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Bon et al.

[11] **3,759,660**

[45] **Sept. 18, 1973**

[54] **LOW VELOCITY BURNER FOR THERMAL EXPANSION OF PARTICULATE SOLIDS**

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[21] Appl. No.: **190,068**

[52] **U.S. Cl.** **432/58,** 432/13

[51] **Int. Cl.** **F27b 11/00**

[58] **Field of Search** ..... 263/21 B, 21 R; 432/13, 58

[56] **References Cited**

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2,855,191	10/1958	Blaha	263/21 B
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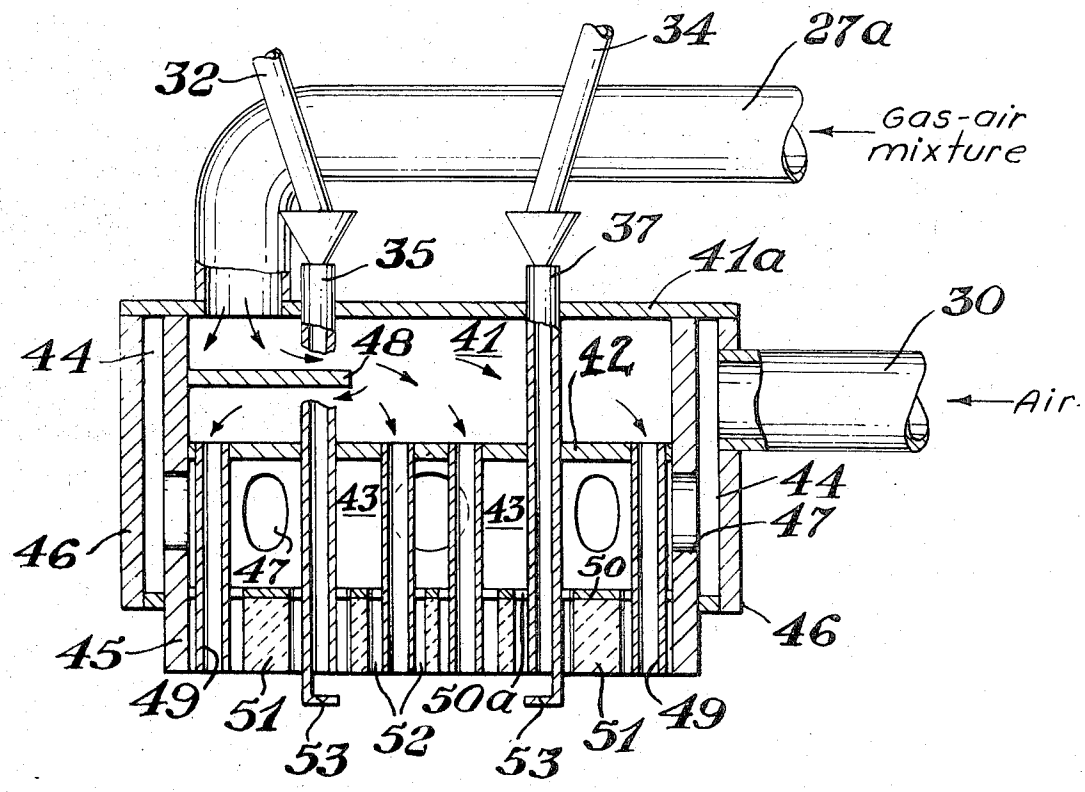
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[57] **ABSTRACT**

The burner of this invention is particularly adapted for use with a furnace for thermally expanding a particulate solid, such as clay particles. The burner pot, which comprises basically an upper compartment, lower compartment and a surrounding peripheral compartment, is mounted at the top of the furnace chamber. A mixture of natural gas and air, as a fuel mixture, is directed into the upper compartment from a mixer in communication with the upper compartment. Simultaneously, an auxiliary air supply is directed into the peripheral compartment and on into the lower compartment through several ports which open into the lower compartment. The clay particles to be expanded are fed downwardly through the burner pot and into the furnace through vertical feed nozzles in the burner pot. The fuel mixture is directed into the top of the furnace chamber through flame nozzles in the burner pot which surround the feed nozzles. At the tip of the flame nozzles, which is the underside of the burner pot, the fuel mixture and auxiliary air converge to provide the flame front for expanding the clay particles.

