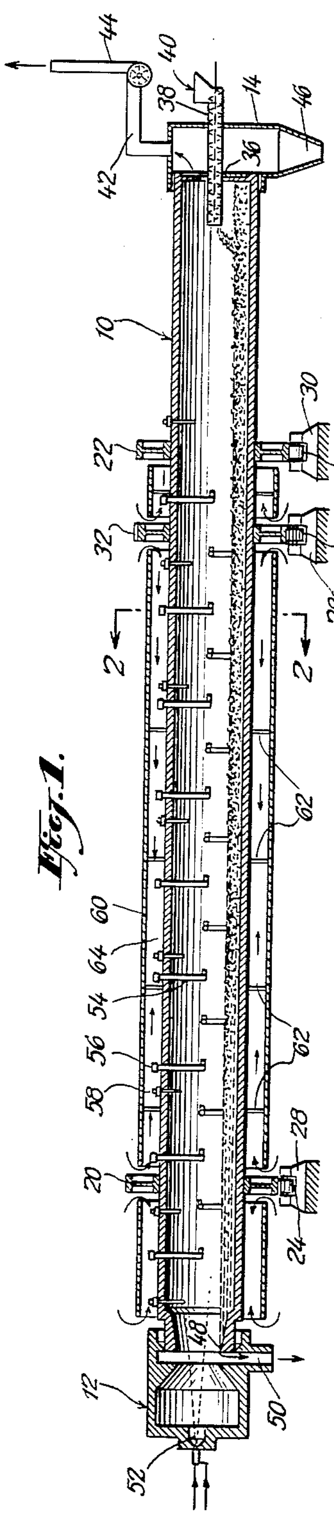
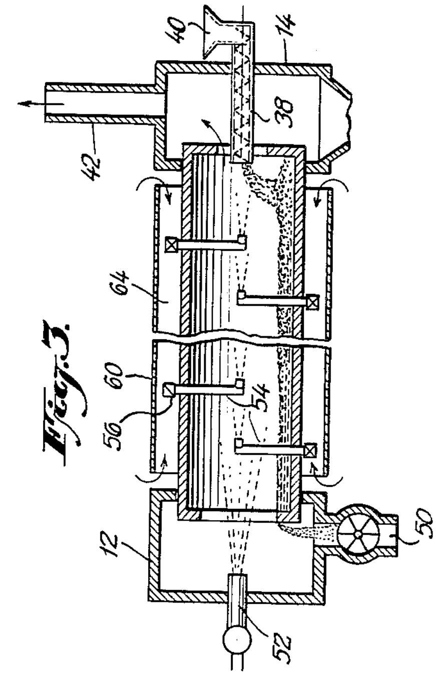
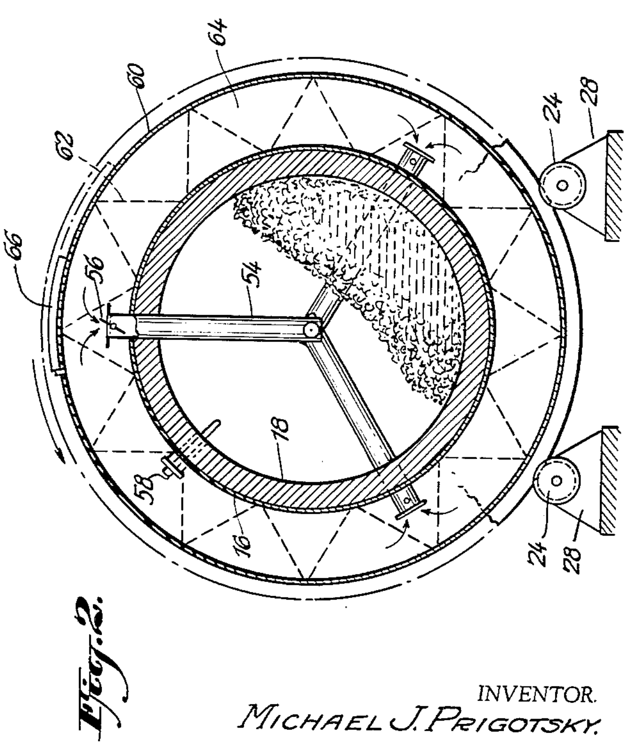
Aug. 10, 1965 M. J. PRIGOTSKY 3,199,851

ROTARY KILNS

Filed June 27, 1963







INVENTOR.

MICHAEL J. PRIGOTSKY.

