

[72] Inventor **Frederick A. Kramer, Jr.**
2040 Conway Road, St. Louis County, Mo.
63131

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Primary Examiner—Carroll B. Dority, Jr.
Attorney—Gravely, Lieder & Woodruff

[54] **BURNER**
15 Claims, 6 Drawing Figs.

[52] U.S. Cl. 263/19 A,
431/352

[51] Int. Cl. F231 9/04

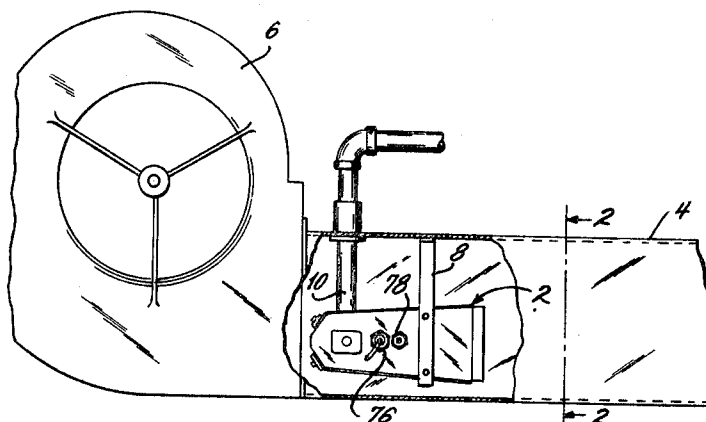
[50] Field of Search..... 431/351,
352; 263/19 A

[56] **References Cited**
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ABSTRACT: A burner having opposed walls defining a combustion chamber is disposed in an airstream with the combustion chamber opening downstream. At the upstream end of the walls, orifices of a gas manifold open into the combustion chamber. The opposed walls are each composed of a plurality of segments which are secured together along side flanges so that the intervening bight portions of the segments form a continuous wall surface. Slots extend across the segments, terminating at the side flanges thereof, and the slots on some of the opposed wall segments are staggered with respect to one another and with respect to the orifices so that air introduced through them forms vortices within the combustion chamber about the orifices. Outer walls form air supply chambers with the back faces in the combustion chamber walls and the air supply chambers are fed with combustion air from the airstream through an inlet opening upstream.



