

June 21, 1960

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2,941,791

ROTARY KILNS

Filed Aug. 23, 1956

Fig. 1.

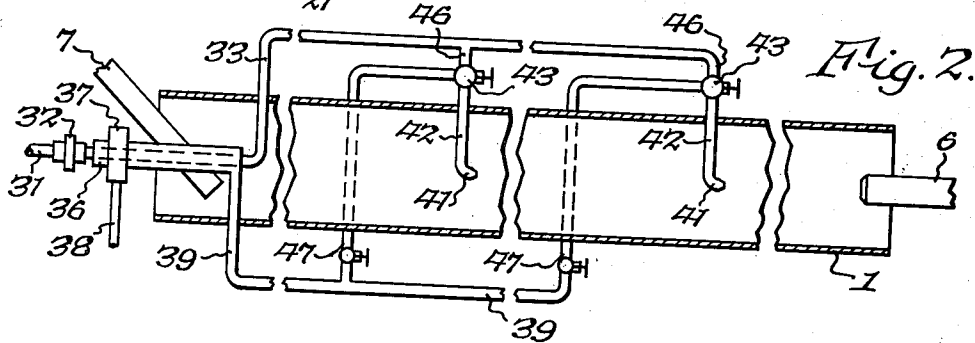
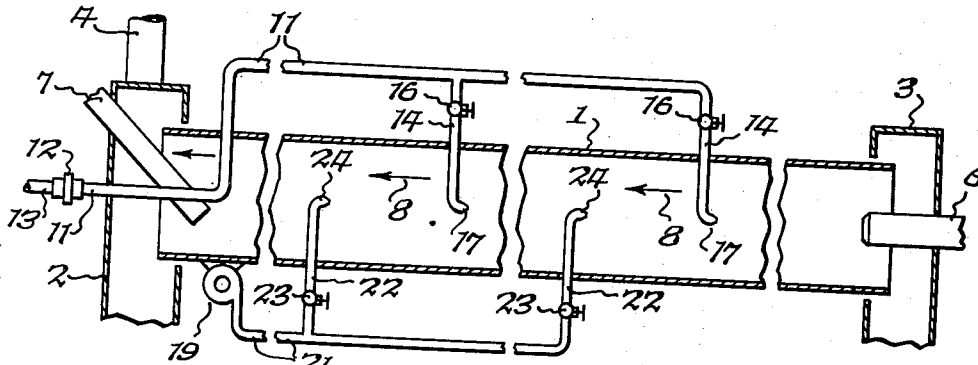
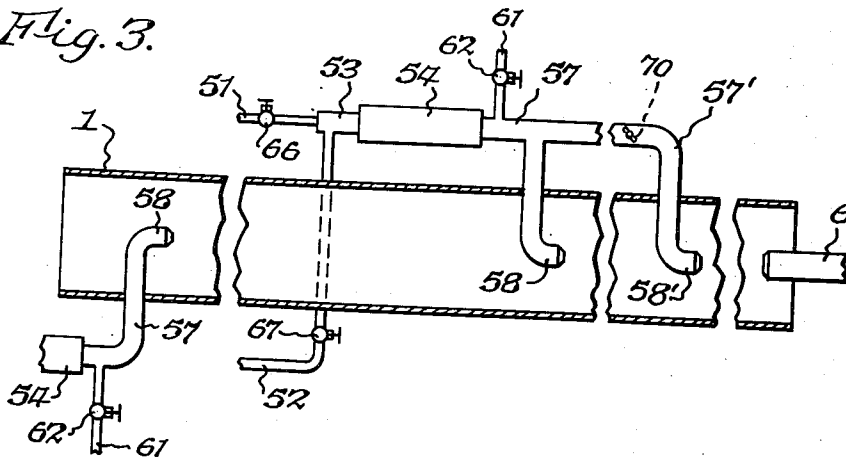


Fig. 3.



