

Dec. 9, 1952

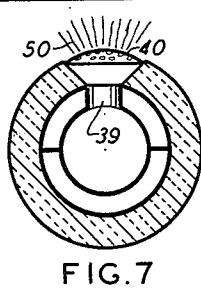
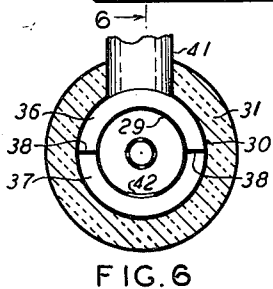
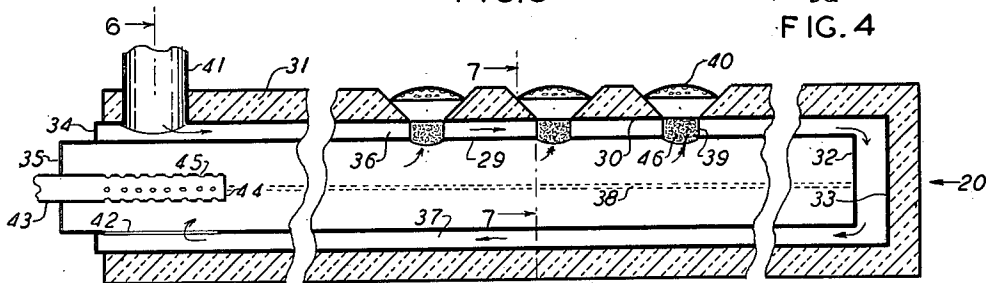
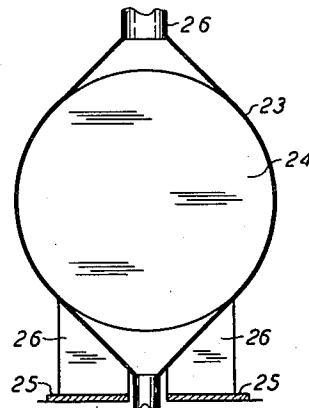
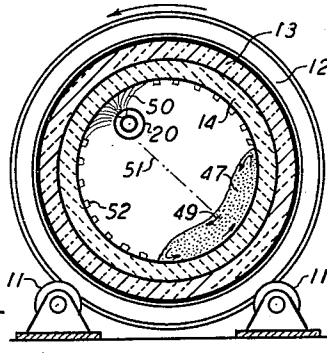
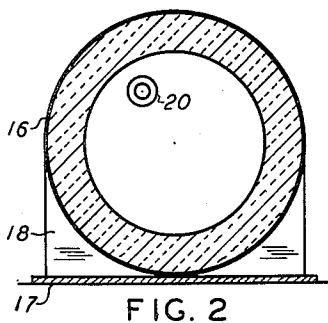
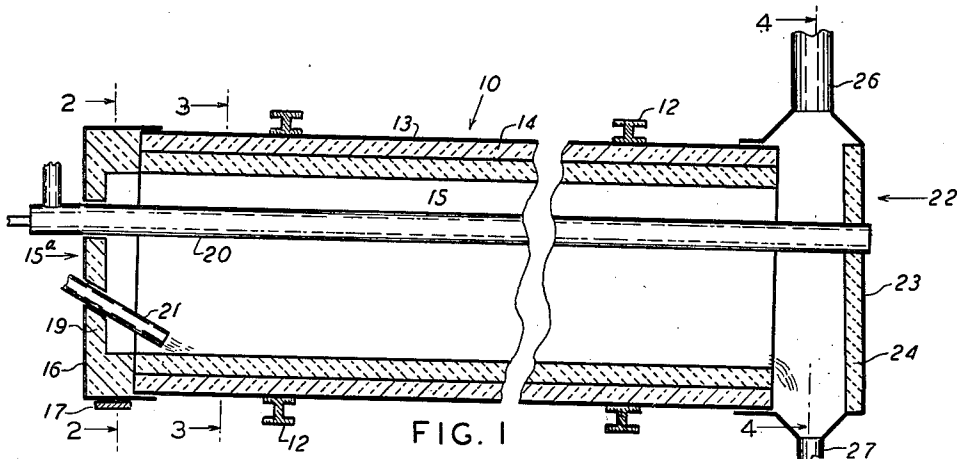
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2,621,160