4 Claims, 3 Drawing Figures



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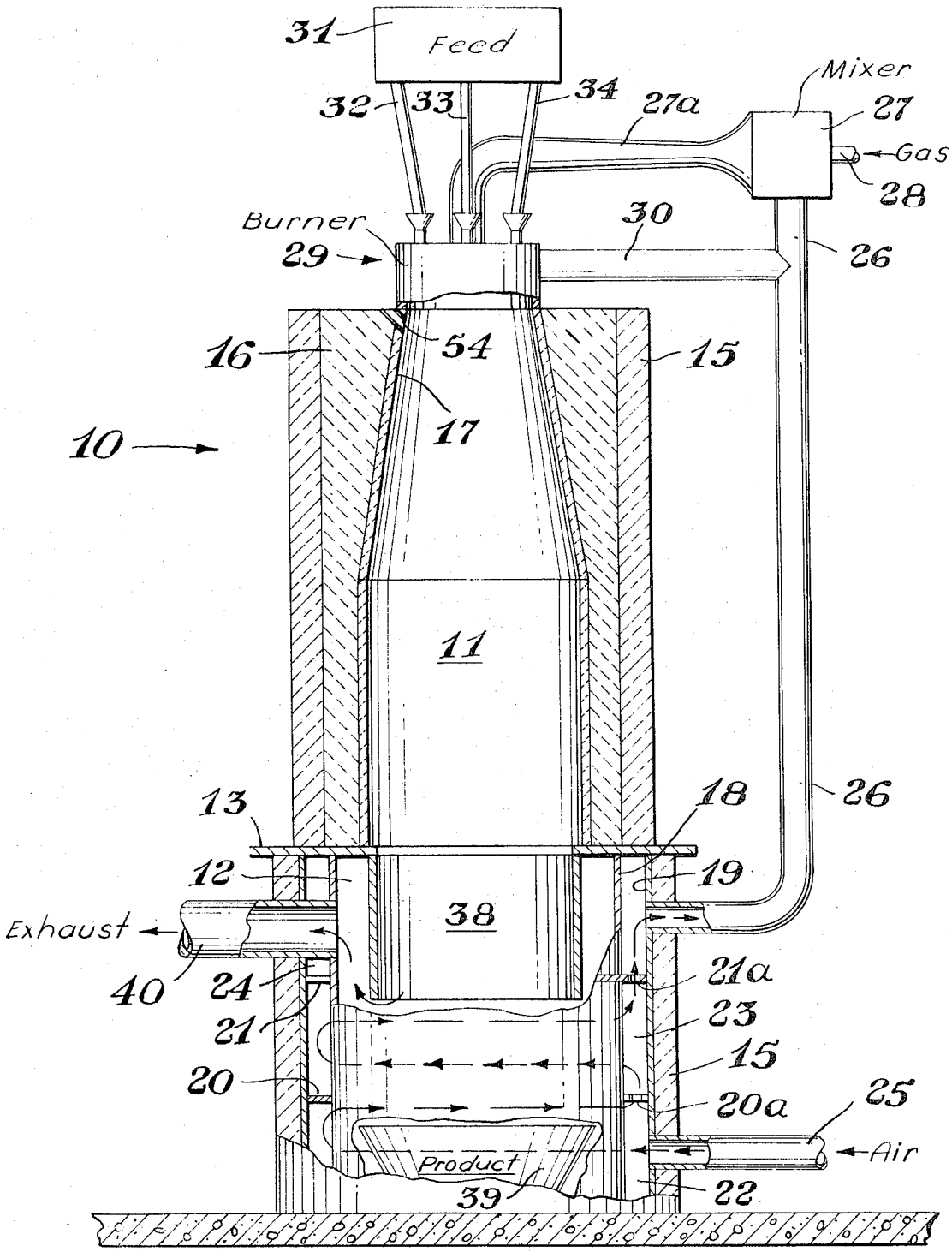


