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COMBUSTION CHAMBER BURNER FOR PRODUCING GLASS FIBERS

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This invention relates to a combustion chamber burner and it has particular relation to an improved combustion chamber burner for producing a high velocity, high temperature gaseous blast useful for forming fibers from heat softenable material.

It is known that combustion chamber burners are useful for making glass fibers. They produce a high-temperature, high velocity blast which can be directed against a solid filament of glass to melt it and attenuate it into fine fibers.

The amount of fiber production according to such process is dependent upon the velocity, temperature and turbulence of the blast. The velocity of the blast depends upon the amount of combustible material which can be put through the burner and the rate at which it will burn. It is also somewhat dependent upon the shape of the burner chamber and discharge orifice. The temperature of the blast is determined by the mixture of the combustible gases and the completeness of combustion of the combustible gases. The turbulence is dependent upon the burning pattern and velocity of the gases and the shape of the burner chamber and discharge orifice.

In a commercial process utilizing these burners, a number of the burners are placed side by side in a horizontal row in a forming area. Solid glass rods known as primary filaments or rods are drawn vertically through bushing orifices from a source of molten glass located above the burners. The primary rods are introduced vertically into horizontal blasts produced by the burners, heated and drawn out into fine fibers which are collected on a suitable conveyer belt approximating the general width of the blasts as formed by the plurality of burners.

The blast as created by the burners is not a continuous, lateral blast. The refractory chamber plus the steel shell therefor and the space between adjacent burners represent lateral area in which no blast is available to engage the fibers. In order to increase the rate of production in a given system as described above, it has been proposed to increase the size of the burner and the width of the blast produced thereby. In this way, the number of burners could be reduced and the amount of unproductive space between the burners and blasts produced therefrom reduced. This would enable the production of a blast extending substantially completely across the width of the forming area and conveyer. The greater effective width of the combined blasts would enable the introduction of a greater number of primary filaments into the blasts and hence, a higher production per given amount of forming area.

It was found, however, that increasing the size of the burner did not provide the increase in production contemplated by the increased number of primary filaments which could be introduced into the blast. It was obvious that the attenuating efficiency per primary filament of the enlarged burner was not as great as compared to a smaller burner. The velocity and temperature of the blast were not as high as they should have been and there was incomplete combustion in the chamber of the combustible gases supplied to the chamber.

It is an object of the present invention to provide an enlarged combustion chamber burner which is capable of producing a blast of higher temperature and higher

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velocity than heretofore possible with burners of similar design and size.

Another object of the present invention is to provide a combustion chamber burner capable of producing a high velocity, high temperature blast of greater lateral dimensions and higher temperature and velocity than previously produced. A blast of greater width and high velocity and temperature is capable of fiberizing a greater number of primary filaments and hence, of producing a greater amount of secondary or fine fibers.

It is another object of the invention to increase the mass flow of combustible material through a combustion chamber burner so as to increase the ultimate velocity of the blast and to achieve complete combustion of the material within the chamber. The complete combustion of the greater mass of combustible gases provides a higher velocity and higher temperature to the blast than if the gases were incompletely combusted within the chamber.

It is a further object of the present invention to provide a large combustion chamber burner having its interior so divided into individual compartments as to obtain the maximum efficiency of combustion of combustible gases introduced into the burner at a high rate of mass flow. The particular design of the chamber is critical in obtaining maximum burning efficiency of large amounts of combustible material.

Other objects and advantages of the invention will become more apparent during the description of the figures of the drawing in which like numerals refer to like parts throughout and in which:

FIG. 1 is a diagrammatic view of a combustion chamber burner as employed in a fiber forming process;

FIG. 2 is an enlarged plan view of the combustion chamber burner shown in FIG. 1;

FIG. 3 is a view in section taken along lines III—III of FIG. 2, and,

FIG. 4 is an end view looking into the orifice of the burner illustrated in FIGS. 1 to 3.