BY

Ward, Neal, Haselton, Orme & McElhannon

ATTORNEYS.

United States Patent Office

3,199,851
Patented Aug. 10, 1965

1

3,199,851
ROTARY KILNS

Michael J. Prigotsky, Morganville, N.J., assignor to R–N Corporation, New York, N.Y., a corporation of Delaware

Filed June 27, 1963, Ser. No. 291,108
7 Claims. (Cl. 263—33)

This invention relates to rotary furnaces or kilns and more particularly it concerns improvements in kiln structures.

One of the most important factors in the proper operation of rotary kilns is that of maintaining close control of temperature variations and distributions within the kiln itself. Where the kiln is used, for example, for the reduction of oxidic iron ores, it is necessary that a mixture of iron ore and solid carbonaceous reducing material be subjected to sufficiently high temperatures to produce the desired reducing reaction. However, if this temperature becomes too high, the iron ore and the reducing material begin to sinter in the form of hardened chunks which adhere to the walls of the kiln. This sintered material builds up in the form of a ring and impedes flow of material through the kiln. This sintered material may also cause serious damage to the kiln walls.

In general the kiln temperature must be closely controlled from two aspects, namely, temperature variations with time resulting from ambient atmospheric conditions, and temperature distribution along the length of the kiln. In the operation of large ore reduction kilns, it is most economical, and also more desirable for working conditions of the operating personnel, that the kiln be installed out of doors rather than housing the same within a building. The one serious objection, however, to the out of door installation is that ambient weather conditions affect the operating temperature of the kiln to a considerably greater extent than where the kiln is installed within a building interior. For example, heavy winds and also heavy rainfall will cool the kiln shell and thereby tend to upset the temperature control within and along the kiln, thereby requiring readjustment of the kiln operation with deleterious effects on production before normal operating conditions are restored and with further corresponding readjustments required upon cessation of heavy wind or rain conditions requiring the initial adjustment referred to. Temperature distribution, on the other hand, is that change in temperature which occurs along the length of the kiln. This problem is especially acute in the ore reduction rotary kilns where fuel to be burned is introduced at one end of the kiln and the flame of combustion is directed toward the other end. Since the highest temperature is at the point of combustion, a considerable temperature differential occurs between this point and points further along the length of the kiln.

Unfortunately, prior techniques for controlling temperature variation have been incompatible with control of temperature distribution. In general, temperature variation has been controlled by increasing the thickness of the kiln walls so that heat transfer through them takes place at a slower rate. This technique, however, produces no helpful effect as regards the temperature distribution problem; and, in fact, aggravates this problem, for it tends to maintain high temperature concentrations in localized areas of the kiln. As to the control of temperature distribution, this is preferably achieved by causing combustion to take place in a controllable manner along the length of the kiln. One manner for doing this is described in U.S. Patent No. 2,829,042 entitled Furnacing Process. According to the teaching of that patent, various openings of controllable size are provided along the length of the kiln for admission of oxygen or air so as to cause the combustion of the incoming fuel to occur at various distributed points along the length of the kiln. While this arrangement has been highly successful in the control of temperature distribution, it increases the temperature sensitivity of the kiln to atmospheric variations. This occurs because the air being burned along the length of the kiln is admitted directly from the atmosphere and therefore is subject to atmospheric temperature variations. Also, wind and other atmospheric pressure disturbances may radically affect the quantity of air entering the side openings and this likewise affects the combustion temperature.

It is an object of the present invention to provide an improved rotary type kiln which permits very close control of both temperature variation and temperature distribution.

Another object is to provide such temperature control in an extremely simple structure at relatively low cost.

It is a further object to improve the efficiency of operation of rotary kilns while maintaining said temperature control.

It is a still further object to provide such advantages with a very simple and economical structure of high durability.

In general, these objects are achieved through the creation of a wind and rain protected air space in the immediate vicinity of the kiln. This air space, being thermally insulative, experiences a considerable temperature differential across it; and since it is wind protected, convection type heat from the kiln is minimized. Inasmuch as internal kiln temperature varies with variation in convection type heat losses, the protected air space renders the internal kiln temperature insensitive to such atmospheric variations. Also, this protected air space further serves as a reservoir, cooperating with lateral air openings along the sides of the kiln to supply controlled amounts of preheated air in quantities which are not dependent upon atmospheric wind velocity. Preferably, this protected air space is provided by means of an outer shell mounted at a fixed distance from the outer surface of the kiln and rotatable with it.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized in a variety of ways for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent ways as do not depart from the spirit and scope of the invention.