Fig. 1

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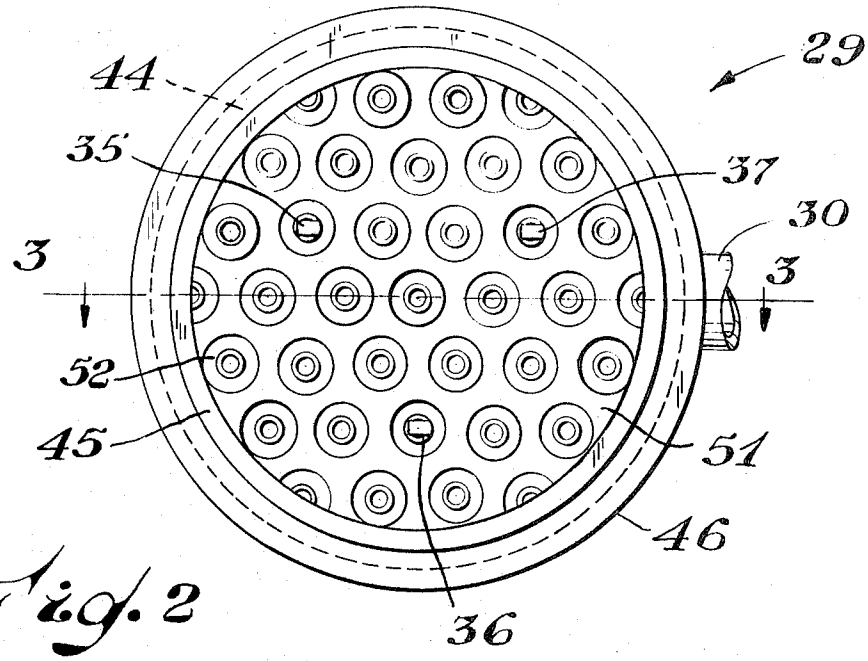


