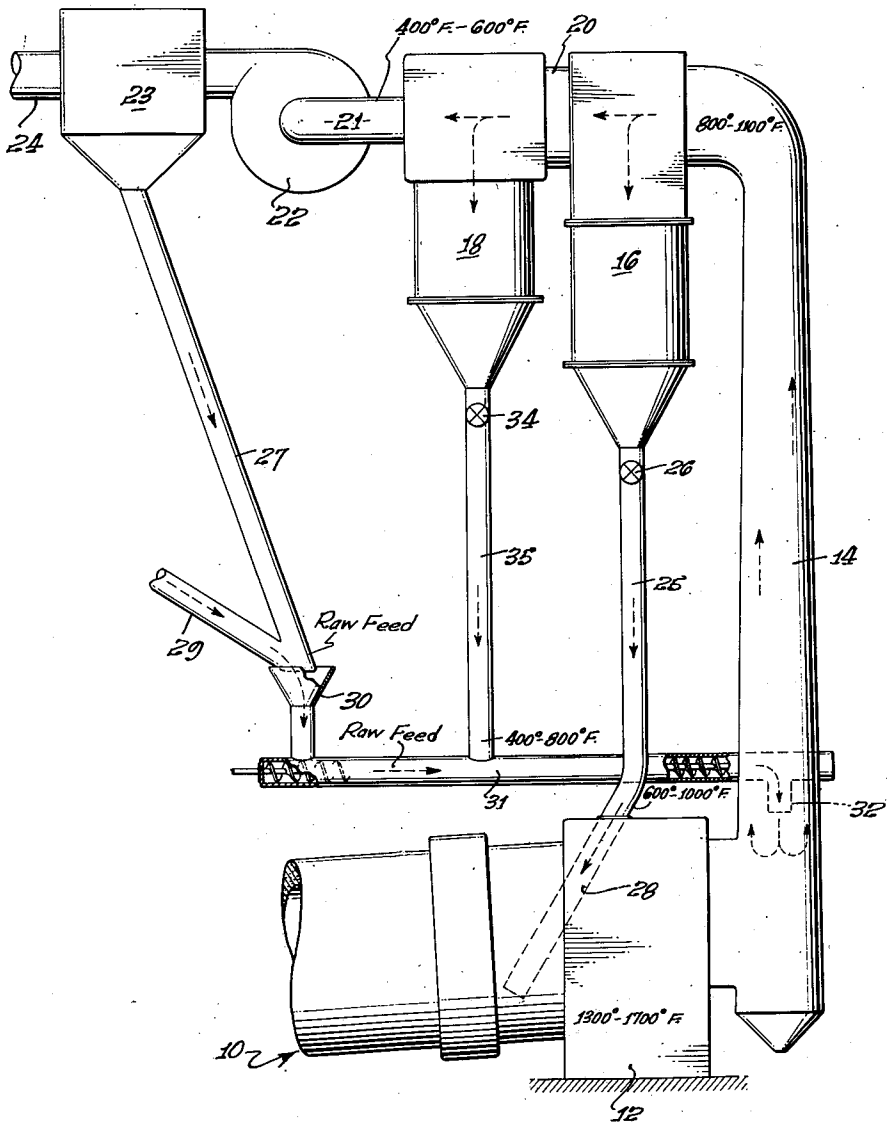
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APPARATUS FOR HEATING FINELY DIVIDED SOLID MATERIAL

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APPARATUS FOR HEATING FINELY DIVIDED SOLID MATERIAL

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1 Claim. (Cl. 263—32)

This invention relates generally to a method and means for heating finely divided solid material; and more especially, for heating the raw feed prior to introduction into a rotary kiln in the manufacture of cement.

In a process of this character, the most effective and quickest way in which the finely divided material can be heated is by direct contact with the heated gases leaving the kiln. Recognizing this, various types of apparatus have been devised in which the raw feed is introduced directly into the stream of gases from the kiln and is suspended in or carried along by the gas stream. This then creates the problem of effecting a substantially complete or highly efficient separation of the solid and gaseous phases of the mixture.

