VIBRATION CANCELLING BURNER GRID FOR A HEATING SYSTEM

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Filed: Nov. 6, 1974

Appl. No.: 521,259

U.S. Cl. 431/114; 431/328
Int. Cl.2 F23D 13/00

Field of Search 431/328, 114, 326, 329, 431/346; 126/91 A; 165/69

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ABSTRACT

A plate-like burner grid is adapted for use with a heating system including a housing defining a combustion chamber therewithin, a conduit adapted to supply a combustible fuel-air mixture to a multi-port burner head provided with a large number of perforations through which the mixture may pass to be ignited and burned within the combustion chamber, and an elongated flue pipe adapted to convey the products of combustion from the combustion chamber. The burner grid has a large diameter primary port and a plurality of smaller diameter secondary ports. Dynamic flame fronts produced at the primary and secondary ports generate dissimilar vibrational wave trains which tend to destructively interfere with one another when superimposed in the flue pipe to reduce the possibility of audible sounds being generated by the heating system.

5 Claims, 5 Drawing Figures
VIBRATION CANCELLING BURNER GRID FOR A HEATING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to devices for reducing the possibility of audible sounds being generated by a heating system, and more particularly to a burner grid adapted to modify the normal dynamic flame front produced at a pre-mix multi-port burner head and to cause primary and secondary vibrations to be generated by the flame front, which vibrations tend to destructively interfere with one another when superimposed in a flue pipe.

2. Description of the Prior Art

The problem of audible sounds being generated by a heating system has plagued the heating industry for years. While there are many sources of vibrations in a heating system, the parameters influencing or affecting such vibrations are so numerous as to render quantitative analysis a practical impossibility.

However, it has long been known that a dynamic flame front produced by ignition and burning of a combustible gas passing through a perforated burner head will produce vibrations which in connection with other vibration-producing elements of the heating system may adversely affect the audible level of the vibrations within the system.

SUMMARY OF THE INVENTION

The present invention provides a vibration cancelling burner grid for a heating system having a housing defining a combustion chamber therewithin, a conduit adapted to supply a combustible fuel-air mixture and having at one end thereof a multi-port burner head provided with a plurality of perforations through which said mixture may pass to be ignited and burned within said combustion chamber, and an elongated flue pipe communicating with the combustion chamber to convey products of combustion, normally hot gases, therefrom.

The inventive burner grid is adapted to alter the normal vibrations generated by a dynamic flame front produced by so burning the supplied mixture.

In the presently preferred embodiment, the inventive burner grid is a plate-like member having one surface arranged to cover the burner head, an opposite surface arranged to face into the combustion chamber; this plate-like member being further provided with a primary port communicating these surfaces and through which the mixture may pass to support combustion of a primary flame front generating primary vibrations, and a plurality of secondary ports communicating these surfaces and through which the mixture may pass to support combustion of a corresponding plurality of secondary flame fronts generating secondary vibrations dissimilar to the primary vibrations and adapted to destructively interfere with the primary vibrations when the wave trains of these two vibrations are superimposed upon one another in the flue pipe.

In this preferred embodiment, the diameter of the primary port is from 8 to 40 times the diameter of each of the secondary ports; and the open area of the primary port, when measured in the plane of the opposite surface, is within 20% of the aggregate open area of the secondary ports, when also measured in this plane.

Accordingly, one primary object of the present invention is to provide a vibration cancelling burner grid for a heating system which is adapted to produce dissimilar vibrations that tend to destructively interfere with one another to reduce the possibility of noise generation within the heating system.

Another object is to provide a vibration cancelling burner grid which may be attached to a pre-mix multi-port burner head without adversely affecting its efficiency to an intolerable degree.

Still another object is to provide a relatively simple and inexpensive attachment for a heating system which may significantly reduce the propensity of such system to generate objectionable noise.

These and other objects and advantages will become apparent from the foregoing and ongoing written specification, the drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary longitudinal vertical sectional view of the heating system showing the housing defining the combustion chamber therewithin, the flue pipes, the control device, and the burner assembly; and further showing the inventive burner grid operatively covering the multi-port burner head.

FIG. 2 is an enlarged fragmentary transverse vertical sectional view thereof, taken generally on line 2—2 of FIG. 1, illustrating the lower portion of the burner assembly in front elevation, and further showing the inventive burner grid arranged to cover the multi-port burner head, this view further illustrating some burner head perforations left uncovered by the burner grid primary port.

FIG. 3 is a view generally similar to FIG. 2 but with the burner grid removed to show the downstream surface of the burner head in full front elevation.

FIG. 4 is a greatly enlarged fragmentary longitudinal vertical sectional view thereof, taken generally on line 4—4 of FIG. 2, principally depicting the burner grid and the burner head in longitudinally cross-section and further showing the burner grid secondary ports generally misaligned with the burner head perforations to produce the desired secondary flame fronts.