Fig. 2

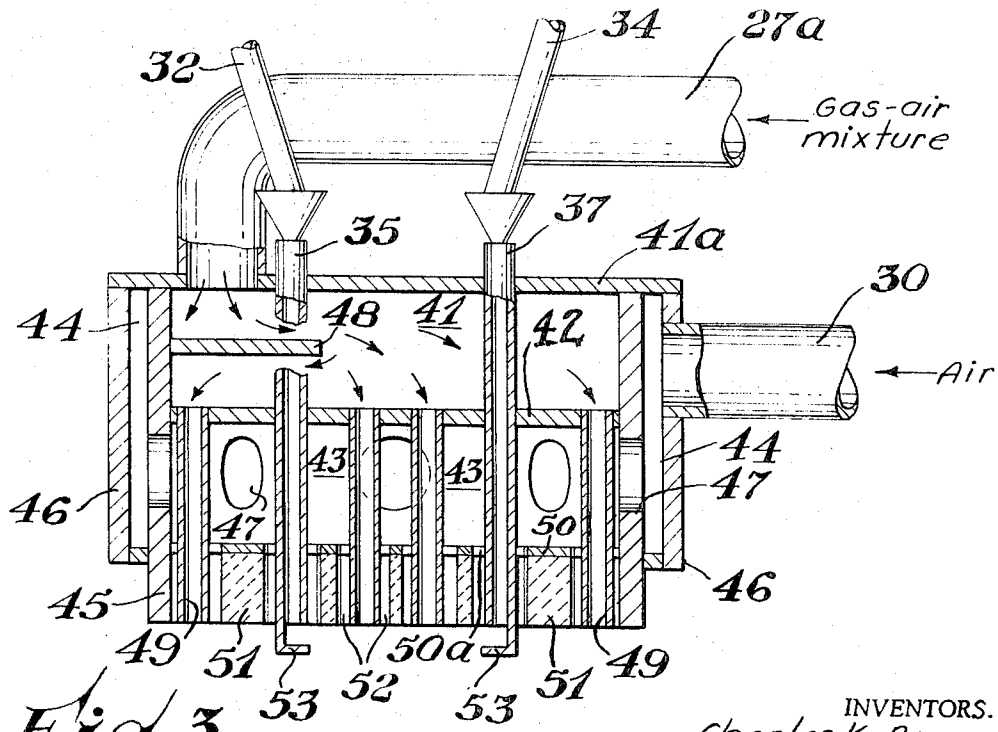


Fig. 3

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LOW VELOCITY BURNER FOR THERMAL EXPANSION OF PARTICULATE SOLIDS

BACKGROUND OF THE INVENTION

It is common practice to thermally expand mineral solids, such as perlite, vermiculite, or clay to obtain various products such as light weight concrete aggregate, insulation, filter media, packing, and the like. A general type of furnace which may be used for this purpose is described in U. S. Pat. No. 2,676,892. Such a furnace consists basically of a vertical chamber with a gas burner mounted at the top of the chamber. The solid particles to be expanded are fed into the top of the chamber through a tube or other means which is adjacent to or surrounds the flame nozzle of the burner. As the particles fall downwardly through the furnace chamber, they are heated to a high temperature by the burner flame. The high temperature causes the particles to expand and the expanded material is collected in a bagging hopper or other type of receptacle at the bottom of the furnace chamber.

The known furnaces are somewhat inadequate for thermally expanding small aggregate, such as clay products. A primary disadvantage is that the usual burner apparatus has only one flame nozzle, so that the heating flame is directed into the furnace chamber through the single nozzle at a fairly high velocity. With a high velocity flame at the nozzle tip, therefore, the downward movement of the light weight particles in the furnace chamber is greatly accelerated. Because of this acceleration the particles do not remain in the furnace "hot zone" long enough to expand. Another disadvantage is that the high velocity flame creates considerable turbulence in the furnace chamber. The turbulence causes some of the particles to hit against the walls of the furnace chamber and stick to these walls, thus resulting in substantial product loss.

SUMMARY OF THE INVENTION

Accordingly, a broad object of the present invention is to provide a burner apparatus suitable for a thermal expansion furnace which produces a slow velocity flame.

A more specific object of the invention is to provide a burner apparatus as described in which the slow velocity flame is achieved by distributing the flame front uniformly over a large surface area.

Broadly, the invention provides a low velocity burner apparatus suitable for use with a furnace for thermally expanding particulate solids such as clay particles. The burner pot is mounted at the top of the furnace chamber and is divided into an upper compartment, lower compartment and peripheral compartment. A fuel gas mixture, preferably natural gas and air, is directed from a mixer into the upper compartment. At the same time an auxiliary air supply is directed from a main air line into the peripheral compartment and on into the lower compartment through port holes which provide communication between the peripheral compartment and lower compartment. The particles to be expanded are fed downwardly into the top of the furnace chamber through vertical feed nozzles in the burner pot. Simultaneously, the fuel mixture is fed into the top of the furnace chamber through vertical flame nozzles in the burner pot which are positioned adjacent to the feed nozzles. As the fuel mixture reaches the tip of the flame nozzle (the underside of the burner pot), it mixes with the auxiliary air which is directed downwardly from the lower compartment through annular spaces surrounding the flame nozzles. The combination of auxiliary air and fuel mixture provide a low velocity flame for expanding the downwardly falling particles.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical elevation view, mostly in section, of a thermal expansion furnace, including the burner apparatus of this invention.

FIG. 2 is a view of the burner apparatus shown in FIG. 1, as it would appear looking upward toward the bottom of the burner.

FIG. 3 is a vertical section view of the burner apparatus, as taken on line 3—3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring particularly to FIG. 1 of the drawing, the numeral 10 indicates generally a furnace for thermally expanding a particulate solid, such as a clay product. The upper part of the furnace comprises an expansion chamber 11, while the lower part comprises a product recovery chamber 12. The expansion chamber 11 is separated from the recovery chamber 12 by a horizontal plate 13, preferably stainless steel, having a central opening therein. An outer covering for expansion chamber 11 consists of a layer of conventional pipe insulation 15, which encloses a wall of fire brick 16. The inner surface of fire brick wall 16 is lined with a layer of a castable refractory 17.

