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Budden et al.

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[54] **VIBRATION CANCELLING BURNER GRID FOR A HEATING SYSTEM**

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[52] **U.S. Cl.** **431/114;** 431/328

[51] **Int. Cl.²** **F23D 13/00**

[58] **Field of Search** ..... 431/328, 114, 326, 329, 431/346; 126/91 A; 165/69

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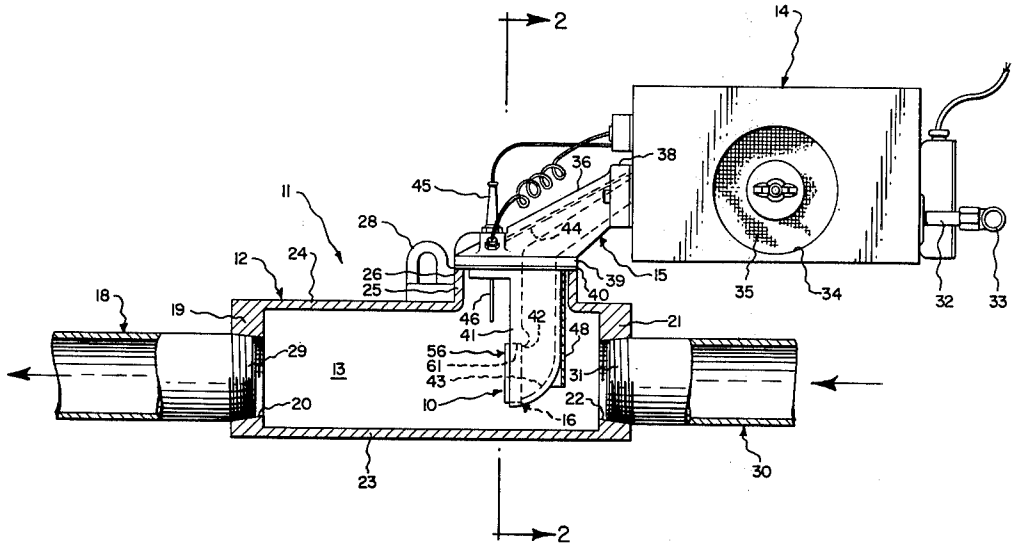
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Attorney, Agent, or Firm—Sommer & Sommer