METHOD FOR EXPANDING PERLITIC MINERALS

Filed May 24, 1948

2 SHEETS—SHEET 1



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METHOD FOR EXPANDING PERLITIC MINERALS

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2 SHEETS—SHEET 2

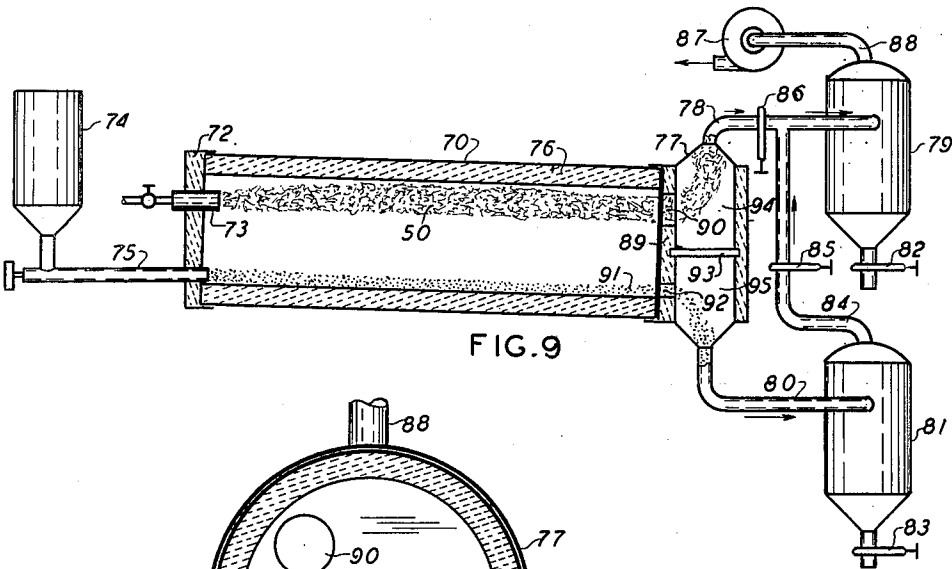


FIG. 9

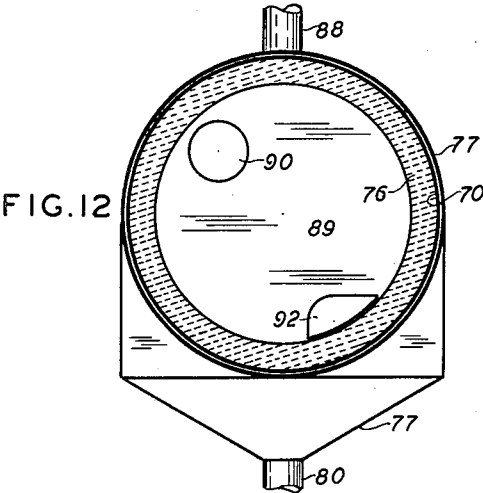


FIG. 12

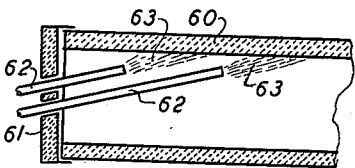


FIG. 8

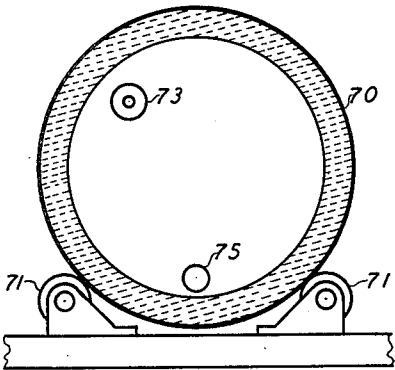


FIG. 10

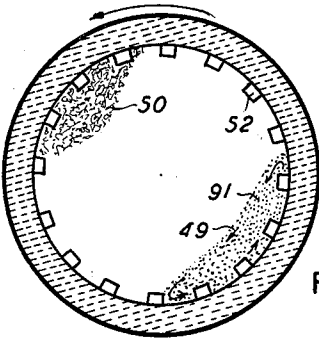


FIG. 11

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METHOD FOR EXPANDING PERLITIC MINERALS

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3 Claims. (Cl. 252—378)

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This invention relates to the expansion and vesiculation of minerals of the perlite type, by which mineral aggregates of very light weight and of considerable crushing strength are produced.