Recovery chamber 12 is defined generally by an inner vertical wall member 18, which is spaced from an outer vertical wall member 19. The space between wall members 18 and 19 defines, in general, a pre-heat chamber. Positioned horizontally between wall members 18 and 19 is a lower ring member 20 and an upper ring member 21. The ring members 20 and 21 divide the pre-heat chamber into a lower section 22, an intermediate section 23, and an upper section 24. Recovery chamber 12 is insulated with the same type of material as the expansion chamber 11, namely, a conventional type insulation 15, which covers the outer wall member 19.

Air is directed into the pre-heat chamber through an air inlet 25, which connects into the lower section 22. As explained more fully below, the air directed into lower section 22 is circulated upwardly through intermediate section 23 and into upper section 24. The preheated air leaves upper section 24 through an outlet line 26, which connects section 24 with a conventional venturi mixer 27. A fuel gas, preferably natural gas, is directed into mixer 27 through a gas inlet line 28. In mixer 27, the fuel gas is mixed with the preheated air from line 26. From mixer 27 the fuel gas mixture is directed to outlet line 27a and into a burner, indicated generally at 29.

A portion of the preheated air in line 26 is diverted through a branch line 30 into burner 29, in which it combines with the natural gas-air mixture from the mixer 27. Mixing of the fuel gas and combustion air described above is done to achieve a low velocity flame in burner 29, as explained in more detail later in this text. The amount of preheated air directed into mixer 27 is controlled by a valve means, such as a butterfly valve (not shown), which is installed in line 26 just below mixer 27. The portion of preheated air which is

diverted into burner 29 through branch line 30, is regulated by a similar valve means (not shown) installed in line 30.

As noted in FIG. 1, the burner 29 is mounted at the top of expansion chamber 11, so that the entire bottom surface of the burner covers the top opening in the expansion chamber. The particulate solids to be expanded are contained in a feed hopper 31, which is mounted above burner 29. From hopper 31 the particles are fed by gravity through feed lines 32, 33 and 34 and down into feed nozzles 35, 36 and 37 in burner 29 (note FIGS. 2 and 3). As the solids fall downwardly through the feed nozzles and into chamber 11, they are expanded by the heat of the combusting gases from burner 29. Thereafter, the expanded particles drop through the opening in plate 13 and down through a shroud member 38, which extends below plate 13. As the particles drop through shroud 38 they fall into a container 39 or other collection means positioned directly below the shroud in recovery chamber 12. The spent fuel gas in expansion chamber 11 travels downwardly with the expanded particles and is exhausted from chamber 12 through an exhaust outlet 40.

Referring particularly to FIGS. 2 and 3, the burner 29 is basically a burner pot made up of three separate compartments. An upper compartment 41 has an upper wall 41*a*, which includes an inlet connecting into the outlet line 27*a* of venturi mixer 27. The upper compartment 41 is separated from a lower compartment 43 by a horizontal plate member 42. Surrounding the upper compartment 41 and lower compartment 43 is a peripheral compartment 44, which is separated from the upper and lower compartments by a common side wall 45. The auxiliary air line 30, which branches off from air outlet line 26, connects into an outer wall 46 of peripheral compartment 44. Branch line 30, therefore, provides means for directing a portion of the air in line 26 into the peripheral compartment 44. From the peripheral compartment 44 the auxiliary air flows into the lower compartment 43 through several spaced apart air ports 47 (openings) in the common side wall 45.

To illustrate the practice of the invention a typical operation in which clay particles are expanded will now be described. The clay product used in the operation was attapulgite clay. The average size of the particles before expansion was about 60–90 mesh. At the commencement of the operation, the combustion air, which is received from a compressor (not shown), was directed into lower section 22 of recovery chamber 12 through the air inlet 25. The rate of the incoming air was about 53.5 cubic feet per minute. The air directed into lower section 22 flowed in a circular pattern around the inner wall 18. In actual practice, the air can circulate around inner wall 18 either in a clockwise or counter clockwise direction. In the present description the air is illustrated in FIG. 1 as circulating in a counter clockwise direction.