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2,941,791

ROTARY KILNS

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Filed Aug. 23, 1956, Ser. No. 605,900

2 Claims. (Cl. 263—33)

This invention relates to rotary kilns and is particularly concerned with rotary kilns in which there are provided a plurality of heating zones.

In conventional rotary kilns the tube of the kiln is slightly inclined from the horizontal so that rotary motion of the tube will cause longitudinal movement of the charge through the tube from the higher end to the lower one. Heating is accomplished by a fixed burner arranged axially with respect to the tube and having the nozzle thereof entering the lower end of the tube so that the flow of the material through the kiln is counter-current to the path of the heated combustion gases. The latter pass upwardly through the tube and to a stack located at the other end of the tube. Consequently, the temperature of the kiln charge increases during its passage through the tube until it reaches a maximum near the fixed burner at the discharge end of the kiln.

For some purposes such an arrangement is entirely satisfactory. Often, however, it is desired to maintain the kiln charge at a high temperature but less than the maximum for a prolonged period of time or to maintain an even temperature throughout the major portion of the length of the kiln. Such is the case, for instance, if dehydration, calcination or distillation operations are to be carried out in the kiln. In these processes high or non-uniform temperatures are often detrimental to the product or cause mechanical trouble in the kiln due to sintering and sticking of the charge.

Attempts have been made to obtain a long hot zone in a kiln by producing an elongated flame from the burner. However, the length of flame which can be feasibly produced is limited and the temperature in the hot zone is not particularly uniform. It has also been known to introduce air and combustible gases into a rotary kiln at various points along its length. As previously used, however, such arrangements have produced local overheating and have not been effective to maintain a uniform temperature throughout the kiln.

It is an object of the present invention to obtain a more satisfactory distribution of heat in a rotary kiln while at the same time regulating the nature of the kiln atmosphere.

Another object of the invention is to provide more uniform temperature over a longer zone in a rotary kiln.

A further object of the invention is to provide a rotary kiln with a plurality of longitudinally arranged heating zones.

Another object of the invention is to provide a rotary kiln in which the heat loss in the stack is reduced to a minimum while satisfactory heating conditions throughout the length of the kiln are maintained.

Another object of the invention is to provide a rotary kiln having a construction which makes possible its use in heat processing of many different materials.

Other objects and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawing in which:

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Figure 1 is a somewhat diagrammatic view showing the tube of a rotary kiln and means associated therewith for introducing a combustible fluid and an oxidizing gas into the kiln at longitudinally spaced intervals;

Figure 2 is a view similar to Figure 1 showing a modified form of auxiliary heating arrangement; and

Figure 3 is a view similar to Figures 1 and 2 showing a still further modification.

In Figure 1 there is shown a kiln 1 which is provided with conventional or other suitable supporting and rotating means (not shown) and which may also be provided, if desired, with a suitable refractory or heat resistant lining (not shown). The ends of the tubular kiln 1 extend into headers or housings 2 and 3, the end in the former being somewhat higher than the end in the latter. An exhaust duct 4 is connected to the header 2 and is adapted to lead combustion gases from the header to an exhaust stack (not shown). At the other end of the kiln a fixed burner nozzle 6 projects through the side of the housing or header 3 and extends into the end of the kiln, being arranged axially therein. In the operation of the kiln shown in Figure 1 a charge of material to be heated is introduced into the kiln through the charging pipe or chute 7 that extends through the header 2 into the higher end of the kiln and the charge falls from the lower end of the kiln into the header 3 from which it is withdrawn in any desired manner. The construction described above is essentially conventional with rotary kilns.

According to applicant's invention, the kiln is provided with auxiliary heating means whereby a plurality of heating zones may be established therein. This may be accomplished, as shown in Figure 1, by providing a fuel pipe 11, arranged axially with respect to the kiln, and extending through the header 2 where it is connected by a rotary joint 12 to a fuel supply line 13. The pipe 11 is led out through the wall of the kiln 1 and is extended longitudinally of the kiln on the outside thereof. At spaced intervals along the pipe 11 branch pipes 14 controlled by valves 16 extend from the pipe 11 radially into the kiln. At their inner ends the branch pipes 14 are provided with nozzles 17 arranged axially of the kiln and having the openings thereof directed toward the burner 6.