The primary purpose of the invention is to provide a process and an apparatus in the use of which, products of the highest quality may be obtained at a reduced cost as compared with methods previously in use.

A purpose of the invention is to prevent the too rapid heating of the raw mineral and thus avoid decrepitation and the resultant production of fines.

A purpose of the invention is to heat the mineral with sufficient rapidity to bring it to intumescent temperature before the water necessary for intumescence has been driven off.

A purpose of the invention is so to control the temperature relations within the heating chamber as to avoid the sintering or fusion of the intumescent particles and their adherence to each other and to the walls of the heating vessel.

The minerals referred to herein as "perlite" include the perlites and such of the pitchstones and obsidians as contain sufficient water of combination to cause them to intumesce when heated to a temperature at which they soften and become ductile. These minerals, often referred to as the volcanic glasses, are massive igneous rocks, characterized by a glassy or vitreous lustre and by the presence of small proportions of chemically combined water (water of constitution), usually of the order of 2% to 6%. This water, or at least a portion of it, is essential to expansion, which is not produced by the presence of free water, not combined in the molecule.

While the expansion and vesiculation of a perlite mineral is in theory very simple, involving merely bringing it to a sufficiently high temperature to soften the glass and thus permit the water vapor generated in the decomposition of the molecule to expand, the production of a commercially satisfactory light weight aggregate at a suitably low cost has proven to be a matter of some difficulty. This difficulty has its origin in certain properties which characterize the volcanic glasses and which distinguish them sharply from the carboniferous clays, shales and slates, which intumesce by evolution of carbon monoxide, and from the vermiculites, which exfoliate and thus expand by warping of the component micaceous crystals.

For example, too rapid heating of the larger granules of a crushed feed causes them to de-

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crepitate with the production of numerous fine particles. On the other hand, too slow heating tends to eliminate all water from the smaller granules of the mixed feed before they come to the softening temperature, and these completely dehydrated particles are incapable of expansion.

Again, the softening temperature of the mineral, which must be attained if expansion of the granule is to occur, lies very close to the temperature at which the discrete granules begin to stick to each other and to the wall of the heating vessel, the range between these two temperatures being sometimes as much as 150° Fahr. but more often closer to 100° Fahr. Excessive heating of any part of the mineral must be avoided as it breaks down the cell walls, allowing the imprisoned vapor to escape, and causes the accumulation of solid glass on the walls of the heating vessel. And finally, the temperature of the flame itself, in the burning of the commercial fuels available for this purpose, is far above the temperature to which the mineral may be brought, from which it follows that particles brought directly into contact with the flame must be withdrawn before they reach full flame temperature.

These factors make the control of the heating operation difficult and uncertain, particularly in the usual case in which the mineral, after crushing, is sized only at its upper end and thus consists of granules of widely different dimensions.

The expansion of more or less finely divided perlite by heating the mineral to the temperature at which the vaporization of the combined water causes it to intumesce and become vesiculated is now an established industry. Numerous relatively small plants are now in operation and their product is in demand for the production of light weight concrete and similar uses.

So far as we are aware, all the methods of expansion which have been made public, by patenting or by commercial use, have involved the direct contact of the comminuted mineral with a high temperature flame. In some of these methods the mineral has been introduced to the heating zone in dispersion in the air or fuel from which the flame is produced; in others the flame is directed upwardly and the mineral is allowed to fall through it; in still others the mineral is fed into one end of a relatively long and narrow rotating tube through which the flame is passed directly over the surface of the stream of mineral, usually in counterflow.

It has recently been discovered that the quality of the product may be materially improved, as to lightness, proportion of unbroken vesicles and

freedom from fines, by heating the perlitic minerals out of contact with the gases of combustion, as on an underfired hearth or in externally heated, rotating tubes. This method, while highly satisfactory as regards quality of product, is handicapped by high first cost and rapid depreciation of apparatus, and by excessive consumption of fuel, placing a heavy burden of cost on a product which must be sold at a low price to be competitive.

We have now discovered that products of a quality almost or quite equal to the product of the indirect firing method may be obtained by a relatively slight modification of the operation of the conventional, internally fired, rotating kiln by which its functioning for this purpose is radically altered. This method involves less cost for apparatus and a lowered operating charge without sacrifice of quality.