In its circulation around inner wall 18 the air strikes a vertical baffle (not shown), which is positioned between walls 18 and 19 and extends downwardly from lower ring 20 on the far side of inlet 25. As the air strikes the baffle, it is forced upwardly into intermediate section 23 through an opening 20a, which is positioned in ring member 20 adjacent to the baffle. The air circulating in section 23 strikes a second vertical baffle (not shown) located on the far side of opening 20*a*, and is forced upwardly into upper section 24 through an opening 21*a*, which is positioned adjacent to the baffle. In upper section 24 the circulating air strikes a third vertical baffle (not shown) located on the near side of outlet line 26, which forces the air upwardly through line 26. The purpose of circulating the air peripherally around the recovery chamber 12 is to preheat the air before it enters the venturi mixer 27 through line 26, or the burner 29 through line 30. Before entering the outlet line 26 the air is heated to a temperature of about 395° C., which results in a higher flame temperature than that which would be obtained using air at room temperature. The higher flame temperature thus enables a more rapid and complete expansion of the clay particles than would be possible with room temperature air.

About one-half of the combustion air in line 26, i.e., about 27 cu.ft/min., was fed into mixer 27. The remaining half of the combustion air, or about 26.5 cu. ft/min., was diverted from line 26 through branch line 30 and into the peripheral compartment 44 of burner 29. Natural gas was fed into the mixer 27 through line 28 at a rate of about 4.5 cu. ft/min. In mixer 27 the natural gas combined with the combustion air which was being fed into the mixer through line 26. The resulting fuel gas temperature was fed through line 27*a* into upper compartment 41 of burner 29. As the fuel premixture entered compartment 41 it struck a horizontal baffle 48, which extends outwardly from side wall 45. The purpose of baffle 48 is to spread the incoming fuel gas outwardly to provide a more uniform distribution of the gas into each of the several flame nozzles 49.

As shown in FIG. 3, the flame nozzle 49 comprises tubular members which are attached to the plate member 42 and which extend vertically downwardly from the plate 42 for the full length of lower compartment 43. Below the plate member 42 is a second plate member 50, preferably a steel plate. The plate 50 is attached to side wall 45 and is positioned horizontally in lower compartment 43 below the auxiliary air ports 47. In plate member 50 are a number of circular holes of slightly larger diameter than the flame nozzles 49. Bonded to the under side of plate 50 is a castable refractory material 51. The thickness of the refractory plate 51 extends from the underside of plate 50 down to the lower tip of flame nozzles 49. The combination of the steel plate 50 and the refractory layer 51 thus form a single-piece elongate plate with circular holes therein which define annular elongate spaces 52 around each of the flame nozzles 49.

At the start of the operation, the fuel gas mixture entering expansion chamber 11 from burner 29 is ignited to initiate a flame at the tip of each flame nozzle 49. This is done by inserting a small starter flame through an opening 54 (in the upper part of expansion chamber 11) just prior to introducing the gas-air mixture into burner 29. Once the burner 29 is ignited, the starter flame is removed and the gas-air mixture into the burner is gradually increased until the desired flame temperature is reached.

In burner 29 the fuel gas mixture is spread over a large area, i.e., the fuel gas is directed into the several flame nozzles 49 simultaneously. The result is a relatively slow gas flow and a low velocity flame at each nozzle tip. A problem usually associated with slow-flowing combustion mixtures is a flash back of the flame into the burner apparatus. The flash back prob-

lem has been eliminated in the burner apparatus of this invention.

One way in which flash back is eliminated in the present burner is to premix the fuel with only a portion of the combustion air, keeping the mixture rich in fuel, before entry into the flame nozzles **49**. The premix technique also results in a smoother combustion of the fuel gas mixture. Secondly, the additional combustion air which enters the lower compartment **43** through the openings **47** in side wall **45** is dircted downwardly through the annular spaces **52** around each flame nozzle **49**. By providing a curtain of air around each flame at the nozzle tip, any flame turbulence is considerably reduced and the combustion is spread over the entire surface area of the burner.

