

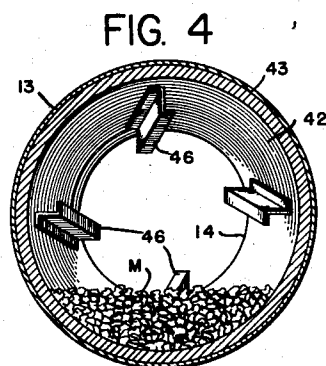
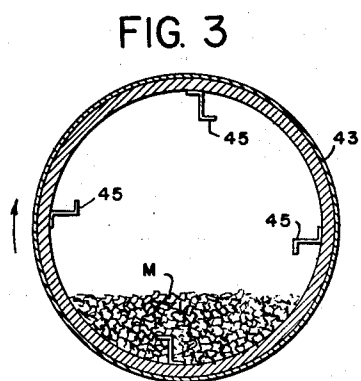
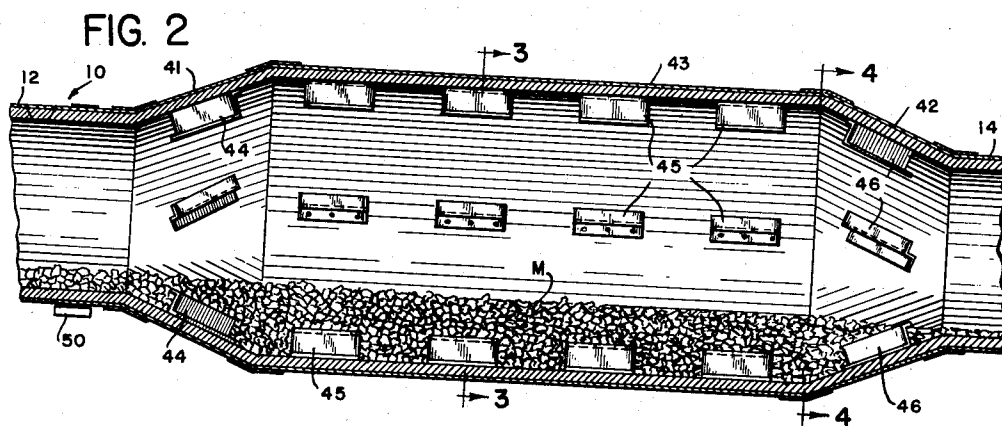
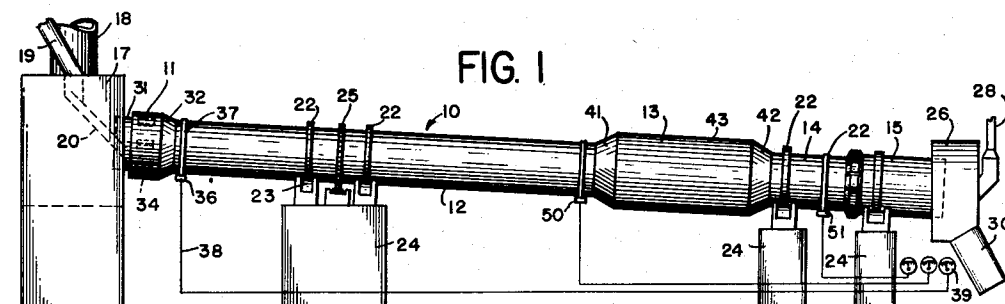
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A. F. OLD ET AL

2,939,693

ROTARY KILN

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2,939,693

ROTARY KILN

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This invention relates to heat treatment and more particularly to an improved kiln structure and process especially adapted for the production of lightweight aggregate. The apparatus and the general class of materials which are treated therein are in the same broad class as those described in our Patent No. 2,721,069 although the invention is not thereby limited.

In the production of lightweight aggregates such as those produced from argillaceous weathered slate, from non-argillaceous slate deposits, and the like, in order to obtain the desired product it is necessary that the raw material be treated in a particular manner including being raised to an elevated temperature briefly to permit expansion and other changes to occur and then to be cooled and handled in such a way as to prevent coalescence of the aggregate.

While it has been known for many years that certain materials would expand and have useful properties in their expanded form, the present invention includes apparatus and process by means of which the upper temperature limit may be closely controlled in order to achieve additional useful characteristics of the material such as glassification of the outer skin and walls, this requiring very close control of the temperature, which has not been commercially possible heretofore.