Basically this modification consists in so directing the heating flame or flames as regards the mineral passing through the kiln that the mineral cannot at any time pass into or through the flame itself, that is, the zone in which combustion of fuel takes place and is completed. Operating in this manner, the extremely hot gases produced in the combustion zone are moderated in temperature before coming into contact with the mineral, both by contact with the wall of the kiln and by dilution with the cooler gas mass with which the material to be expanded comes into contact and which occupies the greater part of the space within the kiln.

In putting this principle into practice it is possible to utilize various forms of apparatus in which the flames are differently positioned, these forms having the feature in common that the zone of combustion is spaced from the portion of the kiln through which the mineral feed is passing. Two of these forms, illustrative of the theory involved, are shown in the attached drawings and the following description thereof, in which:

Fig. 1 is a diagrammatic representation, in longitudinal vertical section and internal elevation, of a kiln and its accessories arranged to direct the heating flames radially against the wall of the kiln and away from the mineral stream;

Fig. 2 is a cross section through the same as on the line 2—2 of Fig. 1;

Fig. 3 is a cross section through the same as on the line 2—3 of Fig. 1;

Fig. 4 is a cross section through the same as on the line 4—4 of Fig. 1;

Fig. 5 is a longitudinal section, on a larger scale, of a suggested form of burner adapted to the heating of the kiln wall;

Fig. 6 is a cross section through the same as on the line 6—6 of Fig. 5;

Fig. 7 is a cross section through the same as on the line 7—7 of Fig. 5;

Fig. 8 is a line diagram showing an arrangement of a plurality of burners by which the flame is directed against the wall of the kiln at a relatively narrow angle;

Fig. 9 is a diagrammatic representation, partly in elevation and partly in section, of a form of apparatus in which the flame is directed longitudinally of the kiln and adjacent that portion of the wall farthest from the mineral stream;

Fig. 10 is a cross section on the line 10—10 of Fig. 9;

Fig. 11 is a cross section of the line 11—11 of Fig. 9;

Fig. 12 is a cross section on the line 12—12 of Fig. 9, showing certain parts in elevation.

Referring first to Figs. 1 to 4 inclusive: 10 is a rotating kiln which may be mounted in the conventional manner on trunnions 11—11 engaging stiffening rings 12—12. The kiln is rotated around its longitudinal axis by power applied to one or more of the trunnions by means not shown. The kiln should have a slight slope toward its discharge end, preferably of the order of about 3° to the horizontal.

The steel cylinder 13 which forms the shell of the kiln is lined internally with a relatively refractory heat insulating material, as for example preshrunk bricks of diatomaceous earth, this lining being indicated at 14. The temperature attained in this layer is not such as to require the use of fire brick or other high refractories, light weight and high heat insulating value being preferable properties.

Within the insulating liner 14 is a second liner 15 of a refractory material suitable for temperatures of the order of 2000° Fahrenheit or somewhat higher. This layer may consist of fire brick or fire tile, but for reasons which will appear we prefer to form it of a material having a high K-factor at high temperature coupled with stability and at least moderate wear resistance. Silicon carbide, having a K-factor (in B. t. u. per hour per square foot per inch thickness per °Fahrenheit mean temperature difference) of about 100 at 2000° Fahrenheit is a suitable and preferred material for this inner liner, which may be thinner than the outer, heat insulating liner, for example in the ratio of 4" to 6" or even 8".

The feed end of the kiln (the left end as shown in Fig. 1) is provided with a closure 15a which may consist of a steel casing 16 supported by a bed plate 17 and a saddle 18 and lined with a heat insulating material as at 19. This closure is provided with openings to receive one or more burners 20 and a raw mineral feed tube 21.

At its discharge end (right hand) the kiln is provided with a breeching 22 having a steel shell 23. This shell may be lined throughout with a refractory material or it may have only a refractory rear end wall as indicated at 24. The shell may be supported in any convenient manner, as by bed plates 25—25 and saddleplates 26—26 and is continued upwardly into a smoke flue 27 and downwardly into a product withdrawal tube 28. The flue may discharge into the air or into a gas scrubber, or it may be connected with a cyclone or other means not shown for the recovery of floating solid particles. The withdrawal tube may connect with any tank or bin from which the product may be withdrawn as needed.