A specific embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is an elevational cross section view illustrating an improved rotary kiln construction of the type embodying the principles of the present invention;

FIG. 2 is a cross section view taken along line 2—2 of FIG. 1; and

FIG. 3 is a schematic illustration analogous to FIG. 1 and useful in explaining the principles of operation of the embodiment of FIG. 1.

The rotary kiln shown in FIGS. 1 and 2 includes an elongated tubular shaped reaction chamber or kiln 10 mounted for axial rotation between a combustion chamber 12 and an exhaust chamber 14. The kiln 10 is provided with an outer shell 16 constructed of steel plates and is lined with firebrick or similar heat resistant, refractory material as indicated at 18. Riding rings 20 and 22 are mounted coaxially about the reaction chamber near its ends, and are provided with hardened peripheral surfaces which rest upon and roll with corresponding roller bearings 24 and 26 which are set into fixed pillow blocks 28 and 30. The pillow block 30 nearest the exhaust chamber 14 is somewhat higher so as to provide a slight tilt to the rotational axis of the reaction chamber. This causes the reaction chamber to induce a very slow movement of material therein toward the combustion chamber 12 as it rotates. A bull gear 32 is attached to the outer surface of the reaction chamber in a manner similar to the riding rings. The bull gear engages a pinion gear 34 which in turn is driven from a power source (not shown) to produce the desired rotation of the reaction chamber.

There is provided a central end opening 36 at the exhaust chamber end of the reaction chamber, this opening receiving the discharge end of an auger type conveyor 38. The other end of the conveyor is connected to a hopper 40 into which the various ingredients to be processed, such as iron ore and some carbonaceous material, are deposited. The end opening 36 of the reaction chamber also communicates with the interior of the exhaust chamber 14 which in turn receives from the reaction chamber the various products of combustion. A stack 42 is provided near the top of the exhaust chamber for discharging the various gaseous products of combustion. A fan means 44 may also be provided in the stack to control the flow of gases from the reaction chamber thereby controlling the internal pressure of the chamber. The exhaust chamber is also provided with a bottom opening 46 for discharging ash and other solid products of combustion into a settling chamber or similar receptacle (not shown).

There is provided at the lower or combustion chamber end of the reaction chamber a circular dam 48 over which the completely processed products of the kiln must pass. This dam maintains a layer or bed of materials being processed at a fixed thickness to make most efficient use of the heat produced in the kiln. The dam is positioned close to a discharge passageway 50 which conveys the products from the kiln to a conveyor belt or other receiving means (not shown). The combustion chamber 12 is provided with centrally located nozzle means 52 which admits fuel, such as gas, oil or powdered coal, and a certain amount of air. The fuel is partially ignited in the combustion chamber and the flame and unburned fuel is carried along through the reaction chamber by virtue of the low pressure therein caused by the fan means 44.

At various locations spaced along the sides of the kiln 10 there are provided air tubes 54 which penetrate to the interior of the kiln from points outside its outer shell 16. These air tubes are provided at their outer ends with adjustable valves such as butterfly valves 56 as shown in FIG. 2, for the individual and selective control of the air entering into the reaction chamber at these various points. By proper manipulation of these various adjustable air valves the amount of combustion which takes place along the reaction chamber can be adjusted, thereby providing effective control of temperature along the chamber. There are also provided temperature measuring means such as thermocouples 58 at various discrete points along the reaction chamber for ascertaining the temperature distribution at any given time so that the adjustable valves 56 may be set to their most efficient position.

In accordance with the present invention, there is provided an outer shell 60 which conforms to and completely surrounds the outer periphery of the reaction chamber 10. This outer shell 60 is preferably of a light gage material such as sheet aluminum and is permanently affixed to the reaction chamber by means of brackets 62 located at various points along its surface. These brackets maintain the outer shell at a fixed distance from the reaction chamber so as to create an air space 64 therebetween. This air space operates in a dual capacity acting as a heat transfer barrier and as a source from which the air tubes 54 draw their air supply.

The outer shell 60 extends along the entire length of the reaction chamber, but is interrupted at the riding rings 20 and 22, and the bull gear 32 so that the reaction chamber may be properly supported and driven. The interruption of the outer shell at these locations provides for the admission of air into the air space 64. As shown, most clearly in FIG. 2, there may also be provided at various points along the outer shell, slide doors, as at 66, for access to the adjustable valves 56 on the air tubes and for adjustment thereof. These doors also permit changing or checking of the temperature measuring elements 58 along the reaction chamber.

