **40**, and the hot gases pass through the preheating zone generally countercurrent to the direction of material flow into a space **25** overlying the preheating zone **40**. The general process is improved by passing all of the hot exhaust gases through the preheating zone **40** and varying the length of the preheating zone by controlling the length of the flow path through the preheating zone by means of the valve means **50**.

Further, it should be obvious that the objects of this invention have been carried out. A preheating method and apparatus has been provided which can be responsive to both the temperature of the material discharged from the apparatus and the pressure drop across the apparatus.

Modifications of the apparatus may be made without altering the scope of the present invention. For example, it may be desirable to replace the pusher means **45** with some other means for advancing the material to the outlet **11** such as a reciprocating grate conveyor along floor **8**. It may be desirable to replace the external piston-cylinder means **53** for moving the valve member **51** with a toggle mechanism which is operated by a rotary drive shaft through the end of the vessel **2**. Such an arrangement would permit the use of a rotary seal which is more adaptable to the seal requirements of the apparatus than a seal for reciprocating movement.

As a further modification, it may be desirable to provide a multiple piece valve member **51** or some other arrangement to compensate for potential changes in the material angle of repose between the inlet **10** and the lower portion **15** of the sidewall **6**. This change in the slope **22** could be caused by changes in particle size of the feed material.

It is intended that the foregoing description be merely that of a preferred embodiment and that the invention be limited solely by that which is within the scope of the appended claims.

I claim:

1. A gas-solids heat exchange apparatus comprising:

a vessel having an inlet for solid particulate material, an outlet for solid particulate material, an inlet for gaseous fluid and an outlet for gaseous fluid;

means defining a gas-solids contact zone intermediate said inlet and said outlet for gaseous fluid and intermediate said inlet and said outlet for solid particulate material whereby solid particulate material which moves from said inlet for solid particulate material to said outlet for solid particulate material passes through the gas-solids contact zone;

means for directing substantially all of the gaseous fluid through the gas-solids contact zone for heat exchange contact with the solid particulate material; and

means for varying the length of the gas-solids contact zone through which substantially all of gaseous fluid is directed.

2. A gas-solids heat exchange apparatus according to claim **1** wherein said means for varying the length of the gas-solids contact zone includes valve means mounted in said vessel for controlling the length of the flow path of gaseous fluid from said inlet for gaseous fluid to said outlet for gaseous fluid through said gas-solids contact zone.

3. A gas-solids heat exchange apparatus according to claim **2** wherein said vessel includes a sidewall, a floor and a downwardly and outwardly extending wall means positioned with respect to each other and with respect to the inlet and the outlet for solid particulate material so that solid particulate material moves from said inlet for solid particulate material along said downwardly and outwardly sloping wall means and forms the natural material angle of repose between said inlet for solid particulate material and said sidewall to thereby define the gas-solids contact zone.

4. A gas-solids heat exchange apparatus according to claim **3** wherein said outlet for gaseous fluid is positioned above the natural material angle of repose between said inlet for solid particulate material and said sidewall and said valve means extends from said sidewall upwardly toward said inlet for solid particulate material between the outlet for gaseous fluid and the natural material angle of repose formed between the inlet for solid particulate material and the sidewall.

5. A gas-solids heat exchange apparatus according to claim **4** further comprising means for moving solid particulate material along said floor toward said outlet for solid particulate material.

6. A gas-solids heat exchange apparatus according to claim **4** further comprising means for adjusting the position of said valve means relative to the natural material angle of repose to thereby provide the means for varying the effective length of the gas-solids contact zone.

7. A gas-solids heat exchange apparatus according to claim **1** wherein said vessel includes a sidewall, end wall and a floor; a downwardly and outwardly sloping wall means mounted in said vessel and spaced from said sidewall and floor, a downwardly and inwardly sloping wall means extending from said sidewall toward but spaced from said downwardly and outwardly sloping wall means; said inlet for gaseous fluid being positioned under said downwardly and outwardly sloping wall means; said outlet for gaseous fluid being positioned under said downwardly and inwardly sloping wall means; said gas-solids contact zone being defined by said downwardly and outwardly sloping wall means, said downwardly and inwardly sloping wall means, said floor, said sidewall and said valve means.

8. A gas-solids heat exchange apparatus according to claim **7** wherein said means for varying the length of said gas-solids contact zone includes valve means mounted in said vessel for controlling the flow path of gaseous fluid from said gaseous fluid inlet to said gaseous fluid outlet through said gas-solids contact zone; said gas-solids contact zone being further defined by said valve means.

9. A gas-solids heat exchange apparatus according to claim **8** wherein said outlet for solid particulate material is in said floor and further comprising means for

moving solid particulate material along said floor to said outlet for solid particulate material.

10. In a process of preheating solid particulate material by direct contact with hot gases as the solid particulate material moves through a preheating zone and discharging the gases from the preheating zone by passing them into a space overlying the preheating zone, controlling the preheating operation by passing all of the hot gases completely through the preheating zone and varying the length of the preheating zone.

11. In a process according to claim **10** wherein the length of the preheating zone is varied by controlling the direction of flow of gases through the preheating zone to thereby control the length of the gas flow path through the preheating zone.

12. A method of achieving heat exchange between solid bulk material and gas comprising the steps of passing the solid bulk material through a gas-solids contact zone; passing the gas through the gas-solids contact zone in a generally countercurrent direction to the direction in which the solid bulk material passes through the gas-solids contact zone, and controlling the effective length of said gas-solids contact zone.

13. A method of achieving heat exchange according to claim **12** wherein the effective length of said gas-solids contact zone is controlled by controlling the direction in which the gas passes through said gas-solids contact zone.

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