Referring now to Figs. 5, 6 and 7 which illustrate a form of gas burner adapted to the practice of the invention, the burner 20 of Fig. 1 may consist primarily of two concentrically arranged metallic conduits 29 and 30, the outer being surrounded by a layer of heat insulating material 31. Both conduits have closed ends as at 32, 33, 34 and 35. The annulus between the conduits is divided into two semicircular passages 36 and 37 by ribs 38 projected radially from the inner element.

The gas nozzles 39, of which the number will vary with the length of the kiln, communicate with the inner tube and are sealed to the outer tube where they pass through its wall, to avoid leakage of air. These nozzles may be of metal

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but it is desirable that the crown plates 40, which are provided with numerous perforations for the escape of the air-gas mixture, should be of refractory material such as fire clay or Carborundum.

An air supply provided by a fan or blower not shown is introduced into passage 36 through a conduit of which a fragment is shown at 41. The air flows through this passage as indicated by the directional arrows, passes over the closed end of the inner tube and returns through passage 37 to a point opposite the point of introduction, where it passes through a slot 42 into the inner tube. Here it meets and mingles with a plurality of streams of combustible gas introduced through a gas supply pipe 43 which is closed at its outer end 44 and is provided with a considerable number of small perforations 45. The intimate mixture of air and gas thus produced flows through the inner tube and is ejected through the perforations in crown plates 49, burning outside the burner assembly. It may be desirable to stuff the nozzles 39 loosely with brass or copper wool, as indicated at 46, to prevent the striking back of flame into the mixing tube.

In this form of burner the metal parts which are within the highly heated kiln are protected by the outer covering 31 of heat flow resisting material and are also cooled by the rapid flow of air through the passages between the concentric tubes. It will be understood, however, that the form of burner here described is not limiting and should be considered as illustrative.

The perlitic mineral to be expanded, first brought to the desired particle size range by crushing and screening, is introduced onto the floor of the kiln through feed pipe 21, flows the length of the kiln and gravitates from its lower end into withdrawal tube 27. The kiln should be rotated at such speed that the stream of mineral granules passing through it will follow up the rising side at least to the horizontal center line and preferably to a higher level, for example as at 47 in Fig. 3. If the kiln be of large diameter, sufficient peripheral speed to carry the granules up to this level may set up excessive vibration. In such case it is desirable to provide the inner wall with longitudinal ridges or lifters to prevent the mass from sliding down the rising wall. It is permissible, and in some cases desirable, to lift the mass far enough to cause it to shower down through the mass of hot gases, provided it is not thus carried into the edge of the zone of combustion. This showering increases the heat transfer area and helps to avoid local overheating. Ordinarily the optimum flow will be that indicated by directional arrows 43, in which the upper edge of the mass of mineral rolls over and slides down the exposed face.

The longitudinal axis of burner 23 should be at least approximately parallel with the inner wall of the kiln and the burner should be so oriented that the flames 50 (Fig. 3) impinge directly on the uncovered, downwardly moving wall. The radial location of the burner should preferably be in a line 51 passing through the center line of the kiln and the center of the rolling mass 47, or slightly above rather than below this diametric plane. The air-gas mixture may have a slight excess of air, to produce a short, hot flame, but the pressure under which the mixture is ejected from the nozzles should not be sufficient to cause the flame to roll back against the mineral stream. The minor degree of turbulence

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incident to the rotation of the kiln and to the rolling or showering of the mineral within it is sufficient to disperse the fresh combustion gases into the cooler mass of gas within the kiln.

Referring now to Fig. 8, 60 is a fragment of the feed end of a rotating kiln and 61 the stationary end wall. One or more burners 62 pass through the end wall at an acute angle to the axis of rotation of the kiln and direct flames 63 against its inner face. The mineral feed enters at 64 and is rolled over and over during its passage through the kiln and, if desired, showered through the hot gases. As in the previous description, the flames play on the uncovered portion of the kiln wall in a line more or less opposite the position of the moving mineral stream, and the movement of that stream is so controlled that the mineral does not enter the zone in which combustion of fuel occurs.

Referring now to Figs. 9 to 12, a cylindrical kiln 70 is rotatably mounted on trunnions 71—71 so proportioned as to height that the kiln has a slight slope toward its discharge end. At the higher end the kiln is closed by a stationary wall 72 having suitable openings for the insertion of one or more fuel burners 73. A bin 74 holds a supply of crushed and screened perlite which is fed onto the floor of the kiln at a measured rate by a screw or other feeder 75. The steel shell of the kiln is lined with firebrick or other refractory material as at 76.