FIG. 5 is a greatly enlarged perspective detail view of the described embodiment of the burner grid, this view showing the number, size, and spacing of the secondary ports relative to the size and position of the primary port.

DESCRIPTION OF THE PREFERRED EMBODIMENT

At the outset, it should be clearly understood that like reference numerals are intended to identify the same elements and/or structure consistently throughout the several drawing figures, as such elements and/or structure may be further described or explained by the entire written specification of which this detailed description is an integral part.

Referring initially to FIG. 1, the inventive burner grid, generally indicated at 10, is illustrated in the environment of a radiant-type heating system, generally indicated at 11, which broadly includes a housing 12 defining a combustion chamber 13 therewithin, a fuel-air control device 14, a burner assembly 15 having its upper end communicating with an outlet of control device 14 and having its lower end arranged in combustion chamber 13 and provided with a multi-port burner head 16 having a large plurality of small perforations.
through which a combustible fuel-air mixture may pass at a high velocity to be ignited and burned within the combustion chamber, and a leftward horizontally-elongated flue pipe 18 communicating with the combustion chamber and adapted to convey the products of combustion therefrom.

In FIG. 1, the housing 12 is shown as having a horizontally-elongated generally rectangular longitudinal cross-section including a vertical left end wall 19 provided with a central internally-threaded rightwardly-converging frusto-conical opening 20 therethrough, a vertical right end wall 21 provided with a central internally-threaded leftwardly-converging frusto-conical opening 22 therethrough, a horizontal lower wall 23, and a horizontal upper wall 24 which proximate right end wall 21 is shown provided with an upstanding collar portion 25 having an uppermost open end 26. This housing is shown further provided with a lifting ring 28 suitably secured to the upper wall 24 and to collar portion 25.

The heating system is of the radiant type, more fully described and explained in U.S. Pat. Nos. 3,115,302 and 3,394,886, the aggregate disclosures of which are hereby incorporated by reference. To this end, the leftward flue pipe 18, having a nominal inside diameter of about 2 1/2 inches, is shown to have its externally-threaded rightwardly-converging frusto-conical right end portion 29 provided in housing left end opening 20. Moreover, since this type of heating system may contemplate a closed conduit in which heated flue gases are circulated, the heating system 11 is shown as further including a rightward horizontally-elongated flue pipe 30, generally similar to flue pipe 18, having its externally-threaded leftwardly-converging frusto-conical left end portion 31 suitably received in housing right end opening 22. In this manner the combustion chamber may be arranged in the flow path of a closed radiant-type heating system, the arrows in FIG. 1 indicating the direction of such flow.

The control device 14 may be of the general type disclosed in the aforesaid incorporated patents and is shown arranged to receive a supply of gaseous fuel through horizontal standpipe 32 operatively communicating with gas supply pipe 33, and to receive air through an inlet 34 provided with a suitable filter element 35. Functionally, this control device 14 operates to receive gas and air and to mix these components to provide a combustible fuel-air mixture of optimum proportions for burning in combustion chamber 13.

Still referring to FIG. 1, the burner assembly 15 is shown as having a rightwardly-inclined upper portion 36 which at its uppermost vertical right end 38 is suitably connected to a fuel-air outlet of control device 14, an intermediate horizontal mounting flange 39 adapted to bear against the open upper end 26 of housing collar 25 through an intermediate gasket 40, and a lower conduit portion 41 continuing downwardly into combustion chamber 13 and having at its lower end a downstream-facing (leftwardly in FIG. 1) transverse rectangular opening 42 in which the pre-mix burner head 16 is mounted. It will be appreciated that the burner assembly 15 includes an internal mixing duct or main conduit, this being shown by the dashed lines in FIG. 1 and indicated at 43, adapted to deliver the supplied fuel-air mixture from the outlet of the control device 14 downwardly to pass through the burner head perforations and enter combustion chamber 13; and also includes a similar internal pilot duct 44 arranged to deliver a smaller quantity of the fuel-air mixture to the combustion chamber 13 downstream (leftwardly in FIG. 1) of the burner assembly, at which location such pilot fuel-air mix may be ignited by an arc bridging the electrodes of a conventional spark plug 45 suitably threaded into a vertical tapped hole provided through the burner assembly upper portion 36. In the well known manner, this pilot flame is adapted to ignite the main supply of the fuel-air mixture delivered by duct 43 and passing through burner head 16. If desired, the burner assembly may further include a pilot flame sensor probe 46 arranged to sense the presence of the pilot flame, and adapted to cause an arc to bridge the electrodes of spark plug 45 to reignite the pilot flame, should it be extinguished. Finally, the burner assembly is shown as including a transversely-extending vertical haffle plate 48 suitably mounted on the upstream side of the burner assembly lower portion 41 to protect the pilot flame from being extinguished by the flow of gases passing through the heating system, this flow being leftwardly in FIG. 1 as previously noted.