In FIG. 1 of the drawing, a combustion chamber burner 10 of the present invention is shown in a fiberizing process. Molten glass 12 in melting container 14 is drawn through orifices 16 in bushing 18 to form primary filaments 20. The filaments 20 are drawn from the orifice 16 by means of coacting drawing rollers 23 and projected into a guide 25 which guides the filaments into a high temperature, high velocity blast 28 as produced by the burner 10.

The burner 10 as shown in the figures of the drawing is composed of a chamber 30 having walls 32 formed of refractory or other material capable of receiving heat and transferring heat to the combustible mixture within the chamber. The chamber is substantially rectangular in cross-section, however, it is understood that it may be oval or of other cross-section as desired. The chamber 30 is closed at one end by a refractory grid plate 34 containing a series of small orifices 37 in the general outline of three, horizontally disposed circles in the plate 34. These orifices 37 connect chamber 30 with chamber 40 and supply a combustible mixture of gaseous fuel and air to the chamber 30 from the chamber 40. The fuel-air mixture is supplied to chamber 40 by a suitable conduit 42. The refractory chamber 30 is provided with a metal shell 44. This metal shell is bolted by means of bolts 46 to the metal housing 48 enclosing the chamber 40 which brings the combustible gases into the burner.

The walls 32 are of substantially the same cross-section throughout most of the length of the chamber extending from the grid plate 34 to a point near the other end of the chamber. Near the end of the chamber opposite the grid plate, the top and bottom walls 32 begin to taper and converge so as to reduce the cross-section

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of the chamber and form a long, narrow, horizontal discharge orifice 52. The discharge orifice extends substantially completely across the width of the chamber and its width is much greater than its height. For example, the orifice defining the shape of the blast may be 12 inches in width and $\frac{1}{2}$ to $\frac{3}{8}$ inch in height. This necking down of the walls of the chamber to form the orifice and constrict the blast enables the production of a much higher velocity blast than if the orifice were of greater cross-section, i.e., corresponding to the general cross-sectional area of the chamber.

As stated above, it was desired to produce a combustion chamber burner having increased volume so as to permit an increase in the mass flow of combustible material through the burner and produce a wider blast for attenuation of fibers. It was found that merely increasing the volume of the chamber was insufficient to efficiently burn such an increased mass flow of combustible material. In accordance with the present invention, a combustion chamber burner of increased volume is provided which is able to combust a greater mass flow of combustible material with greater efficiency. This is accomplished by providing the burner with dividing walls or baffles 55 of particular design and located in a particular manner within the chamber of the burner.

The most efficient design from a theoretical standpoint would be to have an infinitesimally thin dividing wall. This is desired so that the surface area within the chamber can be increased with a minimum reduction of volume. The theory of this desirability is discussed in more detail below.

The walls 55 should be capable of being heated to a temperature sufficient to enable them to act as a source of ignition for the combustible material. The dividing walls are heated by radiation from the walls 32 and by conduction and radiation from the flame produced by the burning of the combustible material within the chamber. The walls 55 in turn transfer this heat, mainly by conduction, to the combustible material.

The walls 55 should be opaque to radiation emitted by walls 32 and the flame. They may be composed of refractory or metal material capable of withstanding temperatures involved in the burning of the combustible material, which temperatures may vary according to the mixture of the combustible material and to the conditions of combustion employed to produce glass fibers. An infinitesimally thin dividing wall is not practical from a structural standpoint, therefore, a wall of some thickness is desired. A tapered or wedge-shaped wall has been found to be most suitable.

The walls 55 are connected to the grid plate 34 and the top and bottom walls 32 of the chamber and extend from the plate 34 substantially the length of the chamber. They terminate at a point approximating the area where the refractory walls 32 begin to neck down to form the orifice 52. The baffles 55 taper in cross-section with the thickest portion being at the end nearest to the grid plate 34 and with the cross-section tapering to a minimum at the end or point of termination near the orifice 52. For example, they may be $\frac{1}{2}$ inch in thickness at the end nearest to the grid plate and $\frac{1}{8}$ inch or less at the point of termination nearest to the orifice 52. They may even taper to a point somewhere within the chamber 30 near the discharge orifice. The tapered shape permits the blast which issues from the orifice 52 to extend continuously across the mouth or discharge orifice of the burner with a minimum alteration of the horizontal velocity profile.