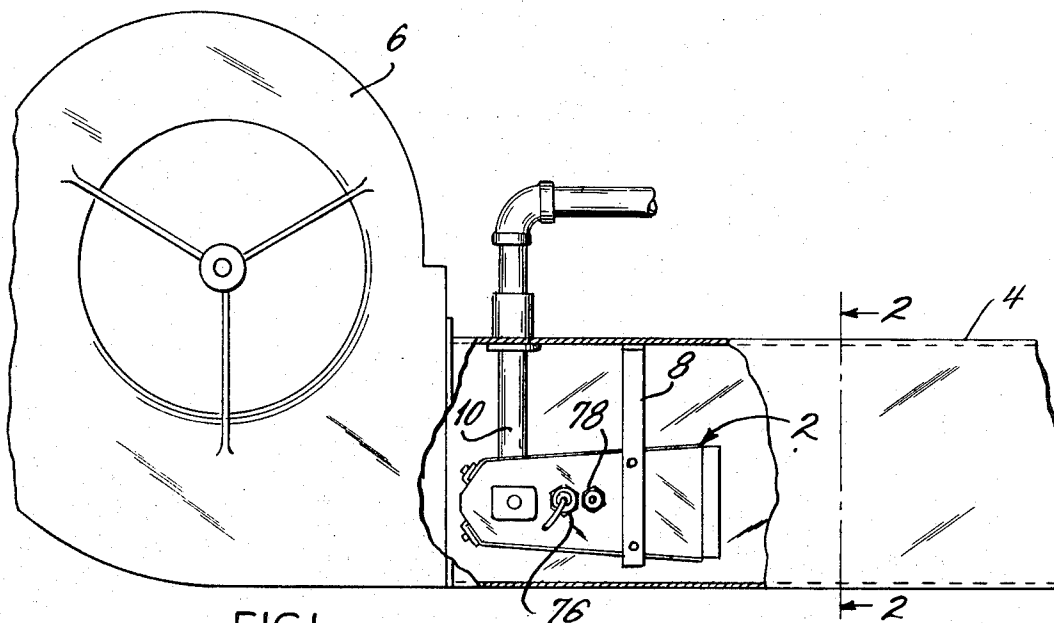


FIG. 1

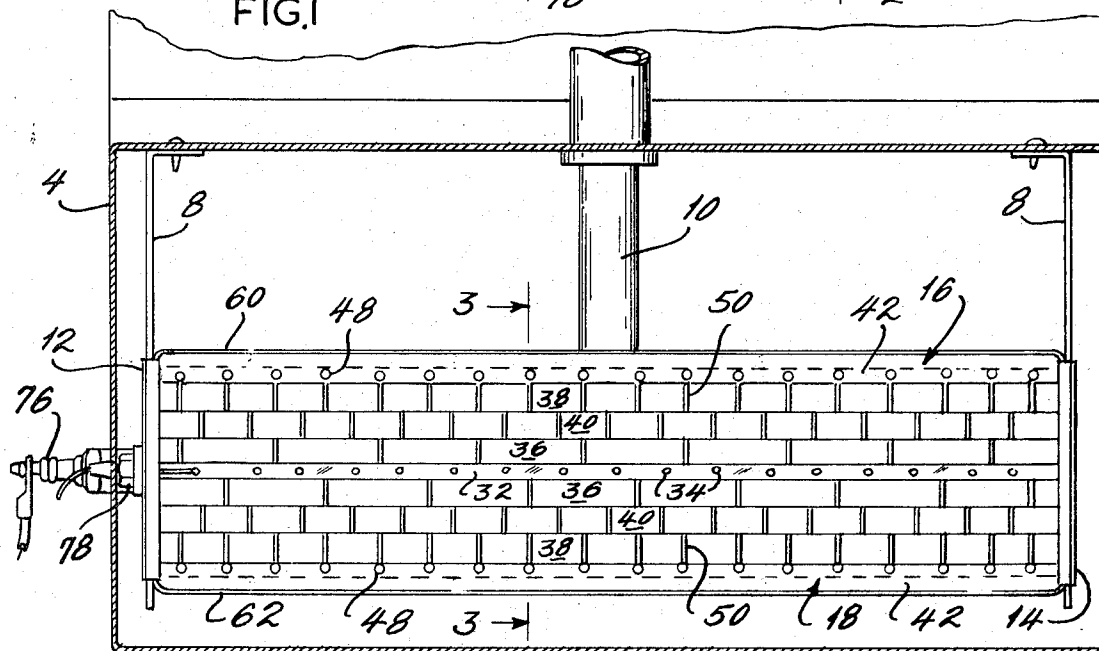


FIG. 2

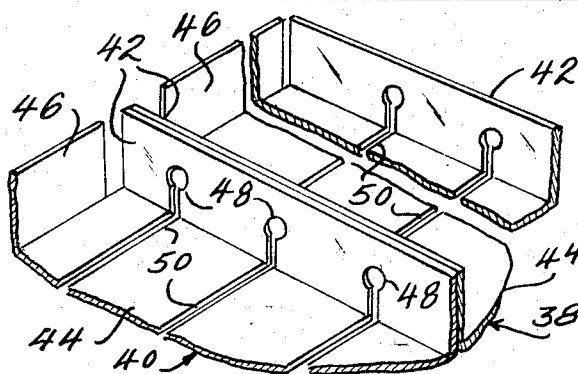