As best shown in FIGS. 3 and 4, the burner head 16 is a transversely-elongated rectangular block of a suitable ceramic material and is shown provided with a large plurality of horizontal cylindrical through-holes or perforations 49 which extend from its upstream face 50 (rightward in FIG. 4) through the block to its opposite downstream face 51 (leftwardly in FIG. 4). In FIG. 4, this burner head 16 is shown mounted in burner assembly opening 42 such that its upstream face 50 is arranged to face into mixing duct 43, and its downstream face 51 is arranged to face into combustion chamber 13. Inasmuch as the fuel-air mixture by duct 43 is highly combustible, persons skilled in this art will recognize that the diameter of perforations 49 is relatively small so that the velocity of the mixture passing therethrough (leftwardly in FIG. 4) will cause the rightwardly propagating dynamic flame front to remain in the combustion chamber at all times. While the particular heating system shown in the drawings includes the specific burner head depicted in FIG. 4, the present invention further contemplates that a cavitated burner head could be used in lieu of burner head 16.

Since it is known that a dynamic flame front will produce vibrational waves, this having been first reported about 1777 by Byron Higgins in his "singing flame experiments", it is presently believed that much of the objectionable noise produced by the heating system results from superimposed reinforcement of these flame front vibrational waves with vibrational waves produced by other oscillation-generating components of the heating system, such as vacuum pumps, fans, and the like.

To reduce accoustical problems associated with the vibrations produced by this dynamic flame front, the present invention provides a vibration cancelling burner grid 10 which is adapted to modify the normal vibrational characteristics produced by this flame front without adversely affecting its heating efficiency to an intolerable degree.

Referring now to FIGS. 3, 4, and 5, a presently preferred embodiment of burner grid 10 is shown as being a transversely-elongated rectangular vertical plate-like member made of 16 gauge stainless steel and having a downstream surface 52 (leftwardly in FIG. 4), an opposite upstream surface 53 (rightwardly in FIG. 4), a centrally-positioned primary port 54 extending through the plate and having a relatively large diameter (D),
and a large plurality of secondary-ports 55 extending through the plate and having a relatively small diameter (d). As best shown in FIG. 5, these secondary ports 55 are shown arranged in a plurality of vertically-spaced horizontal rows, the secondary ports in each of these rows being staggered or offset with respect to the secondary ports of each adjacent row.

Adverting now to FIG. 4, the burner grid 10 is shown mounted on the heating system 11 such that its upstream surface 53 is arranged to cover the downstream face 51 of the burner head 16, and its downstream surface 52 is arranged to face into combustion chamber 13. The burner grid 10 may be retained in this position by a perimetral mounting flange 56 having a vertical flange portion 58 arranged to bear against the grid downstream surface 52, and having a horizontal flange portion 59 suitably secured, as by cementing, between the perimetral surface 60 of the burner head and a rectangular recess surface 61 provided in burner assembly lower portion 41 about opening 42.

Since the number, size and spacing of grid secondary ports 55 are different from the number, size and spacing of the burner head perforations, these secondary ports 55 will generally misalign with the burner head perforations 49 when the grid 10 is arranged as shown in FIG. 4. Hence, it is expected that some of the burner head perforations 49 will be completely blocked or covered by the burner grid, this being represented by the uppermost perforation 49 in FIG. 4, while the majority of the perforations 49 will be partially blocked or obstructed by the burner grid, this being represented by the lower two perforations 49 in FIG. 4. On the other hand, a large number of these perforations 49 beneath primary port 54 will remain uncovered, as shown in FIG. 2.

In this manner, the burner grid 10 functions to obstruct, randomly and without any precise pattern, some of perforations 49 while leaving others unobstructed. Hence, rather than producing a normal dynamic flame front by a flow of the mixture through a plurality of uniform orifices, the burner grid 10 modifies this flame front to produce a primary flame front through the primary port 54 and generating primary vibrations, and a plurality of secondary flame fronts through the secondary ports 55 and generating secondary vibrations which, although generally dissimilar to the primary flame front in amplitude and phase, need not necessarily be identical to one another. In short summary, the burner grid 10 causes the mixture to burn in a primary flame front and in secondary flame fronts, these primary and secondary flame fronts having different vibrational characteristics which tend to cancel one another when later superimposed in the flue pipe.

Inasmuch as the various factors affecting these vibrational characteristics are numerous and uncontrollable practically, it is not felt possible to define explicitly, with precision and accuracy, the relationship of the number and size of the secondary ports to the primary port.

Notwithstanding the foregoing, it is presently preferred to design the burner grid 10 such that the aggregate open surface area of the secondary ports 55, measured in the plane of grid surface 52, will nominally equal the corresponding open surface area of primary port 54, with an acceptable tolerance of about ±20%. It is also preferred to configure the burner grid such that the diameter (D) of the primary port 54 is anywhere from eight to forty times the diameter of the secondary ports 55.