Operation of the illustrative embodiment of FIG. 1 will be explained with reference to FIG. 3. During operation, various ingredients such as iron ore and a reducing material are deposited in the receiving hopper 40 and are supplied to the upper end of the reaction chamber via the auger conveyor 38. As the reaction chamber 10 rotates its slight tilt downward to the left causes these various ingredients to advance slowly toward its lower or combustion chamber end. During this time fuel and air being supplied through the entrance nozzle in the combustion chamber are ignited and the flame therefrom is impelled toward the upper end of the chamber. A portion of the heat resulting from this combustion is utilized in sustaining the combustion, that is, in bringing the unburned combustibles up to ignition temperature. The remaining heat, liberated by this exothermic reaction, however, is utilized in carrying out the endothermic processes of the kiln whereby the iron ore or similar material undergoes chemical reduction.

While a certain amount of combustion takes place in the combustion chamber, the fuel to air ratio is deliberately made too rich to achieve complete combustion in the region. As the unburned fuel and combustible vapors being driven off from the various ingredients are propelled toward the entrance end of the reaction chamber, they are mixed with additional amounts of air which enters through the air tubes 54. This causes continuous combustion along the length of the reaction chamber, the amount of combustion at each point being controlled by the degree of adjustable valve opening of the air tube in that particular region. When complete combustion has taken place its products exhaust into the exhaust chamber 14 and out through either the stack 42 or the bottom opening 46. At the same time the chemically reduced materials are driven out through the discharge passageway 50.

The ability of this arrangement simultaneously to provide control of both temperature variations and temperature distribution can be seen from the dual role played by the outer shell 60. The air space 64 created by the shell is thermally insulative and produces a considerable temperature drop between the kiln surface and the outer shell. Also, the air in this space is rather stagnant and consequently heat loss through convection is reduced. Since convection type heat losses vary considerably with wind and rain conditions, variations in heat loss and consequently, temperature variations, within the kiln are rendered insensitive to atmospheric conditions. The second role played by the outer shell **60** is its creation of a protected warm air reservoir for admission of air through the tubes **54** to various displaced points along the kiln. The provision of air inlets allows, as described above, close and selective control of combustion, and hence temperature, along the length of the kiln. Very important moreover, is the fact that the air reservoir is protected; and not being subject to atmospheric wind variations the amount drawn into each point along the kiln is rendered closely controllable.

It will be noted that all of the air which passes through the air tubes **54** must first pass through the air space **64** between the reaction chamber and the outer shell. This air, in traveling laterally along the reaction chamber absorbs heat which is radiated from its outer surfaces and consequently is at a much higher temperature as it passes through the air tubes than it would be without the effect produced by the outer shell **60**. In this manner, heat which otherwise would be lost to the atmosphere is captured and reutilized in the reaction chamber for achieving the desired chemical reactions. It has been found, for example, that the temperature of the incoming air can be raised by as much as 25 degrees Fahrenheit and the heat loss through the sides of the kiln can be reduced by as much as two-thirds with this arrangement.

Other advantages which accrue from the provision of the outer shell lie in the fact that the reaction chamber is protected by the outer shell **60** from the usual corrosion and wear, which result from exposure to climatic conditions. Further, by providing an outer shell which is affixed to the reaction chamber and which thereby rotates with it, a far more economical and simple structure is afforded than would be expected as by building a fixed shelter about the reaction chamber. This rotating outer shell also serves to maintain a more even temperature distribution about the circumference of the reaction chamber, and thus ensures complete reaction within the kiln and a more homogeneous output therefrom.

Having thus described my invention with particular reference to the preferred form thereof, it will be obvious to those skilled in the art to which the invention pertains, after understanding my invention, that various changes and modifications may be made therein without departing from the spirit and scope of my invention, as defined by the claims appended thereto.

