Jan. 23, 1951 | A. P. SAHA | 2,539,165

DISPERSIBLE FUEL BURNER HAVING A REVERSE GAS FLOW FLAME STABILIZER

Filed Nov. 30, 1946

FIG. 1.

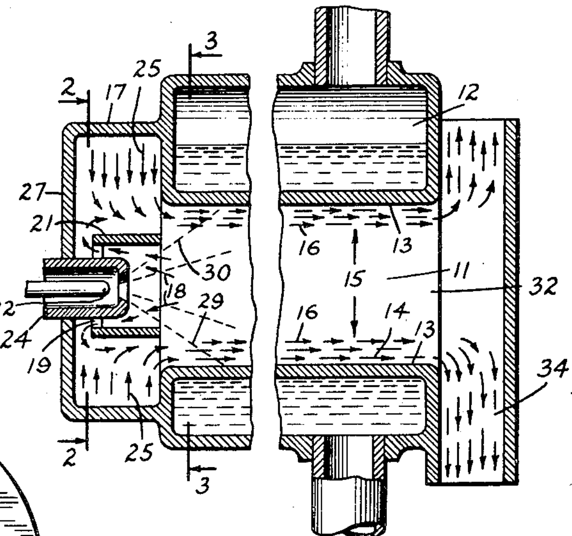


FIG. 2.

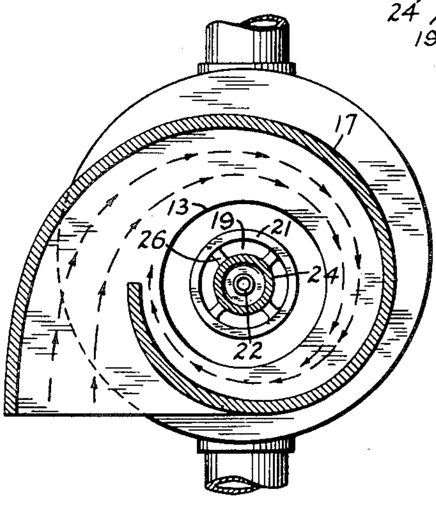
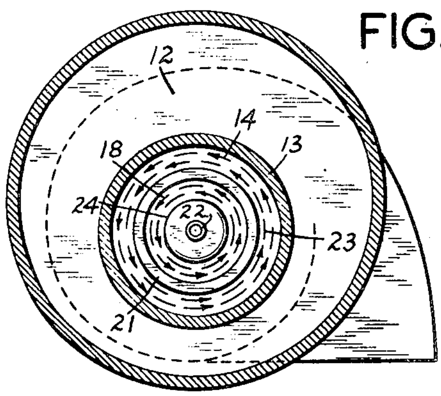


FIG. 3.



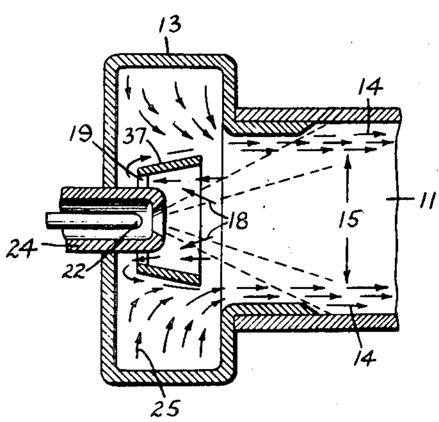


FIG. 4.

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Patented Jan. 23, 1951 2,539,165

UNITED STATES PATENT OFFICE

2,539,165

DISPERSIBLE FUEL BURNER HAVING A REVERSE GAS FLOW FLAME STABILIZER

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Application November 30, 1946, Serial No. 713,217

3 Claims. (Cl. 110—28)

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The present invention relates to a novel and improved apparatus for effecting combustion of dispersible fuels.