Known arrangements for this purpose have generally included a plurality of serially connected collectors of the cyclone type. These collectors effect successive collections of the suspended material, which, after collection is introduced into the kiln. These known arrangements have various disadvantages, as for example the extensive and complicated duct work required to convey the gas stream carrying the material in suspension from one collector to another and to convey the collected portions back to the kiln. Such piping may include sharp bends or other places where the drop in gas velocity causes an excessive accumulation of dust particles. Also, the piping arrangements are often expensive and take up an excessive amount of space; or, because of the great length of duct work through which the particles are conducted, they may cause an excessive amount of heat loss.

Thus it becomes a general object of my invention to devise a method of heating finely divided material by direct contact with heated gases and subsequently separating the suspended material in a plurality of collectors in such a way as to effect maximum heat transfer to the finely divided material and minimum loss of heat before ultimate introduction of the material into the kiln in order to maintain the kiln feed at a desired high temperature.

It is an object of the invention to provide apparatus for carrying out this method, which apparatus is relatively simple and enables short, direct connections between the various parts, but without sacrificing collection efficiency.

A further object of my invention is to provide apparatus for carrying out my improved method in which one or more fractions of material collected at a relatively low temperature can be recirculated and reheated in order to raise the temperature of the ultimate feed to the kiln.

The above objects of my invention are achieved according to my improved method by introducing the feed in the form of finely divided solids into a rising stream of heated gas taken from the head end of the kiln, the finely divided material being heated by direct contact with the gas stream as it is carried upward in suspension by the gas stream. After the desired time of contact, a first partial separation of the heated material is effected by passing the material through a dust collector from which

the collected material is introduced directly into the head end of the kiln, The gas stream with the remaining material in suspension is then subjected to a second separation in which a second and smaller fraction of the suspended particles is removed from the gas stream, this generally being composed of finer particles since the larger part of the coarser particles has already been removed. This second fraction is then added to and mixed with the unheated feed to raise the temperatures of the feed by direct contact with it prior to the introduction of the feed into the heated gas stream.

My improved method is carried out in a rotary kiln which is connected at its head and to a vertically extending stack in which the heated gases from the kiln rise. Feed means, preferably in the form of a screw conveyor or the like, introduces the finely divided solid material into the stack at some suitable point in the lower portion of the stack in order to obtain a satisfactory length of contact time between the hot gases and the feed as they are carried upward in the stack by the rising gas stream. Two cyclone separators are arranged side by side, the gas stream being passed first through one and then through the other. In the first collector a major portion of the suspended material is removed from the gas stream and this portion of the heated material is then allowed to pass by gravity through a conduit which introduces it directly into the kiln. A smaller portion of the material is collected in the second collector and then allowed to pass by gravity through a conduit which is connected to the feed means. This material, while heated, is not hot enough for introduction into the kiln, so it is added to the raw feed at some point ahead of the location of the discharge of the feed into the stack. Preferably a certain amount of mixing of the feed takes place during the conveying in order that the preheated material may be thoroughly mixed with the raw feed and raise the average temperature of all the particles in the feed by the time the feed is introduced into the stack.

A suitable blower is provided through which the gas stream passes, the blower providing the energy to force the gas stream through the two collectors. It is normally located so that the blower inlet is connected to the outlet of the second cyclone collector and the gas passing through the blower is not only at a lower temperature but also carries only a small amount of suspended material.

In order to effect a high degree of total collection, it is desirable that the outlet of the blower discharge into an electrical precipitator which is particularly well adapted to remove substantially all of the very fine particles remaining suspended in the gas stream. From the precipitator, the cleaned gases may be discharged from the atmosphere while the material collected in the precipitator is returned to the raw feed.

How the above objects and advantages of my invention, as well as others not specifically mentioned, are attained will be more readily understood by reference to the following description and to the annexed drawing, in which there is shown schematically an apparatus embodying my invention for heating finely divided material by direct contact with heated gases and then subsequently separating the heated material from the gas stream in two or more fractions which are either introduced directly into the kiln or mixed with the raw feed.

Referring now to the drawing, there is indicated generally at **10** the upper end of a rotary kiln which may be of any conventional design. The open upper or head end of the kiln is surrounded by a stationary housing **12**. The housing **12** is connected to the lower end of vertically extending stack or flue **14** which receives the heated gases discharged from the kiln. Stack **14** in conventional practice discharges the heated gases into the open atmosphere;

but according to this arrangement advantage is taken of the heat contained in the gases within the stack to heat the feed material before entering the kiln. In accordance with the usual practice, stack **14** rises vertically.