In the kiln heat treatment process it is necessary that the material be uniformly heated in order to obtain close control of the resulting product and to obtain maximum benefit from the power input to the kiln. It has long been known that chains or bars or other mixing devices on the inner wall of the kiln assisted in stirring the material so that the hot gases could more nearly uniformly heat all portions of it. However, the use of such mixing devices has tended to increase the erosion of the kiln because of the continual lifting and dropping of the material within the kiln. Furthermore, the lifting devices themselves because of being exposed to the high kiln temperatures have had a relatively short life.

A further problem has been that because of the necessity of keeping an adequate flow of material passing through the kiln at all times, a temporary interruption in the supply has oftentimes required that the kiln be shutdown in order to prevent injury to the kiln and to maintain a high quality product. A shutdown of a kiln of substantial size, in order to replace lining, lifting devices or because of a temporary cessation of supply, substantially increases the cost of operation and reduces the output and is therefore undesirable, it being the custom to keep kilns in continuous operation so far as possible.

Accordingly, it is an object of the present invention to provide an apparatus and process for the heat treatment of raw materials to produce an improved lightweight aggregate, the process and apparatus being particularly designed to permit close control of such heat treatment and particularly at the maximum temperature to which the material is raised.

A further object is to provide a kiln of nominal diam-

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eter which is substantially equivalent to a kiln of larger diameter insofar as temperature control and efficiency of operation are concerned.

A further object is to provide a kiln which is highly efficient in operation and in which erosion and exposure to injuriously high temperature of the wall and mixing devices, respectively, are reduced.

A further object of the invention is to provide a kiln in which the operator may be constantly aware of the temperature of the material at key locations within the kiln so that he may control its operation accordingly.

Other objects of the invention will become apparent from the following description in conjunction with the accompanying drawings, in which:

Fig. 1 is a side elevation of a kiln constructed in accordance with the present invention;

Fig. 2, a vertical section to an enlarged scale of the intermediate enlarged portion of the kiln of Fig. 1;

Fig. 3, a section on the line 3—3 of Fig. 2; and

Fig. 4, a section on line 4—4 of Fig. 2.

Although the kiln of the present invention may be used for the processing of various materials it has been found to be particularly useful in the treatment of non-argillaceous slate which is described in our Patent 2,721,069. It has been found that an improved lightweight aggregate may be produced from such argillaceous slate if the material is raised to a temperature in the upper portion of the critical temperature range. By subjecting the material to the upper portion of the critical temperature range, it has been possible to produce material having a glassy external skin and one in which substantially all of the internal cell walls are glassy.

The "glassy phase" product is desirable for various reasons. For example, as an aggregate in concrete it has been found that the mixture requires less water because the aggregate has less absorbency. It is well known that reduction of the quantity of water used in producing concrete increases its strength. A further advantage is that bleeding of the concrete is decreased if a smaller amount of water is used.

It has been difficult or substantially impossible to obtain a glassy phase aggregate commercially heretofore because it has not been possible to control the temperature within close enough limits, and attempts to heat material to the upper portion of the critical range have resulted in coalescence of the material, the breaking down of air cells and other deficiencies, resulting in loss. The present invention not only provides for an apparatus and process for producing glassy phase aggregate under closely controlled temperature conditions but also for increased efficiency of operation and reduction in wear on the lining and lifting devices of the kiln.

Briefly stated, one embodiment of the present invention is a kiln having a short enlarged section with lifting devices therein at its feeding end, a section of uniform diameter of approximately half the total length connected to the feeding end, a substantially enlarged section of substantial length with lifting devices therein, another section of reduced diameter, and a section of slightly enlarged diameter at the discharge end. Temperature responsive and indicating devices are mounted at specified locations on the kiln wall and connected to gauges at a central control point by means of which the operator may at any moment ascertain the condition of material at spaced locations within the kiln.

In passing into and through the feed end the raw material is thoroughly exposed to discharging gases by being lifted and dropped which results in substantially lowering the temperature of the discharging gases, as well as removing moisture and extremely fine particles from the raw material as it enters the kiln. The mate-

rial then passes through approximately 50% of the kiln's length during which it is slowly raised in temperature, lifting devices not being necessary in this portion, thereby eliminating most of the wear on the lining which would otherwise occur to substantial degree. The material then enters the substantially enlarged section which is approximately 25% of the total length of the kiln and is provided with lifting devices. Within the enlarged section the material is exposed thoroughly to the hot gases, its axial movement being controlled by the structure and arrangement of the lifting devices and the speed of rotation of the kiln.