The term" dispersible fuel" as hereinafter used in the specification and the claims is intended to include solid fuels in powdered or pulverized form, such as powdered coal, and fluid fuels, such as gaseous, vaporous and liquid fuels, for example, combustible gases and vapors as well as combustible liquids such as fuel oils, capable of being atomized by spraying and the like.

Attempts have been made in the past to use luminous flames, created by burning atomized fuel, for example, in air introduced under pressure to a combustion device, as a means of increasing the transfer of heat. While such methods are satisfactory, one difficulty has been that the flame front in the combustion device does not remain constant unless the device is carefully designed and operated, with the result that the flame front pulsates and thus causes an uneven transfer of heat and intermittent periods or cycles of incomplete combustion. This is particularly true when a variable capacity nozzle is used.

The primary object of this invention is to provide an improved apparatus for burning dispersible fuel in which substantially complete and perfect combustion may be obtained with a stabilized, non-pulsating flame and which has special utility in the firing of heat transmission apparatus, furnaces, boilers, and any other apparatus where the object is the transmission of the potential energy of fuel into useful heat.

Other objects of the invention are to provide an apparatus of simple, practical construction, dependable in operation, durable in use, and capable of effecting substantial fuel economy due to efficiency and simplicity in operation, and to provide an apparatus of this character which is of compact and inexpensive construction.

Further objects of this invention will be apparent from a consideration of the description herein, especially when considered in connection with the accompanying drawing hereinafter described.

According to the present invention, apparatus is provided in which the flow of the combustion supporting air and of the dispersible fuel are such as to insure the maintenance of a uniform flame and of constant heat emission conditions in the combustion space. The combustion supporting air and the fuel within the apparatus are introduced into the combustion chamber in relation to the flame stabilizer in such a manner

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that the combustion progresses at a constant rate throughout the apparatus for a given setting of air and fuel admission.

The combustion chamber and flame stabilizer provided in accordance with this invention eliminates the "flash back" of the flame to the fuel nozzle, such a "flash back" being a defect which at times may cause the apparatus to vibrate severely under exaggerated conditions. Hence, the apparatus of the present invention insures a constant flame front and radiation emissivity for given conditions of operation and, therefore, results in a smooth operation and in constant flame temperatures for the entire combustion space.

In operation, air is introduced so as to flow through the combustion chamber in an annular, rotating air stream. This may be and preferably is in the form of a substantially free spiral vortex, i. e., the air has axial as well as tangential velocity components. If the combustion chamber is divergent or convergent, the air will also have radial velocity components within the combustion chamber. The axial flow of air within the combustion chamber is away from the zone or nozzle from which the fuel is introduced so that the axial components of motion of fuel and air are in the same direction. When air flows through the combustion chamber in substantially the form of a whirling, annular stream or free spiral vortex, a cross section through the combustion chamber perpendicular to the longitudinal axis thereof shows an annular cross-section of air adjacent the walls of the combustion chamber. Within this annular section there is a cylindrical zone referred to hereinafter in the specification and claims as a core. As will be described hereinafter, this core serves as a suitable space for dispersing the fuel.

The dispersible fuel is injected preferably at one end of the apparatus through a nozzle which may, if desired, be of variable capacity. The dispersible fuel ejected from the nozzle is dispersed through the flame stabilizer, to be described presently, and within the core of the whirling, annular air stream.

The flame stabilizer is a substantially annular element proximate the fuel injection nozzle, and is designed to induce and maintain a secondary stream or flow of material from the core through and around the flame stabilizer. The stream moving around the stabilizer has both axial and tangential velocity components and, if the flame stabilizer is divergent or convergent, also has radial velocity components. Unlike the air in the combustion chamber, however, the stream of material within the flame stabilizer has an axial component of motion toward the fuel injection nozzle so that the flame stabilizer, in effect, acts as a means to bring the flame toward the fuel injection nozzle. It is believed that the material flowing through the flame stabilizer toward the nozzle is a mixture comprising unused air, unburned fuel particles, burned products, cracked fuel particles and possibility free hydrogen.