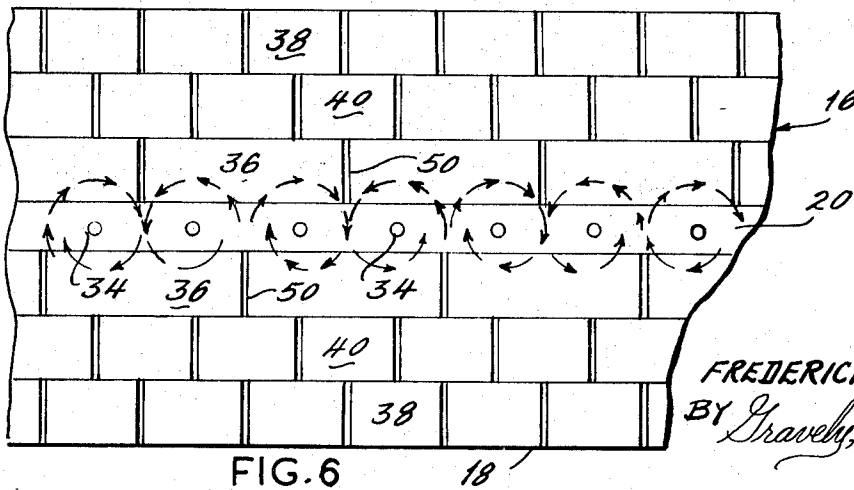
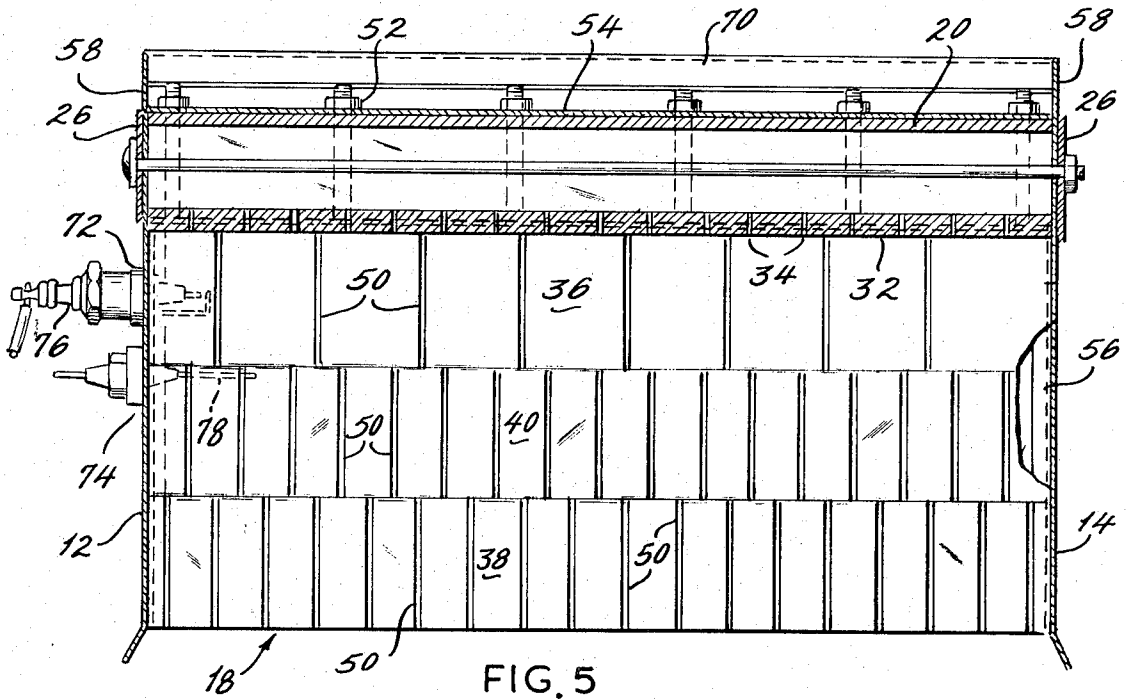
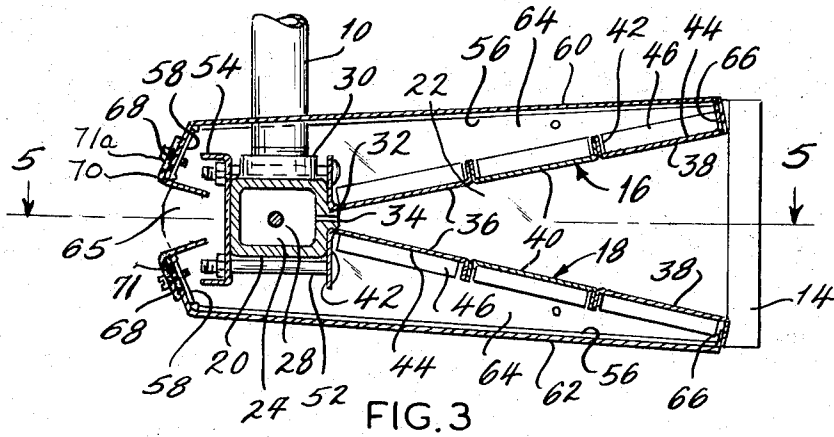