At its lower end the rotating cylinder passes through the wall of a stationary breeching or smoke box 77 which in turn communicates at its upper end through a conduit 78 with a cyclone separator 79 and at its lower end through a conduit 80 with a cyclone 81. These separators are provided at their lower ends with valves 82 and 83 respectively.

The upper end of cyclone 81 communicates with conduit 78 through a conduit 84 provided with a valve or damper 85 and a similar valve 86 is placed in conduit 78 between the point of junction of the conduits and the breeching. A fan or blower 87 draws air into and flue gases out of the kiln and through the cyclones, having its suction side communicating with the upper end of cyclone 79 through conduit 88. The discharge from this blower may be to the atmosphere or to a baghouse, scrubber or other means for preventing a dust nuisance.

In the operation of a kiln of considerable length the maintenance of the flame in the desired position close to the kiln wall may be aided in the following manner. A curtain wall 89 is placed in breeching 77, as close as possible to the end of the rotating kiln. An opening 90 is formed in this wall in alignment with burner 73. Along the lower, inner edge of the kiln and in approximately the position taken by the moving mineral stream 91, another opening 92 is formed through the curtain wall. A horizontal partition 93, which may be a slab of fire tile, divides the breeching into two chambers 94 and 95, communicating respectively with conduits 78 and 80. Valves 85 and 86 are so regulated as to draw from the lower side of the kiln only enough gas to keep the stream of granular product moving through opening 92 into chamber 95 and thus to cyclone 81 while the greater part of the combustion gas passes into chamber 94 through opening 91.

A common principle is involved in the operation of the three forms of apparatus just described: this being such restriction and location of the zone in which combustion occurs, in rela-

tion to the position assumed by the mineral in its passage through the kiln, as will substantially exclude the mineral from contact with mixtures of fuel and air undergoing combustion.

In the form of Figs. 1 to 4 this is accomplished by directing a row of short flames against the exposed kiln wall at approximately a right angle. In the form of Fig. 3 the burner enters the feed end of the kiln and the flame impinges on the exposed wall at an acute angle. In the form of Figs. 9 to 12 the flame is directed along and parallel to the kiln wall. In each form the flame is applied to the kiln wall in an elongated area parallel and opposite to the area occupied by the rolling mineral stream. It should be understood, however, that this elongated area does not necessarily, nor in many cases even desirably, extend the entire length of the kiln and often will not occupy more than two-thirds or even one-third of the total length.

The advantage of the first form described is in the closed control over the position of the flame which is made possible by the location of the burner tips close to the kiln wall. The advantage of the third form is in the greater simplicity of the burner arrangement. In this connection it should be stated that the combination of separators and conduits shown in Fig. 9 is desirable but not at all essential to successful operation by this method, it being possible to discharge the combustion gases and the expanded product from any form of breeching and directly into the air if desired.

By reason of the close control over flame position, the form of Figs. 1 to 4 is better adapted to relatively long and narrow kilns, while the straight-through form of Figs. 9 to 12 is best adapted to relatively short and wide kilns.

In the use of this firing method, which may be described in a word as off-center firing, the mineral receives the heat requisite for expansion from four sources, named in the order of their importance, viz:

1. By radiation from the heated kiln wall to the outer, exposed surface of the rolling mineral stream;
2. By radiation from the flame itself;
3. By conduction, from the hot gas mass within the kiln; and
4. By conduction, from the hot wall of the kiln, which is heated as it passes through or over the zone of combustion and cooled by the passage over it of the cooler mineral stream.

The third and fourth sources of heat supply will ordinarily be unimportant, though the value of the third is increased by showering the material through the gas in case it is possible to do so without carrying it into the combustion zone.

The greater part of the total heat supply will in most cases be provided from the first two sources, and particularly from the first named. Obviously, the higher the temperature to which the kiln wall is raised in passing over the flame, the more rapid will be the transference of heat to the mineral stream. There is, however, a limit to which the temperature of the wall may be raised, that being the temperature (ordinarily 1850° to 1900° Fahr.) at which the mineral begins to stick to the kiln wall.