[57] **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



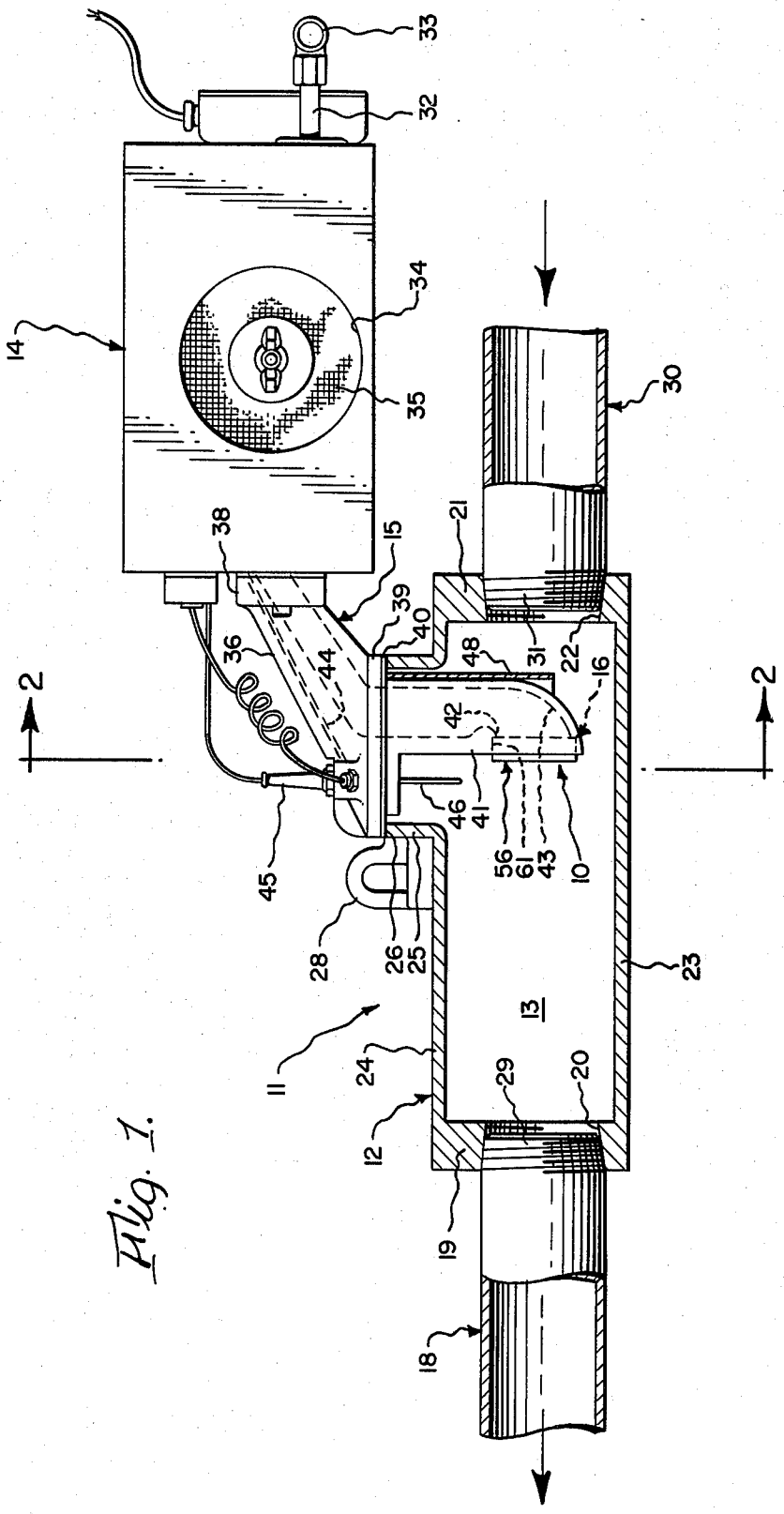

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Fig. 1.

Fig. 3.

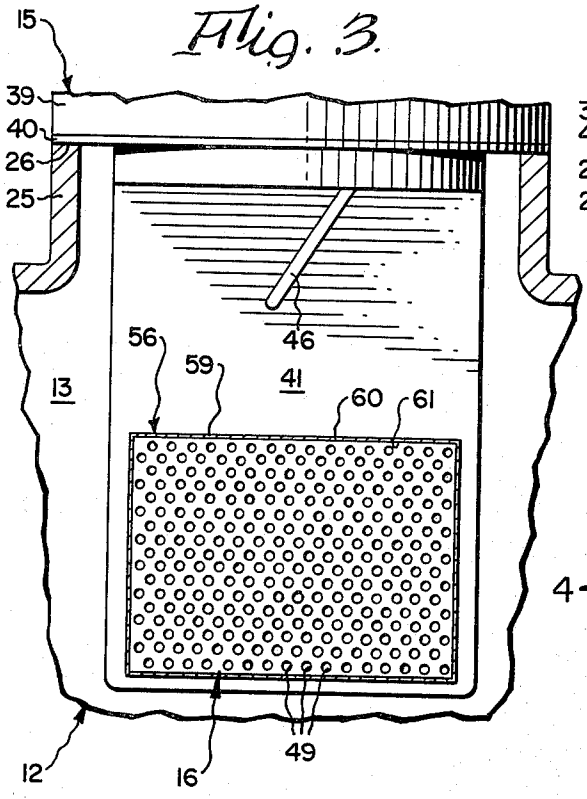


Fig. 2.