After leaving the enlarged section in which the material is heated to just below the critical range, it passes into the zone of extreme heat in which it is rapidly raised to the necessary temperature and then discharged.

Referring to the drawings, a kiln 10 is illustrated having an enlarged feed end section 11, a nominal size intermediate portion 12, a substantially enlarged section or mixing chamber 13, a relatively short section of nominal size 14, and a slightly enlarged section 15 within which the maximum temperature occurs and from which the material discharges.

At the feed end the kiln extends into a housing 17 from which a stack 18 extends, the raw material supply chutes 19 and 20 preferably extending into the stack and housing into the enlarged feed end section 11 of the kiln.

The kiln is rotatively supported by means of rings 22 at spaced locations on its exterior which are mounted on rollers 23 carried by blocks 24. The kiln may be driven from a ring gear 25 by suitable power means, not shown.

At the discharge end the kiln has a firing hood 26 within which an operator may be positioned for observing the operation and controlling the same. The hood also receives supply conduit 28 for the burner and has a discharge chute 30 at its lower side.

With further reference to the feed portion 11 of the kiln it will be observed that it has a straight reduced neck 31 extending into the housing 17 and a tapered connecting portion 32 attached to the section 12 of the kiln. The straight neck facilitates receiving the kiln within the housing and provides a recess at its junction with the section 11 for receiving material from the chute. A plurality of lifting devices 34 are placed within the portion 11 for initially mixing and stirring the entering raw material, thus removing moisture and extremely fine particles and incidentally lowering the temperature of the stack gases.

Just beyond the tapered connecting portion 32 a temperature responsive device 36, such as a thermocouple or the like, is engaged with a collector ring 37 on the outer wall of the kiln. The device is connected by a line 38 to a gauge 39 which may be conveniently mounted at a central location such as adjacent to or within the hood 26 so that the operator may be able to see it from within the hood.

As the material slowly moves through the kiln from the entrance to the discharge end its temperature is gradually raised. The speed of movement lengthwise of the kiln depends on the angle of inclination of its axis to the horizontal and the speed at which the kiln is rotating.

The mixing chamber 13 through which the material next flows has tapered connecting portions 41 and 42 at its entering and leaving ends respectively, and a central portion 43.

The portions 41, 42 and 43 are provided on their inner walls with lifting devices or cleats 44, 45 and 46 respectively. Although the number and arrangement of the lifting devices may be varied, it has been found advantageous in connection with processing of the raw material described to have them arranged as shown. The lifting devices 44 are inclined at an angle to face into the section 12 and tend to hold back or retard the

flow of material into the section 43 whereas the lifting devices 46 are inclined the other way within the portion 42 to speed up the flow so that heated material may be more rapidly moved into the zone of maximum temperature and also to cause hot gases entering the enlarged section to become turbulent at this point.

It will be observed that the depth of the raw material within the section 43 is higher than the lifting devices at the bottom of the kiln and is of substantial depth. As a result, the material being lifted and dropped instead of falling on the lining of the kiln and the lifting devices falls on to the bed of material at the kiln's bottom. Thus, wear and erosion on the kiln lining and lifting devices is substantially minimized.

Because of the large volume of material within the mixing chamber 13 and the thorough lifting, dropping and stirring therein, the velocity of the hot gases passing therethrough is reduced substantially, say on the order of 60%, and excellent heat transfer is afforded. The temperature of the gases leaving the enlarged section are substantially lowered resulting in lower heat losses through radiation and the like from the remainder of the kiln namely, sections 11 and 12.

In addition to the decrease in wear already mentioned, the enlarged section mixing chamber assures equal heating of all sizes of material so that closer temperature control in the succeeding sections is possible. Furthermore, in the event that the supply of raw material to the feed end is temporarily interrupted it is not necessary to shut down operation of the kiln because of the substantially larger quantity of material that is being processed therewithin which is capable of absorbing a correspondingly larger amount of heat than a smaller quantity without overheating either the material or the kiln.

From the enlarged section 13 the material flows into the smaller section 14 and then into the firing section 15 which may be slightly larger than the section 14 if desired. Within the firing section the material is quickly raised to the upper limit of the critical range of temperature at which it enters the glassy phase and is then discharged from the kiln.