A first dust separator or collector **16** and a second dust collector **18** are provided at positions suitably elevated above the level of kiln **10**. These two collectors are preferably arranged in side-by-side relationship and are horizontally spaced apart only a short distance, to reduce the length of connecting duct work and heat losses therefrom. For this same reason they are close to, but not necessarily directly over the kiln. Each of the two collectors is of the cyclone type, preferably of the type having a plurality of small cyclone tubes operating in parallel, since this type of collector has no moving parts and is well able to withstand the relatively high temperatures of the gases flowing through them.

Each of the two collectors **16** and **18** is provided with a gas inlet and a gas outlet at opposite sides and with a material outlet at its bottom. The upper end of stack **14** is connected to the gas inlet of the first collector **16** while the gas outlet of collector **16** is connected by a short duct **20** to the gas inlet of the second collector **18**. In this way the gas stream after passing through stack **14** passes in succession through the two dust collectors.

Upon leaving the second dust collector **18**, the gas stream passes through duct **21** into blower means **22**, which may be any type of air moving device, such as a centrifugal fan. The outlet or discharge from blower means **22** is connected to electrical precipitator **23** so that the gas upon leaving the blower enters the electrical precipitator. The gas outlet **24** of the electrical precipitator may be open to the atmosphere or be connected to any desired piece of apparatus. Material collected in the precipitator is very fine and may be returned to the system at any desired position, suitable conveying means, either power or gravity, being indicated diagrammatically at **27**.

At the lower end of collector **16** there is a material outlet opening to sealing valve **26** through which the material collected in the collector is discharged into duct **25**. Valve **26** prevents flow of gases past the valve and through duct **25**. Duct **25** is preferably vertical or steeply inclined, and is connected to feed pipe **28** which corresponds to the conventional means for introducing feed into the head of kiln **10**. This feed pipe passes through a portion of housing **12** and into the open end of kiln **10** to discharge material by gravity into the kiln.

The materials to be fed into the kiln are ground or pulverized to the desired degree of fineness by machinery not shown in the drawing. This raw feed, in finely divided form, is then brought by suitable means, indicated diagrammatically at **29**, to the feed or supply means as shown in the drawing. This means consists of a hopper **30** which is connected at its lower end to screw conveyor **31** or other suitable positive conveying means, which extends preferably in a generally horizontal direction. Near one end screw conveyor **31** discharges the finely divided material through a discharge pipe **32** into stack **14**. Discharge pipe **32** is located in the lower portion of stack **14**. Obviously it is desirable that the material be introduced into the stack at as low a position as possible, but at the same time it is preferable that the point of entry be at a location at which all of the gas within the stack is moving upwardly.

At the lower end of the second collector **18** is a material outlet which is connected to sealing valve **34**. This valve is also connected to the vertically extending conduit **35**. By operation of valve **34** material collected within the hopper is transferred to conduit **35** and then falls by gravity through the conduit, the lower end of which is connected to the housing of screw conveyor **31**.

Having described the apparatus, I shall now describe the method involved and the operation of the apparatus. Prior to introduction into hopper **30**, the component parts of the raw feed are ground to the desired degree of fineness and mixed together in the proper proportions; and this mixture is finely divided, dry solid material is then conveyed by means **29***b* to hopper **30** from which it flows by gravity to the screw conveyor or other means for supplying the raw feed to the system. The flow of the material is indicated by the arrows. The flights of the screw-conveyor as they rotated advance the powdered material to the right and finally introduce it through pipe **32** into stack **14**. The material has been ground to such a degree of fineness that it is substantially all carried upward in the stream of hot gases rising within stack **14**. Being in dry form, the pulverized material is easily dispersed throughout the gas stream by the turbulence of the gases.

Being in direct contact with the heated gas, the particles of material are heated quickly and efficiently; and by the time the top of the stack is reached, these particles have reached a temperature of approximating that of the gas stream in which they are suspended. During this upward travel, of course the gas has dropped considerably in temperature and therefore decreased in volume. For example, gas leaves the kiln at temperature usually within the range of 1300°–1700° F. and are cooled to about 800°–1100° F. at the inlet to the first collector. In order to compensate for this volume change and keep the gas velocity throughout the stack at a substantially constant value, the stack tapers upwardly. The diameter or cross sectional area of the stack decreases in an upward direction and at a rate designed to substantially compensate for the decrease in volume of the gases.