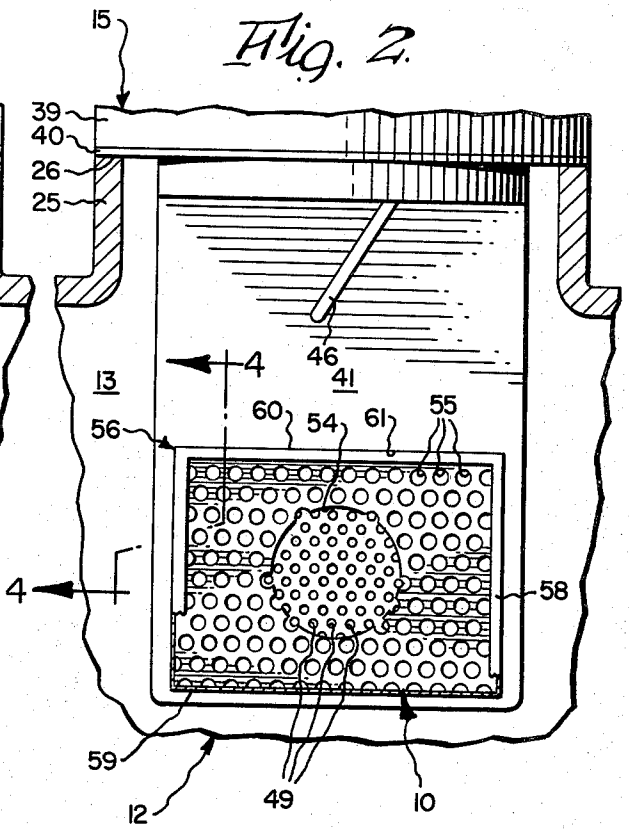


Fig. 5.

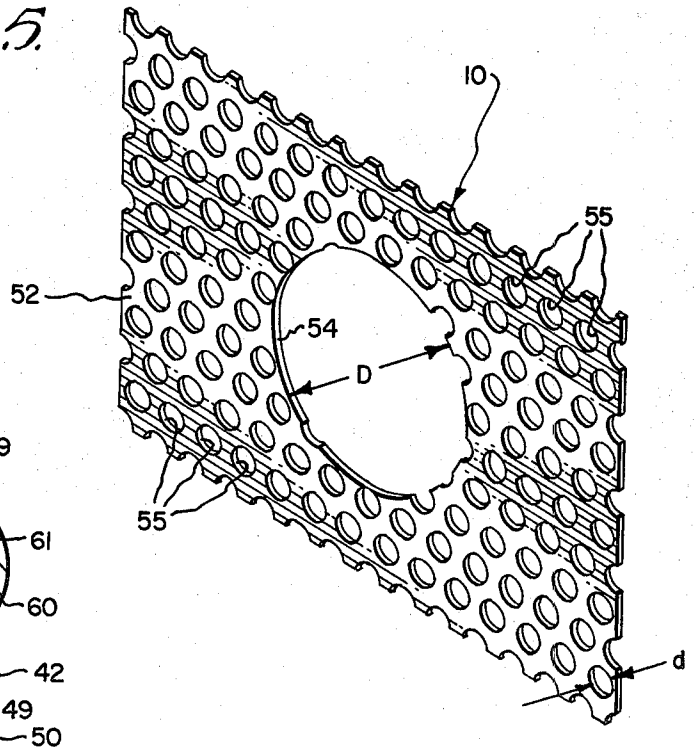
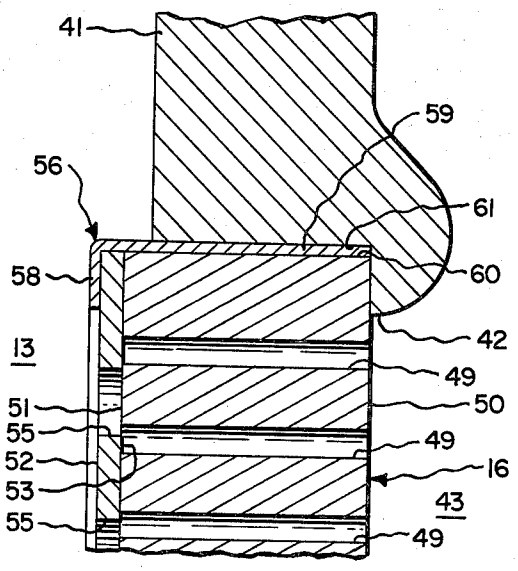


Fig. 4.



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 distructively 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 along 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 ½ inches, is shown to have its externally-threaded rightwardly-converging frusto-conical right end portion **29** received 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** anad 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 baffle 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-ports 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 frame 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:

$$n = (d^2/d^2)$$

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*:

D(in.)	*d*(in.)	*D/d*	*n*
1.00	0.125	8	64
1.00	0.100	10	100
1.00	0.067	15	225
1.00	0.050	20	400
1.00	0.033	30	900
1.00	0.025	40	1600

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 $D/d = 8$ belived 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 adpated 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.

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