With these design parameters in mind, the required number of secondary ports (n) will be related to the ratio of the square of the primary port diameter (D) to the square of the secondary port diameter (d), or:

\[ n = \left( \frac{D}{d} \right)^2 \]

where: \( n \) = required number of secondary ports;
\( D \) = primary port diameter; and
\( d \) = secondary port diameter.

For the further convenience of those skilled in this art, the following table is provided to illustrate the number of secondary ports required for illustrative values of \( D \) and \( d \):

<table>
<thead>
<tr>
<th>( D/d ) (in.)</th>
<th>( d ) (in.)</th>
<th>( D/d )</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.125</td>
<td>8</td>
<td>64</td>
</tr>
<tr>
<td>1.00</td>
<td>0.100</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>1.00</td>
<td>0.067</td>
<td>15</td>
<td>225</td>
</tr>
<tr>
<td>1.00</td>
<td>0.050</td>
<td>20</td>
<td>400</td>
</tr>
<tr>
<td>1.00</td>
<td>0.033</td>
<td>30</td>
<td>900</td>
</tr>
<tr>
<td>1.00</td>
<td>0.025</td>
<td>40</td>
<td>1600</td>
</tr>
</tbody>
</table>

The particular burner grid depicted in FIG. 5 is shown as having a primary port diameter of 1.00 inches and a secondary port diameter of 0.125 inches, this illustrating the lowest ratio of \( D/d = 8 \) believed desirable.

When viewed in terms of function, the basic concept of the inventive burner grid is to alter the nature of a dynamic flame front produced at a pre-mix burner head to reduce the possibility of vibrational waves produced by this flame front reinforcing one another to produce objectionable noise when superimposed in a flue pipe. To this end, the burner grid is configured to produce a primary dynamic flame front generating primary vibrations, and a plurality of secondary dynamic flame fronts which, while not necessarily identical to one another, are nevertheless sufficiently dissimilar to the primary vibrations, at least in phase relationship, so that when superimposed in the flue pipe, these primary and secondary vibrations will tend to destructively interfere with one another to reduce the possibility of objectionable noise being generated by the heating system.

As used herein, the term "vibration" is intended broadly in its technical sense to include a train of waves propagated outwardly from a seat of disturbance, such as a dynamic flame front, in an elastic medium. Persons skilled in this art will readily appreciate that each such wave will have a frequency and an amplitude, and that two such waves when superimposed may be represented as a single resultant composite wave, the amplitude of which is the vector sum of the amplitudes of the two waves.

In this manner, the inventive burner grid 10 is adapted to alter the normal vibrational characteristics of a normal dynamic flame front produced at a pre-mix multi-port burner head. The burner grid 10 produces a primary flame front generating primary vibrations, and a plurality of secondary flame fronts generating secondary vibrations which are out-of-phase with the primary vibrations so that the secondary vibrations are adapted to cancel partially the primary vibrations when superimposed in the flue pipe, thereby to reduce the possibility of noise produced by the heating system.

While a presently preferred embodiment of the inventive burner grid has been shown and described, it will be apparent to persons skilled in this art that nu-
merous changes and modifications may be made without departing from the spirit of the invention which is defined by the following claims.

What is claimed is:

1. In a heating system including a housing defining a combustion chamber therewithin, a conduit adapted to supply a combustible fuel-air mixture and having at one end thereof a multi-port burner head provided with a plurality of perforations through which said mixture may pass to be ignited and burned within said combustion chamber, and an elongated flue pipe communicating with said combustion chamber to convey products of combustion therefrom, the improvement comprising:

a burner grid adapted to alter the normal vibrations generated by a dynamic flame front produced by such burning of such supplied mixture, said burner grid being a plate-like member having one surface arranged to cover said burner head, an opposite surface arranged to face into said combustion chamber, a primary port communicating said surfaces and through which said mixture may pass to support combustion of a primary flame front generating primary vibrations, and a plurality of secondary ports communicating said surfaces and through which said mixture may pass to support combustion of a corresponding plurality of secondary flame fronts generating secondary vibrations dissimilar to said primary vibrations and adapted to destructively interfere with said primary vibrations when superimposed in said flue pipe.

2. The improvement as set forth in claim 1 wherein each of said secondary ports is of equal diameter.

3. The improvement as set forth in claim 2 wherein the diameter of said primary port is from 8 to 40 times the diameter of said secondary ports.

4. The improvement as set forth in claim 1 wherein the open area of said primary port, measured in the plane of said opposite surface, is within 20% of the aggregate open area of said secondary ports, measured in said plane.

5. The improvement as set forth in claim 1 wherein said burner grid is constructed of stainless steel.