What is claimed as new and desired to be secured by Letters Patent is:

1. A rotary kiln comprising an elongated tubular reaction chamber, means mounting said reaction chamber for rotation about its longitudinal axis with said axis slightly offset from horizontal, an ingredient feed mechanism positioned at the higher end of said reaction chamber and communicating with the interior thereof for supplying ingredients thereto, a heat source positioned in communication with the interior of said reaction chamber and operable to direct heat energy at elevated temperatures axially through said interior to elevate the temperature of the ingredients therein, and a tubular outer shell completely surrounding and extending over the length of said reaction chamber except in the region of said mounting means and affixed to said reaction chamber for rotation therewith, said tubular outer shell being arranged with its ends displaced longitudinally and isolated from said ingredient feed mechanism and from said heat source so that the ends of said tubular outer shell are positioned such that the annular space defined by said tubular outer shell and said reaction chamber communicates solely with the outer atmosphere at the ends of said shell, whereby there is maintained within said annular space and over the surface of said reaction chamber, a heat insulative space which serves to maintain an even control of temperature about said kiln while substantially reducing heat loss therefrom.

2. A rotary kiln comprising a tubular reaction chamber means mounting said reaction chamber for rotation about its longitudinal axis with said axis slightly offset from horizontal, an ingredient feed mechanism for supplying ingredients to said reaction chamber at its higher end, means for supplying fuel and air at one end of said chamber, a thin walled, tubular shaped, wind and rain protective outer shell structure surrounding said tubular reaction chamber in coaxial relation thereto to create a wind protected heat insulative air space between said outer shell structure and said reaction chamber, said air space communicating with the outer atmosphere through selected openings in said outer shell, and air supply passage means located at various points along said reaction chamber communicating between said air space and the interior of said chamber.

3. A rotary kiln comprising a tubular reaction chamber, means mounting said reaction chamber for rotation about its longitudinal axis with said axis slightly offset from horizontal, an ingredient feed mechanism for supplying ingredients to said reaction chamber at its higher end, means for supplying fuel and air at one end of said chamber, a thin walled, tubular shaped, wind protective, outer shell structure surrounding said tubular reaction chamber in coaxial relation thereto to create a wind and rain protected insulative air space between said outer shell structure and said reaction chamber, the ends of said outer shell structure being open to admit air from the atmosphere into said air space, and controllable air supply passage means located at various points along said reaction chamber communicating between said air space and the interior of said chamber.

4. A rotary kiln comprising a tubular reaction chamber having riding rings mounted coaxially thereabout near each end, roller bearings mounted in fixed pillow blocks and supporting said reaction chamber via said riding rings for rotational movement about its longitudinal axis and maintaining said axis slightly offset from horizontal, a rotational power receiving element fixed to and encircling said reaction chamber, an ingredient feed mechanism for supplying ingredients to said reaction chamber at its higher end, means for supplying fuel and air at the lower end of said chamber and for initiating combustion of said fuel within said reaction chamber, a thin walled, tubularly shaped, wind and rain protective outer shell structure mounted about said reaction chamber to define a heat insulative air space between said reaction chamber and said outer shell, said outer shell structure having a diameter less than the diameter of said riding rings and said power receiving element and having open ends which terminate near said rings and said element to define air passages therebetween for communication between said air space and the atmosphere, and controllable air supply passage means located at various points along said reaction chamber communicating between said air space and the interior of said chamber.

5. The rotary kiln described in claim **4** wherein said outer shell structure comprises a plurality of similar sections independently mounted along said reaction chamber and having open ends located in close proximity to said riding rings and said power receiving element.

6. A rotary kiln comprising a tubular reaction chamber , means mouting said reaction chamber for rotation about its longitudinal axis with said axis slightly offset from horizontal, an ingredient feed mechanism for supplying ingredients to said reaction chamber at its higher end, means supplying fuel to be burned within said reaction chamber, a thin walled, tubular shaped, wind and rain protective outer shell structure surrounding said tubular reaction chamber in coaxial relation thereto to create a wind protected heat insulative air space between said outer shell structure and said reaction chamber, said air space communicating with the outer atmosphere through selected openings in said outer shell, a plurality of air tubes located at various points along said reaction chamber and communicating between said air space and

the interior of said chamber, adjustable valve means associated with each of said air tubes for independently varying the effective size thereof, and openable means located on said outer shell for obtaining access to said adjustable means.

7. The rotary kiln described in claim 6 wherein said outer shell is affixed to said reaction chamber and rotatable therewith and said openable means comprise a plurality of shutters, each located in alignment with a corresponding one of said adjustable valve means.

References Cited by the Examiner

UNITED STATES PATENTS

977,244	11/10	Wiebe	263—33
1,581,522	4/26	Stehmann	263—32
2,941,791	6/60	Wienert	263—33
3,068,091	12/62	Kirkland	263—32 X

CHARLES SUKALO, *Primary Examiner.*