The baffles 55 serve as vertical partitions to divide the chamber 30 into three separate horizontally spaced chambers which are provided with combustible gases by three separate series of orifices 37, each set being arranged in circular outline. The baffles are mounted in the chamber so that they are in a plane which is parallel to the

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general flow of gases through the chamber and substantially perpendicular to the horizontal plane of the discharge orifice 52 and blast. This reduces interference with the lateral dimensions of the blast to a minimum.

It is understood, of course, that only one baffle may be employed so as to divide the chamber into two equal sections or that more than two baffles may be employed. Also, the outline of the orifices 37 may be other than circular, for example, the outline may be oval or rectangular. It is desired that the walls be spaced a slight distance laterally, i.e., $\frac{1}{8}$ to $\frac{1}{2}$ inch from the peripheral orifices in the series of orifices.

It is also desired that the baffles have smooth faces. This is desired so that the baffles do not interrupt the flow of gases or increase the turbulence in the gases near the baffle wall where the combination of velocity gradient and turbulence might prohibit the processes of combustion from propagating in an efficient manner.

The operation of the burner may be described and contrasted to a combustion chamber burner having dividing walls therein as shown in U.S. Patent No. 2,489,244. In the patent, the dividing walls are placed so as to be in line with the discharge orifice. This requires the gases flowing through the chamber to bend or change their line of direction as they approach the discharge orifice so as to be able to flow therethrough. This is designed to increase turbulence in the gases at this point to insure complete combustion of the gases. Also, the dividing walls have rippled, irregular surfaces to increase the turbulence of the gases as they contact the walls and flow through the chamber.

The positioning of the walls 55 and the smooth surfaces thereof, as described in the present invention, reject the theory of the patent. The walls 55 provide additional heat supplying surface in relationship to the volume of the chamber 30 so as to permit complete, efficient combustion of the combustible gases.

The principle involved in the present invention is that the hot baffle walls 55 provide an increased amount of surface area capable of igniting a combustible mixture. This permits the burning of more combustible material and provides a higher temperature and higher velocity to the blast which issues from the discharge orifice 52. The higher the temperature and the greater the velocity of the blast, the faster the primary rods can be introduced into the blast, softened and attenuated into fine fibers.

The combustible material has a certain normal or laminar burning velocity and this burning velocity is dependent on the type of gas, composition, temperature and pressure of the material.

When the flow is turbulent, as it is inside the combustion chamber 30, the burning velocity is increased by some specific amount due to turbulent diffusion. The amount of increase over the laminar burning velocity is additive and usually in the range of one to ten times as much as the laminar burning velocity.

As the unburned material flows from the orifices 37 in the grid plate 34 and into the chamber 30, it is ignited in the following manner. A very small volume of the combustible material near the peripheral orifices 37 receives heat, largely by conduction, from walls 32 or 55 and is raised to its ignition temperature (approximately 1800° F. for a natural gas-air mixture). This small volume is ignited and propagates by spreading into the unburned material at a velocity equal to its normal or laminar burning rate plus the turbulent diffusion rate. The volumes of combustible material which never contact or approach the walls 32 or 55 are heated and ignited by the volumes ignited by the walls. These volumes in turn ignite other volumes until all of the material is burned.

For most efficient use of the burner, all of the small volumes of material should be burned before reaching the discharge orifice. If the burning velocity of the volumes of material is not sufficient, some of the volumes of material will pass unburned through the discharge ori-

fice and incomplete and inefficient combustion will result. In this situation, it is desirable to increase the points of ignition (i.e., ignition where the turbulence intensity and velocity gradient are such that the flame will propagate) from which the chain of ignition from volume to volume may be begun so as to obtain complete and efficient combustion. This is the function which is performed by the hot baffle walls 55.