We have discovered that this factor of transfer from kiln wall to mineral may be largely increased without exceeding the limit temperature by lining the kiln (as at 15 in Figs. 1 and 3) with a material combining a high degree of heat conductivity with stability at high temperature. As

already stated, the form of silicon carbide known commercially as "Carbofrax" and having a K factor at 2000° Fahr. of about 110 is well adapted to this purpose. The effect of the use of this or a similar material as a kiln lining is to increase the quantity of heat absorbed by the lining and given up to the mineral at each revolution of the kiln. The use of conductive refractory linings makes the greater part or all of the thickness of the lining available for transferring heat from the flame to the mineral instead of merely a thin surface layer as in the use of firebrick linings having a K factor of the order of 10.

The desirable results following from the use of the off-center firing method is illustrated by the following example. These figures show the results of two experiments in which an Arizona perlite of good quality, crushed to pass through a ¼" mesh screen, was fed to a kiln 27 inches in diameter and 30 feet long which was rotated at 8 revolutions per minute. The rate of feed was adjusted in each instance to yield the optimum quality of product. Except for the feed rate, all conditions were identical in the two experiments except that in Experiment 1 the burner was so located and directed that the flame played directly on the surface of the mineral while in Experiment 2 it was located, as above described, close to the side of the kiln opposite to the position of the mineral. The spent gases and the fine mineral particles suspended in them were discharged into the open air, only such of the product as emerged from the bottom of the kiln being recovered. These suspended fines would largely have been recoverable in cyclones and a baghouse.

	Expt. 1— center firing	Expt. 2— side firing
Feed, pounds per hour.....	1,600	1,200
Recovery, pounds per hour.....	1,180	1,050
Recovery, weight percent.....	73.7	87.5
Loss to fines, weight percent.....	26.3	12.5
Screen analysis of product:		
+8 mesh, weight percent.....	10.8	20.4
8 to 14 mesh.....percent.....	24.2	25.2
14 to 30 mesh.....do.....	42.6	36.3
30 to 50 mesh.....do.....	16.2	13.6
50 to 100 mesh.....do.....	4.1	2.4
-100 mesh.....do.....	1.7	2.0
Water flotation test (volume percentage sealed vesicles):		
In total recovered products.....percent.....	46.0	88.1
In 30/50 mesh fraction.....do.....	76.5	80.4
In 50/100 mesh fraction.....do.....	59.5	66.6
In -100 mesh fraction.....do.....	25.7	18.0
Bulk densities, dry:		
On total recovered product.....per cu. ft.....	21.5	16.7
On +8 mesh fraction.....do.....	23.8	16.3
On 8 to 14 mesh fraction.....do.....	23.1	16.0
On 14 to 30 mesh fraction.....do.....	19.7	15.1
On 30 to 50 mesh fraction.....do.....	14.5	12.2
On 50 to 100 mesh fraction.....do.....	11.2	10.6
On -100 mesh fraction.....do.....	15.0	15.9

The improvement in performance resulting from maintaining the flame out of contact with the mineral is evidenced in the much larger recovery of useful product, in the more even distribution of particle size, and in the very greatly increased proportion of particles having sealed voids.

We claim as our invention:

1. A process for vesiculating an expandable volcanic glass subject to decrepitation when suddenly subjected to an expansion temperature, which comprises introducing particles of said glass into an expansion zone out of contact with flame, maintaining the particles in rotation as a flowing stream, said stream being in contact with a surface maintained at a vesiculation tempera-

ture, passing a flame as the sole means of supplying heat into said zone out of direct contact with said stream at all times, directing said flame against a surface approximately diametrically opposite the flowing stream to heat said surface to a vesiculation temperature, continuously and repeatedly bringing said heated surface into contact with said stream, and then recovering the particles of expanded glass.

2. The process of claim 1 wherein the flame and the stream of particles are directed concurrently through said zone.

3. The method of expanding and vesiculating comminuted perlitic mineral which comprises: flowing a stream of said mineral through an enclosed space in an approximately horizontal plane in contact with a moving solid surface rotating at approximately right angles to the direction of flow of said stream; directing a heating flame through the enclosed space and over the surface of said stream but out of contact therewith; continuously heating an area of said moving solid surface by the impingement of said flame thereon; the portion of said stream not in contact with said surface being heated by radiation from said area; and continuously bringing

said heated area into contact with said stream to impart heat thereto by conduction.

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