Although the invention is not limited thereto, the preferred embodiment of the invention contemplates that the source of air for the combustion chamber be the same as that for any air which forms part of the secondary stream of material flowing through the flame stabilizer. In this embodiment the flame stabilizer is so positioned and constructed that the flow of material through and around it is induced by the flow of combustion supporting air into the combustion chamber.

In the continuous operation of the apparatus, the fuel dispersed by means of a nozzle at one end of a combustion chamber is substantially completely burned when the fuel comes in contact with the surrounding atmosphere of combustion supporting air in a whirling, annular air stream which is ample in quantity and so distributed as to insure complete combustion of the fuel. As a result of substantially complete combustion, the flame is maintained at a maximum temperature and a high degree of heat transmission by radiation and convection is obtained.

Reference is now made more particularly to the accompanying drawing wherein;

Figure 1 is a view in longitudinal vertical section through a boiler with which the combustion apparatus may be associated;

Figure 2 is a view in transverse section through the improved combustion apparatus taken on line 2—2 of Figure 1, looking in the direction of the arrows;

Figure 3 is a view in transverse section taken on line 3—3 of Figure 1; and

Figure 4 is a view in longitudinal vertical section through the intake end of a combustion apparatus embodying the invention but having a modified form of flame stabilizer.

Referring now to the drawing, the combustion chamber designated generally by reference numeral 11 is shown incorporated in a boiler 12, it being understood, however, that the combustion chamber may be employed in any apparatus used in heating. The walls 13 of combustion chamber 11 are preferably surfaces of revolution but other forms, for example, polygonal in cross section may be used. Walls 13 may be of metal or refractory material or the like. The combustion chamber 11 is usually cylindrical in form, but it may be conical with diverging or converging walls, or it may be constructed to have a Venturi effect, such as by a shape approximating a hyperboloid of revolution. Any variation in the cross section of the chamber 11 is permissible if such variation is gradual so that sudden changes in the flow of materials therein are avoided.

Combustion supporting air is introduced to combustion chamber 11 so as to move therethrough in a whirling, annular air stream, such as in substantially the form of a free vortex 14 inside of which is a core 15, having an inner boundary 16, substantially free from flow of combustion supporting air other than that which may be introduced with the fuel as a carrier therefor. The rotating air stream 14 may be formed by any means suitable for this purpose, such as volute 17. The core 15 may be of any desired diameter depending upon the dimensions of volute 17 and the combustion conditions as set by any suitable means for regulating the quantity of air and fuel introduced into the apparatus. It has been found that a core having a diameter of approximately 50 to 90%, preferably from 75 to 85% of the diameter of combustion chamber 11, is quite effective for efficient operation.

The combustion supporting air introduced by means of volute 17 induces a suction effect in the openings 19 between the exterior wall of sleeve 24 and the interior wall of a flame stabilizer 21 so as to draw through them a stream 18 of material from the interior of core 15. As shown in Figure 1, for example, stream 18 has within the flame stabilizer 21 an axial component of motion toward fuel nozzle 22 within sleeve 24. Because of the momentum imparted by vortex 14, this stream 18 may also have a tangential component around the inside of flame stabilizer 21, as shown in Figure 3. Upon leaving openings 19, stream 18 mingles with and becomes a part of the fresh stream 25 of combustion supporting air introduced by volute 17.