It can be seen that some turbulence increases the rate of heat conduction between the volumes and thus, increases the rate of burning. It must be pointed out, however, that if the degree of turbulence near the walls 32 or 55 is too great, the heat from the walls is inefficiently conducted to the volumes and also the heat from the ignited volumes is conducted to so many other unburned volumes, that the adjacent unburned volumes are not raised to their ignition temperature and the flame is not propagated throughout the material. Thus, it is desired that the faces of the baffle plates be smooth rather than of rippled configuration, which configuration unduly increases the turbulence of the gases flowing along the length of the chamber.

It is further desired that the gases should not have to change direction any more than necessary as they flow from the orifices 37 through the chamber and out of the discharge orifice 52. Any change in direction requires pressure and this is provided at the expense of the velocity of the blast as it issues from the discharge orifice 52. In order to obtain a given blast velocity at the discharge orifice in a system where the gases must flow around corners or bends in a chamber, the initial pressure of the combustible mixture entering the chamber must be higher than it would have to be in a burner such as described in this invention where the flow of gases is comparatively straight through the chamber. For this reason, it can be seen that a straight flow of gases through the chamber as contrasted to an angular flow is desired.

From the above description, it can be seen that the use of thin, smooth surfaced, baffle walls mounted in a chamber of a burner in a line perpendicular to the general plane of the long narrow discharge orifice is beneficial. It provides the proper surface to volume ratio for the burner to permit efficient burning of combustible gases passing through the burner at high rates of flow. This efficient burning at high rates of flow enables the production of a high velocity, high temperature blast which is capable of softening and attenuating greater amounts of fibers.

Although the present invention has been described with reference to specific details of certain embodiments thereof, it is not intended that such details shall be regarded as limitations upon the scope of the invention except insofar as included in the accompanying claims.

I claim:

1. A combustion chamber burner comprising a refractory combustion chamber with an inlet end and a discharge end, a grid plate at the inlet end of the chamber containing a plurality of small orifices therein for intro-

ducing a combustible mixture of gases into the chamber for combustion within the chamber, a single, unobstructed, long, narrow, continuous opening at the discharge end of the chamber, an inlet manifold connected to the chamber at its inlet end for supplying a combustible mixture of gases to the chamber through the orifices in the grid plate and at least one smooth surface, dividing wall mounted in the chamber in a plane which is substantially perpendicular to the length of the discharge opening and parallel to the general flow of burning gases through the chamber, said dividing wall extending from the grid plate along the length of the chamber to a point short of the discharge opening so as to permit the discharge of a single, uniform, high temperature, high velocity blast of burned gases through the unobstructed, discharge opening of the chamber.

2. A combustion chamber burner as described in claim 1 wherein the dividing wall is tapered from a maximum thickness at the end adjacent the grid plate to a minimum thickness at the end closest to the discharge opening.

3. A combustion chamber burner comprising a chamber having top, bottom and side refractory walls, an inlet end and a discharge end, a grid plate at the inlet end of the chamber containing a plurality of small orifices therein for introducing a combustible mixture of gases into the chamber for combustion within the chamber, a single, unobstructed, long, narrow, continuous horizontal opening at the discharge end of the chamber which is formed by the top and bottom walls of the chamber gradually converging toward each other in a streamline manner at the end of the chamber, an inlet manifold connected to the chamber at its inlet end for supplying a combustible mixture of gases to the chamber through the orifices in the grid plate and at least one smooth surface dividing wall attached to the top and bottom walls of the chamber and mounted therein in a plane which is substantially perpendicular to the length of the discharge opening and parallel to the general flow of burning gases through the chamber, said dividing wall extending from the grid plate along the length of the chamber to a terminating point short of the discharge opening approximating the point where the top and bottom walls of the chamber begin to converge to form the discharge opening so as to permit the discharge of a single, uniform, high temperature, high velocity blast of burned gases through the unobstructed, discharge opening of the chamber.

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