The clay particles to be expanded were fed from feed hopper **31** into the feed lines **32, 33** and **34**, at a rate of about 66 lbs./hr. From the feed lines the particles dropped downwardly through feed nozzles **35, 36** and **37** into the expansion chamber **11** of the furnace. As illustrated in FIG. **3**, the feed nozzles are disposed vertically within the upper compartment **41** and lower compartment **43** and extend the full length of each compartment. Referring particularly to FIG. **2**, it will be noted that each feed nozzle is positioned such that it is surrounded by several flame nozzles.

As shown in FIG. **3** the lower end of each feed nozzle includes a finger-like right angle projection **53**. The projection **53** is for the purpose of dispersing the particles as they fall downwardly through the feed nozzle into the expansion chamber. More specifically, the finger **53** distributes the downwardly falling particles into a spread pattern to enable more uniform contact of each particle with the surrounding flame front. The low flame velocity at the tip of the flame nozzles **49** also enhances expansion of the clay particles, since the particles have a longer residence time in the "hot zone" of the expansion chamber. In the practice of the invention, an average flame temperature for expanding an attapulgite clay product was about 1375° C.

In Table I below, are listed some of the properties of attapulgite clay particles which were expanded according to the practice of this invention.

TABLE I

Average diameter	0.35 mm.
Construction	Unicellular (primarily)
Bulk density	0.58 g/cc.
Density of solid material of particle wall	1.89 g/cc.
Void space between particles (when bulk packed)	37%
Space occupied by particle walls	30.8%
Cell space inside particles	30.5%
Average particle wall thickness	0.037 mm.

The actual density of the expanded particles was determined by a float/sink test. In this test a measured quantity of the particles were dropped onto the surface of a test liquid. The particles which floated on the surface of the test liquid were designated as the light fraction. The particles which sank in the liquid were designated as the heavy fraction. The results are set out in Table II below.

TABLE II

Test liquid	Sp. gr. of test liquid	Particles which floated: Volume percent	Particles which floated: Weight percent	Bulk density of particles which floated (light fraction), g./cc.	Bulk density of particles which sank (heavy fraction), g./cc.
Methanol	0.8	38	26	0.386	0.689
Water	1.0	72	58	0.461	0.877
Carbon tetrachloride	1.6	90	81	0.531	1.195

What is claimed is:

1. A burner apparatus with a low flame velocity, for use with a furnace for expanding particulate solids, the furnace having an expansion chamber with a flat top, and the burner apparatus being defined by:

a. a burner pot which is mounted on the flat top of the furnace expansion chamber, and which includes an upper compartment, a lower compartment, and a peripheral compartment; and wherein

b. the upper compartment has an upper wall which includes an inlet in communication with a mixing apparatus, for introducing a pre-mixed fuel gas and air mixture into the said upper compartment;

c. the peripheral compartment surrounds the upper and lower compartments and is separated therefrom by a common side wall, the peripheral compartment also having an outer wall which includes an inlet in communication with an auxiliary air supply line;

d. the lower compartment is positioned directly below the upper compartment and is separated therefrom by a first horizontal plate member;

e. several spaced apart ports are positioned in the common side wall separating the lower compartment and the peripheral compartment, for directing the auxiliary air supply from the peripheral compartment into the lower compartment;

f. feed nozzle means are defined by tubular members disposed vertically within and extending the full length of the upper and lower compartments, for directing particulate solids downwardly into the furnace expansion chamber;

g. flame nozzle means defined by tubular members which are attached to the horizontal plate member, which extend vertically downwardly from the plate for the full length of the lower compartment, and which are positioned adjacent to the feed nozzle members, for directing a flame into the furnace chamber, and

h. a second plate member which is positioned horizontally in the lower compartment below the auxiliary air ports and which has holes therein defining annular spaces around the flame nozzles, for directing the auxiliary air downwardly around the flames issuing from the flame nozzles.

2. The burner apparatus of claim **1** which includes a horizontally disposed baffle plate attached to the side wall of the upper compartment and extending outwardly therefrom to a point below the fuel gas inlet.

3. The burner apparatus of claim **1** in which the lower end of each feed nozzle includes a finger-like projection for distributing the downwardly falling solids into a spread pattern.

4. The burner apparatus of claim **1** in which the recited particulate solids is a clay product.

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