The kiln 1 is also provided with a compressor or blower 19 which is attached thereto and rotates therewith. The compressor or blower 19 is preferably operated by an electric motor (not shown) having suitable slip-ring electrical connections thereto. The outlet of the blower is connected to an air pipe 21 that extends longitudinally of the kiln, preferably diametrically opposite the pipe 11. Branch pipes 22 controlled by valves 23 extend radially inwardly from the pipe 21 at spaced intervals along its length. The branch pipes 22 are provided at their inner ends with nozzles 24 which are arranged axially with respect to the kiln so as to be aligned with the nozzles 17. The nozzles 24 also have their openings directed toward the fixed burner nozzle 6. The branch pipes 14 and 22 and their respective nozzles 17 and 24 are arranged alternately longitudinally of the kiln. The nozzles 17 and 24 may be spaced at equal intervals along the length of the kiln or may be irregularly spaced to provide for the particular requirements of the material being heated. The arrows 8 indicate the direction in which flow of combustion gases or kiln atmosphere takes place through the kiln to the stack.

The operation of a kiln constructed as shown in Figure 1 and described above is extremely flexible. A fluid fuel such as gas, oil, or even finely powdered or fluidized coal or other solid fuel may be introduced through the nozzles 17 while air from the compressor or blower 19 is admitted through the alternately arranged nozzles 24. There will thus be produced along the length of the kiln

a plurality of regions where combustion takes place and the temperature therein may be made much more uniform. It is also possible to adjust the kiln atmosphere as desired by varying the supply of fuel and/or air. For example, by incomplete combustion the atmosphere throughout the kiln or in portions thereof may be reducing while by admitting an excess of air an oxidizing atmosphere may be provided in other portions of the kiln. Both the fuel and the air are introduced into the kiln by the nozzles 17 and 24, respectively, counter-current to the flow of the kiln atmosphere to the exhaust stack. As a result, they tend to form a cone by the forward movement imparted by the nozzle velocity and their expansion in volume. However, the effect of the counter-flowing kiln atmosphere in flattening such cones and sweeping back the outer portion thereof is to produce a zone of considerable length and diameter in the kiln throughout which combustion takes place. This is important as it prevents local over-heating.

In Figure 2 there is shown a modification in which a plurality of auxiliary burners is provided at spaced intervals longitudinally within the tube of the kiln 1, the direction of flow of kiln atmosphere being the same as in Figure 1. As illustrated, a fuel supply pipe 31 is joined by a rotary coupling 32 to a fuel line 33. The line 33 enters the kiln axially from the stack end thereof, is led outwardly through the wall to the outside of the kiln and there extends longitudinally. Surrounding the fuel line 33 where it enters the end of the kiln 1 is a jacket 36 having an inlet with which there is connected, by a rotatable coupling 37, an oxidizing gas supply pipe 38. At its inner end the jacket 36 is closed and an oxidizing gas line 39 extends therefrom through the wall of the kiln 1. The line 39 then extends longitudinally along the outer surface of the kiln and is preferably arranged diametrically with respect to the fuel line 33.