The flame stabilizer 21 as shown in Figures 1 to 3 is cylindrical in shape and may be secured in position by any suitable means, such as by means of supports 26 attached to sleeve 24 or to wall 27 of volute 17. The dispersible fuel is introduced to the apparatus through nozzle 22, which may be a variable capacity nozzle, and is thereby dispersed in the form of a cone indicated by dotted lines 29 and 30. Initial ignition of the fuel dispersed within this cone is accomplished by any well known means, not shown, and not forming a part of the present invention. Once ignition has been accomplished, the temperature of the combustion is sufficient to insure continual ignition of the fuel injected by nozzle 22 and dispersed within cone 29, 30 and core 15. This continual ignition takes place initially within flame stabilizer 21 inasmuch as the flow of air in stream 18, heated in combustion chamber 11, carries the flame back to within close proximity of nozzle 22. The fuel which contacts the heated material in stream 18 is quickly heated to the ignition temperature, ignites, and stream 18, along with new products of combustion, is carried back (to the left in Figure 1) through stabilizer 21, and emerges through openings 19 to mingle with the incoming stream 25 of fresh, combustion supporting air. It is thus evident that flame stabilizer 21 not only has the primary function of stabilizing the flame within the apparatus by continually bringing the flame back to the end of the apparatus, but that it has the additional function of preheating the air stream 25 introduced to combustion chamber 11.

The fuel that is not ignited within flame stabilizer 21 passes to the core 15, so that it is subjected to a thermal breakdown, yielding particles of free carbon that are heated to incandescence. When these particles of fuel come in contact with the air in the annular stream 14 within combustion chamber 11, they are burned very rapidly, the combustion taking place primarily at boundary 16 between core 15 and air stream 14. The hot products of combustion diffuse into the air stream 14 and are eliminated from combustion chamber 11 as the stream 14 exits from end 32 of combustion chamber 11. The combustion chamber may be simply left open at end 32 or may have associated therewith a volute casing similar to volute 17 at the other end of the chamber, or may simply have radial exit means such as designated by reference numeral 34 in Figure 1.

The position and shape of the flame stabilizer may be varied in a great many ways without departing from the scope of this invention. It has been found, however, that as a general principle it is preferable to position the stabilizer coaxially with respect to the fuel nozzle and the combustion chamber, and that the fuel nozzle should project into one end of the stabilizer, as is shown by way of example in Figures 1 and 4 of the drawing thus forming therewith an annular space in the stabilizer. It should be so placed with respect to the air introducing means, and so shaped, that it will induce and maintain a circulation of air somewhat in the nature of an eddy current around the stabilizer as previously described. The stabilizer may have a circular or polygonal cross section and may have divergent or convergent walls. One example of a flame stabilizer having divergent walls is the frustrum shaped flame stabilizer 37 illustrated in Figure 4. It has been generally found preferable to make the overall cross section or diameter of the flame stabilizer somewhat smaller than the cross section or diameter of the combustion chamber, and preferably just slightly smaller than the core. The specific method of supporting the flame stabilizer is optional, so long as the supporting means does not interfere substantially with the flow of combustion supporting air 20 and is capable of withstanding the intense heat given off by the burned fuel and the heated air passing through and around the supported end of the flame stabilizer.

As mentioned previously, Figure 4 illustrates a modification of the flame stabilizer wherein the stabilizer 37 has the shape of a hollow frustrum, and is supported on sleeve 24 by means of spoke-like supports 26, as shown best in Figure 2. It will be noted that in this modification, as in that shown in Figure 1, the periphery of the cone of dispersion of fuel from nozzle 22 does not intersect the walls of the flame stabilizer, but that it does intersect the boundary between core 15 and air stream 14 within the combustion chamber 11.

A great variety of devices may be used for forming whirling air stream 14 having a core 15. The devices shown in the drawing are merely illustrative. It is to be understood, therefore, that the invention is not limited to the specific mechanical construction of the vortex producing means or other means for forming a whirling stream of air, shown in the drawing. It is also to be understood that any known means for varying the quantity of air introduced and for varying the diameter of the core within the combustion chamber may be used without departing from the spirit of this invention.

If a solid fuel is to be used in accordance with the present invention, it is preferable to introduce it into the apparatus in powdered or pulverized form together with a suitable carrier such as air or an inert gas. If liquid fuel is to be burned it is likewise introduced into the apparatus generally in divided state. This may be effected by means of an atomizer employing air, steam or fuel gas as the atomizing medium or by a mechanical atomizer. The atomized particles of liquid are vaporized within the core and within the stabilizer by the heat of combustion, and the vapor is then burned in the same manner as though a gas had been introduced. If it is desired, liquid fuel may be vaporized before it is introduced into the cores. If gaseous fuel is to be burned it may be introduced through an orifice at about the same position as the nozzle 22.