FIG. 4

INVENTOR:
FREDERICK A. KRAMER JR.
BY *Gravelly, Lieder & Woodruff*
ATTORNEYS.



INVENTOR:
FREDERICK A. KRAMER JR.
BY *Gravelly, Lieder & Woodruff*
ATTORNEYS.

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BURNER

BACKGROUND OF THE INVENTION

This invention relates in general to heating devices and more particularly to gas burners for heating moving airstreams.

Perhaps the most efficient method of heating air with natural gas, as well as other combustible gases, is to dispose a flame-producing burner directly in an airstream so that the heat of the flame enters the airstream without passing through some intervening medium. Heating devices of this type are normally disposed in duct work for supplying so-called makeup air for buildings, for heating air used in air curtain constructions, for supplying heated air for building heat, and for heating air introduced into ovens and other drying apparatus. Current burners designed for such applications have not proved entirely satisfactory. In the first place, many are subject to having their flames extinguished when the velocity of the airstream experiences a rapid change. For example, in many burners the flame is projected a considerable distance downstream from the burner envelop where the air in the duct flows at high velocities, for the downstream position is where the air and the gas become mixed sufficiently for combustion. Should the air experience sudden changes in velocity, i.e., turbulence, the chances of the flame burning incompletely are quite high. The same problem exists in turbulent air patterns. Secondly, by reason of the fact that the position of the flame in the burner envelop is dependent on the velocity of the air in the duct and the fuel flow rate, several igniting devices must be employed to ignite the air-gas mixture so that at least one will be in the position at which the gas and air are mixed sufficiently to permit combustion. That position, of course, is dependent on the velocity of the airstream in the duct as previously noted. Similarly, several flame-sensing probes must also be utilized. In addition, since the burners can be operated intermittently, their various components are subjected repeatedly to the effects of thermal expansion. In the case of burners having sidewalls provided with air-conducting orifices, fatigue cracks often develop at the orifices and these cracks eventually weaken and distort the entire burner assembly. Moreover, many burners do not operate adequately over a wide range of gas flows and, therefore, they do not have the capability of providing precise temperature control for the airstream. On the contrary, they either overheat or underheat the airstream.

One of the principal objects of the present invention is to provide a burner for maintaining precise heating control over an airstream. Another object is to provide a burner of the type stated which burns gas completely when subjected to turbulent air patterns or varying high-air velocities. An additional object is to provide a burner of the type which thoroughly mixes the entering combustible gas and the combustion is complete and produces only a minimal amount of carbon monoxide. Still another object is to provide a burner construction which can withstand repeated expansions and contractions due to intermittent operation without failure or distortion. Yet another object is to provide a burner which is simple and rugged in construction and requires only one flame igniter and sensing probe. Still another object is to provide an adjustable air metering arrangement for combustion air to meet varying air velocity conditions. These and other objects and advantages will become apparent hereinafter.

SUMMARY OF THE INVENTION

The present invention is embodied in a burner having apertured walls which define a combustion chamber and closure means sheathing those apertured walls and forming an air supply chamber therewith. The invention also includes segmented combustion chamber walls, the individual segments of which are attached along integrally formed side flanges. The invention also consists in the parts and in the arrangements and combinations of parts hereinafter described and claimed.