Other temperature control devices such as that indicated at 50 just prior to the material's entering the enlarged section 13 and 51 just prior to the material's entering the section of maximum heat may be provided. By observing the temperature at various critical locations in the kiln as indicated the operator may be informed constantly of the condition of the material.

The dimensions of the various sections of the kiln may be varied to suit the material being processed and operating requirements. As an example, however, of one embodiment, the kiln has a total length of 135 feet, a nominal diameter of 8 feet, and a mixing section of approximately 9½ feet diameter, the tapered portions of the enlarged section being approximately 5 feet in length and the entire enlarged portion being approximately 25% of the kiln's length as mentioned above. Variations from about 15-35% should produce good results, depending on the other conditions. Further, the pitch or angle of inclination of the axis to the horizontal is about ¾ of an inch per foot, it being understood that the size of the enlarged section is related to the pitch of the kiln.

Accordingly, it will be understood that the invention includes a novel kiln having at least one enlarged section with mixing devices in which the transfer of heat to the materials is promoted, providing for close temperature control, efficient operation and a larger quantity of material being processed, and at the same time reducing wear on the lining and lifting devices within the kiln and the necessity for shutdown of operation. Because of the exceptionally close control of the temperature of the material that is possible an improved product may be produced having desirable characteristics not previously obtainable.

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It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is illustrated in the drawings and described in the specification, but only as indicated in the accompanying claims.

What is claimed is:

1. The method of heat treating raw material which becomes plastic and expands at a critical temperature range to produce a lightweight aggregate, comprising introducing the raw material into the upper end of a rotatably mounted elongated inclined kiln, initially removing moisture and extremely fine particles by lifting and dropping the material in the gases discharging from the kiln, rotating the kiln to cause the material to progress downwardly therethrough, subjecting it to a slow moving substantially restricted flow of heated products of combustion at a temperature below that required to produce the aggregate for approximately one half of the kiln's length, accumulating a relatively large mass of material just prior to its reaching the firing end of the kiln at which the maximum temperature is attained, continuously lifting and dropping the accumulated mass of material as the heated gases pass therethrough to raise substantially all of said material to just under the critical temperature range and reduce the temperature of said gases substantially, and passing said material into the firing end of the kiln and heating it to the upper range of the critical temperature sufficient to produce expansion and glassification, and then immediately discharging it from the kiln.

2. The method of heat treating raw material to produce a glassified aggregate at a critical temperature, comprising spreading it at a relatively shallow depth along a portion of substantial length in a rotary inclined kiln while subjecting it to the flow of heated gases at a temperature below the critical temperature to produce the aggregate, accumulating a relatively deep mass of the material in a relatively shorter length of the kiln, continuously lifting and dropping the relatively deep mass, passing hot gases through the material as it is lifted and dropped to substantially raise its temperature close to but below a critical upper limit, passing the material into a zone of maximum temperature slightly above that attained in the preceding zone, and sufficient to produce

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expansion and glassification of its outer skin and of its cell walls, and immediately discharging the material.

3. A rotary kiln for producing a glassified aggregate, comprising an elongated substantially cylindrical housing having spaced portions of different diameter and inclined from its feed end to its discharge end, said kiln having a major portion of nominal diameter adjacent to its feed end and subject to a low initial temperature, an intermediate mixing chamber constituting approximately 15-35 percent of the length of the kiln and subject to an intermediate temperature lower than that necessary to produce glassification of an aggregate, and a portion connected to the mixing chamber to receive the material therefrom and subject to the maximum temperature in said kiln for attaining glassification of an aggregate and for immediately discharging the material therefrom, said mixing chamber being substantially larger in diameter than the portions to which it is connected and having tapering sections for connection thereto, and lifting devices mounted in said mixing chamber on the inner wall thereof, said lifting devices which are mounted on the inner wall of the tapering section leading into said chamber being inclined upwardly with reference to the axis of the kiln on the rising side of the kiln wall in order to impede the axial movement of the material into said mixing chamber, and the lifting devices which are mounted on the inner wall of the tapering section leading from said chamber being inclined downwardly with reference to the axis of the kiln on the rising side of the kiln wall in order to assist in the axial movement of the material from out of the chamber.

4. The invention defined in claim 3, and temperature responsive means on the kiln adjacent to the mixing chamber and to the feed end of the kiln.

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