By the time the gas and suspended particles reach the top of the stack, the particles are heated to the temperature of the gas. At the upper end of the stack, the gas stream and the suspended particles are introduced into the inlet of the first collector **16** in which a first partial separation of the heated suspended particles from the gas is effected. In this collector, a major proportion of the suspended material, for example 70% or more, is removed from the gas stream and collected in the hopper at the bottom of the collector. Coarser particles are more easily separated than finer ones, and therefore this first fraction includes most of the coarser particles. It therefore may be considered as being a coarser fraction as compared with any fraction subsequently collected. This first fraction is then passed through sealing valve **26** into pipe **25** through which it flows by gravity to feed pipe **28** through which this material is introduced directly into the head end of rotary kiln **10**. At the time of introduction, the feed is typically at about 600°–1000° F.

After leaving first collector **16**, the gas stream with the remaining particles in suspension is introduced into the inlet of the second collector **18** within which a second partial separation of the suspended material is effected. Since nearly all of the coarser particles had previously been removed, the second fraction collected in collector **18** contains a larger percentage of finer particles and therefore may be referred to as the finer fraction. This fraction of the material is collected in the bottom of collector and passed through sealing valve **34** into conduit **35** through which the material flows by gravity. This second fraction is combined with the raw feed being moved by the screw conveyor. At the point of introducing material from conduit **35**, the raw feed is unheated while the material introduced from conduit **35** is at a higher temperature. For example, the material introduced at this point may be within the range of 400°–800° F.

This second fraction of material is mixed with the unheated raw feed by the mixing action of the flights of the screw conveyor so that as the feed advances, all of the feed is heated to some extent. For example the average temperature of the material leaving the discharge **32** is in the range 100°–200° F. Conduit **35** is preferably spaced sufficiently far from discharge **32** to permit a thorough mixing and heat transfer between particles of

the mix as it is conveyed from the junction with conduit 35 to the point of discharge 32.

In order to keep up the velocity of the gas stream and to compensate for the draft loss in passing through the two collectors, suitable blower means are provided for forcing the gas stream through the collectors. This blower means may take the form of any type of fan or blower, although a fan of the centrifugal type is shown in the drawing. The inlet of the fan is connected by duct 21 to the outlet of central collector 18; and the gas stream leaving the vent is discharged into electrical precipitator 23. The fan may be located at any other desired position in the circuit; but the location shown has the advantages that at this point the gas stream is relatively clean and the volume is smaller than at any point in the system between the blower and the kiln. Gas temperature at the intake to the blower is typically about 400°–600° F.

The gas stream by the time it reaches precipitator 23, is carrying in suspension less than 10% of the original finely divided material; but these particles are the finest ones and therefore the hardest to collect. Because of the relatively high efficiency of the electrical precipitator, normally in excess of 95%, this type of collector is the last one of the series. It is also used in this position in the circuit because here the dust loading in terms of unit weight per unit volume is the lowest.

The finely divided material collected from the electric precipitator has, by the time it leaves the precipitator, cooled down to a temperature only silghtly above ambient temperature. Hence this material may either be returned to the system at hopper 30 as shown or it may be combined with the raw feed prior to proportioning and returned through conveyor 29.

Since changes in my invention may occur to those skilled in the art without departing from the spirit and scope of my invention, the above description is considered as not being necessarily limitative upon, but rather illustrative of, the appended claim.

I claim:

The combination with a rotary kiln, comprising: a vertically extending stack connected to one end of the kiln to receive heated gas therefrom: positive feed means for introducing solid material in pulverized form into the lower portion of the stack to become suspended in the upwardly moving gas stream; a first cyclone-type collector located above the kiln with its inlet connected to the top of the stack to receive the gas stream and suspended dust, the material outlet of said separator being connected to the kiln to discharge collected material by gravity into the kiln; a second cyclone-type collector located above the kiln with its gas inlet connected to the gas outlet of the first collector to receive the gas stream, the material outlet of the second collector being connected to the feed means at a location ahead of the discharge into the stack to discharge by gravity into the feed means material collected by the second collector; blower means connected to the gas outlet of the second collector and through which the gas stream passes to force the gas stream through said collectors; an electrical precipitator above the feed means with its inlet connected to the outlet of the blower means to receive the gas stream; and conduit means connecting the material outlet of the precipitator to the feed means at a position ahead of the connection of the second collector to the feed means to discharge by gravity into the feed means the material collected by the precipitator.

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