At spaced intervals along the length of the kiln 1 there are provided a plurality of nozzles 41 arranged axially of the kiln and having their open ends directed toward the fixed burner nozzle 6 so that flow through the nozzles will be counter-current to the general direction of flow of the kiln atmosphere to the exhaust stack. The nozzles 41 are carried by radially extending pipes 42 that project outwardly through the wall of the kiln and are provided with valves 43. Branch lines 46 and 47 extend from the fuel line 33 and oxidizing gas line 39, respectively, to each of the valves 43. Preferably, the lines 46 and 47 are carried on the outside of the kiln, due care with their arrangement being taken to prevent unbalancing of the kiln. The valves 43 are adapted to regulate flow in the lines 46 and 47 and thus to feed either fuel or oxidizing gas or a mixture thereof to the nozzles 41. With the arrangement illustrated in Figures 2, it is obvious that auxiliary heat may be supplied at intervals in the kiln by burning a mixture of fuel and air at nozzles 41 or, if desired, air (or other oxidizing gas) or fuel may be individually fed into the kiln through one or more of the nozzles 41. The number of nozzles 41 may vary as desired.

In Figure 3 there is illustrated still another arrangement of elements adapted to produce a plurality of heating zones in a rotary kiln. In this modification a fuel line 51 and an oxidizing gas supply line 52 are brought together at a burner 53. The burner has associated therewith a combustion chamber 54 in which the fuel burns. The combustion chamber is provided with an outlet pipe or duct 57 which is carried through the wall of the kiln 1 and provided at its inner end with a nozzle 58. This nozzle is arranged axially of the kiln and the opening thereof is directed away from the stack end of the kiln so that combustion products will flow from the nozzle counter-current to the general direction in which the kiln atmosphere flows to the exhaust stack. An auxiliary inlet pipe 61 is connected to the duct 57 exteriorly of the kiln and flow from the pipe 61 into the duct is controlled by the valve 62. It will be understood

that the combustion chamber 54 and burner 53 are fastened to the exterior of the kiln 1 and are adapted to rotate therewith. Also, of course, the fuel and oxidizing gas lines 51 and 52 and the auxiliary inlet 61 are so connected to their supply pipes as not to interfere with rotation of the kiln, while at the same time maintaining a constant flow.

By the arrangement illustrated in Figure 3, hot combustion gases may be fed from the chamber 54 through the duct 57 and nozzle 58 into the kiln in a direction opposite to the flow of the kiln atmosphere to the stack. The nature of the combustion gases, i.e. their oxidizing or reducing character, may be controlled by adjustment of the valves 66 and 67 provided in the fuel line 51 and air line 52, respectively. Further adjustment of the combustion gases entering the kiln through the nozzle 58 may be obtained by supplying gas to duct 57 through the auxiliary line 61. Thus, by admitting reducing or oxidizing gases thereto the chemical nature of the auxiliary atmosphere entering the kiln through the nozzle 58 may be changed. Also, it is possible by admitting a cold gas, such, for example, as recirculated stack gas, through the auxiliary line 61 to lower the temperature of the combustion gases fed to the kiln through the duct 57. This is of considerable importance where a heat-sensitive material is being processed in the kiln as local over-heating can thus be avoided. It will be obvious that the combustion chamber 54 may be provided with a plurality of outlet ducts each having a nozzle opening axially within the kiln 1 toward the fixed burner 6. This is illustrated by the duct 57' having the nozzle 58' disposed axially within the kiln 1 with its outlet directed toward the main burner nozzle 6 and having a conventional shut-off valve 70 to control flow therein. It will also be obvious that a plurality of combustion chambers 54, outlet ducts 57 and nozzles 58 may be provided on a kiln as shown in Figure 3. In practice, it will usually be desirable to employ a plurality of combustion chambers so located on the outside of the kiln as to counter-balance each other.

It will be obvious that many of the details of construction illustrated and described may be changed or modified without departing from the spirit of the present invention. Thus, for example, it will be understood that if an oxidizing gas other than air were desired in a kiln constructed as illustrated in Figure 1, it could be supplied through an external connection such as is illustrated in Figure 2 for supply of oxidizing gas. Similarly, in the use of a kiln construction in accordance with Figure 2, air could be supplied by a blower or compressor carried on the exterior of the kiln as in Figure 1 instead of being supplied through the pipe 38.