Any other device may be used for introducing powdered or pulverized solid fuel, liquid, vaporous or gaseous fuel without departing from the spirit of this invention.

The combustion apparatus herein described may be advantageously employed in connection with combustion chambers or furnaces in which the heat load varies. When the load is high a larger quantity of fuel is necessarily consumed and a larger quantity of air must pass through the combustion chamber to support the increased combustion. The amount of air passing through the vortex can be varied by altering the diameter of the core in any suitable manner. For example, with a high heat load a smaller core is used. In this case the mean axial velocity component of the air is greater and a larger quantity of air passes through the combustion chamber.

Various modifications of this invention will be apparent to those skilled in the art and while every variation of the apparatus that may be employed within the scope of this invention has not been illustrated, the invention is intended to include all such modifications as may be embraced within the following claims.

I claim:

1. An apparatus for burning dispersible fuel comprising in combination a combustion chamber having an interior surface of a substantially circular, transverse cross sectional shape to maintain substantially a rotating, annular air stream therein and having an air inlet at one end thereof, means at the air inlet end of said combustion chamber having an end wall and formed to introduce air into the combustion chamber in the form of a rotating annular stream having a core, a nozzle for introducing the dispersible fuel into said core, and flame stabilizing means for inducing a reverse flow of material from said core toward said nozzle, said flame stabilizing means comprising a substantially annular element coaxial with the nozzle, open at both ends and having a substantially circular cross section throughout its length, the minimum internal diameter thereof being substantially greater than the external diameter of the nozzle, one open end of the element being adjacent, but spaced from, the end wall and the other open end thereof extending substantially to the combustion chamber, and said nozzle projecting through said end wall and said one open end into the element forming therewith an annular space in the element for reverse flow of the material into said other open end of the element, through the annular space and out of said one open end to stabilize the flame.

2. An apparatus for burning dispersible fuel comprising in combination a substantially cylindrical combustion chamber having an air inlet at one end thereof, means at the air inlet end of said combustion chamber having an end wall and formed to introduce air into the combustion chamber in the form of a rotating annular stream having a core, a nozzle for introducing and dispersing the dispersible fuel into the core of said air stream, and flame stabilizing means for inducing a reverse flow of material from said core toward said nozzle, said flame stabilizing means comprising a substantially cylindrical tubular element coaxial with the nozzle, open at both ends.

and having an internal diameter substantially greater than the external diameter of the nozzle, one open end of the tubular element being adjacent, but spaced from, the end wall and the other open end thereof extending substantially to the combustion chamber, and said nozzle projecting through said end wall and said one open end into the tubular element forming therewith an annular space in the tubular element for reverse flow of said material into said other open end of the tubular element, through the annular space and out of said one open end to stabilize the flame.

3. An apparatus for burning dispersible fuel comprising in combination a substantially cylindrical combustion chamber having an air inlet at one end thereof, means at the air inlet end of said combustion chamber having an end wall and formed to introduce air into the combustion chamber in the form of a rotating annular stream having a core, a nozzle for introducing and dispersing the dispersible fuel into said core, and flame stabilizing means for inducing a reverse flow of material from said core toward said nozzle, said flame stabilizing means comprising a substantially annular element coaxial with the nozzle, open at both ends, and having substantially the shape of a hollow frustrum, the smaller open end of the element being adjacent, but spaced from, the end wall and having an internal diameter substantially greater than the external diameter of the nozzle and the larger open end of the element extending substantially to the combustion chamber, and said nozzle projecting through said end wall and said smaller open end into the element forming therewith an annular space in the element for reverse flow of said material into said larger open end of the element, through said annular space and out of said smaller open end to stabilize the flame.

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