Further it will be understood that combinations of the auxiliary heating means illustrated in the drawings and described above may be made in a single kiln. In general the construction illustrated in Figure 2 is preferred when high temperature operations are called for and the construction illustrated in Figure 3, in which combustion gases that may be adjusted in composition and/or temperature are admitted to the kiln, is preferred when relatively low temperatures are required. Various combinations of the illustrated structures may be employed when desired. Thus, for example, a kiln could be equipped with one or more combustion chambers of the type illustrated in Figure 3 with their accompanying nozzles and also with one or more burners of the type illustrated in Figure 2 and/or one or more of the inlets for fuel and/or oxidizing gas illustrated in Figure 1. Other combinations could, of course, also be made. In all cases, however, as in the illustrated embodiments, the nozzles through which fluids are introduced into the kiln would be arranged along the central axis of the kiln and would have their openings directed so that flow therefrom would be counter-current to the direction of flow of the kiln atmosphere to the exhaust stack. The several nozzles illustrated in the drawings may be integral with the ducts or branch pipes on which they

are carried or, if desired, may be separate. It is also contemplated that the fixed burner situated at the lower end of the kiln adjacent the point of discharge of material therefrom may be omitted or that its use may be omitted or minimized in carrying out various heating operations.

A further modification of the construction illustrated in Figure 3 which on occasion may be desirable comprises making the inlets to the kiln from the combustion chamber tangential to the kiln instead of axial. In some cases this is advantageous. For example, when extremely high kiln temperatures are employed the use of tubes or pipes projecting into the kiln as in Figure 3 is impractical. Tangential inlets to the kiln should, of course, be arranged so that in the normal direction of rotation of the kiln the charge does not fall in the openings.

It will be obvious from the foregoing description that rotary kilns according to the present invention are extremely versatile and may be used to carry out calcination, distillation and other heating operations with a high degree of efficiency. The construction of the improved kilns of the present invention is such that it is possible to obtain much more uniform heating throughout the kiln and at the same time to avoid local overheating. The flexibility of operation permitted by the present construction is very valuable since, for example, in the making of metallurgical coke it is possible to have a long zone in which the temperature is maintained relatively low while the condensable, volatile matter is driven off and then a higher temperature zone for the expulsion of non-condensable gases such as hydrogen. This could be most easily done with a kiln, according to the present invention, in which the charge is first heated by means of auxiliary heating means like that shown in Figure 3 and is subsequently heated by auxiliary burners of the type shown in Figure 2 and/or a fixed burner at the discharge end of the kiln.

In the foregoing description and in the accompanying claims the term "fluid" is meant to include liquids, gases and, where use thereof is not contra-indicated, fluidized

solids such as finely divided coal carried in a gas or liquid. The term "oxidizing gas" is meant to include air as well as oxygen. The term "kiln atmosphere" is meant to include the products of combustion within the kiln produced by the fixed burner 6 if such is used, the products of combustion introduced by the auxiliary heating means illustrated in Figure 3, fluids introduced into the kiln by auxiliary heating means of the types shown in Figures 1 and 2, and the products of combustion of such fluids.

This application is in part a continuation of an application, Serial No. 352,093, filed April 30, 1953, now abandoned.

I claim:

1. In a rotary kiln open at both ends and communicating with an exhaust stack at one end thereof, a plurality of auxiliary heating means spaced longitudinally of said kiln, each of said means comprising a fluid inlet to said kiln having a nozzle arranged axially of said kiln and with the opening thereof directed to introduce fluid into said kiln in a direction counter-current to the general direction of flow of the kiln atmosphere to said stack, each of said auxiliary heating means comprising a combustion chamber carried by said kiln on the exterior thereof and the products of combustion therefrom being introduced into said kiln through a nozzle of said auxiliary heating means.

2. A rotary kiln as set forth in claim 1 in which an auxiliary inlet for fluid is provided, said auxiliary inlet being connected to the outlet of said combustion chamber.

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