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DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which form part of the specification and wherein like numerals and letters refer to like parts wherever they occur:

FIG. 1 is an elevational view, partially broken away and in section, of a fan, duct, and a burner constructed in accordance with the present invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1,

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2,

FIG. 4 is a fragmentary perspective view showing two adjacent wall segments forming part of the present invention,

FIG. 5 is a sectional view taken along line 5—5 of FIG. 3, and

FIG. 6 is an end view of the combustion chamber showing the air swirls induced about the gas orifices of the manifold.

DETAILED DESCRIPTION

Referring now in detail to the drawings, in FIG. 1, the numeral 2 designates a burner which is mounted in a duct 4 adjacent to the discharge of a centrifugal fan 6. The burner 2 may be mounted either on the upstream or downstream side of the fan 6, the latter being more desirable since it does not subject the fan 6 to excessive heating and further permits the fan 6 to handle a greater quantity of air in terms of weight. The burner 2 is suspended from the upper wall of the duct 4 by means of a pair of straps 8, and is further stabilized within the duct 4 by a gas supply pipe 10 which projects through the upper wall of the duct 4.

The burner 2 includes a pair of sidewalls 12 and 14 interconnected by a pair of transversely extending combustion chamber walls 16 and 18 which converge toward a manifold 20 in the formation of a forwardly divergent combustion chamber 22. More specifically, the manifold 20 is preferably an elongated casting interposed between the sidewalls 12 and 14 and having a longitudinally extending channel 24 closed at each end by end plates 26 which are held against the outwardly presented faces of the sidewalls 12 and 14 by means of a stove rod 28 extending through the channel 24. On its upwardly presented face the manifold 20 is provided with a cylindrical boss 30 containing a threaded bore which opens into the channel 24 at its inner end and receives the end of the gas supply pipe 10 at its outer end. On its forwardly presented side the manifold 20 is further provided with a transversely extending ridgelike embossment 32 through which a plurality of gas orifices 34 open into the combustion chamber 22. The orifices 34 are equally spaced in a single line across the embossment 32 and at their rear ends open into the channel 24 so that the orifices 34 establish communication between the channel 24 and the combustion chamber 22.

Each combustion chamber wall 16 or 18 is composed of rear, forward, and intermediate channellike wall segments 36, 38 and 40, respectively, (FIGS. 3, 4, and 5, which extend between the sidewalls 12 and 14 parallel to the manifold 20. Each channellike segment 36, 38, or 40, in turn, has side flanges 42 connected by a flat bight or face portion 44 which is turned outwardly at its ends in the provision of end flanges 46. The side flanges 42 of the wall segments 36, 38 and 40 are provided with equally spaced aligned circular apertures 48 (FIG. 6) which are connected through the bight portions by slots 50 so that the structural continuity of the wall segments 36, 38 and 40 is maintained solely through the outer edges of their side flanges 42. One side flange 42 on each of the inner and outer wall segments 36 and 38 is spot welded to a different side flange 42 on the corresponding intermediate wall segment 40 such that the bight portions 44 and end flanges 46 of all three of the joined wall segments are coplanar. The end flanges 46 are similarly spot welded to the inwardly presented faces of the sidewalls 12 and 14 and, accordingly, maintain the combustion chamber walls 16 and 18 rigid at the proper angle of divergence.

The slots 50 on the adjacent wall segments 38 and 40 are equally spaced (FIGS. 2 and 5), the spacing being equivalent to the spacing between the gas orifices 34, but are staggered with respect to one another. The slots 50 in the intermediate wall segments 40 are further staggered with respect to the slots 50 in the rear segment 36, so that no slot 50 is continuous beyond its particular wall segment. Moreover, the slots 50 on the forward and intermediate wall segments 38 and 40 of the combustion chamber wall 16 are presented directly opposite the corresponding slots 50 in the forward and intermediate wall segments 38 and 40 of the wall 18. The slots 50 in the intermediate wall segment 40, furthermore, align with the orifices 34, making the slots 50 in the forward wall segment 38 offset with respect to those orifices 34. The slots 50 of the rear wall segments 36 of each wall 16 and 18, on the other hand, are spaced apart a distance equal to twice the spacing between the orifices 34 and are staggered with respect to those orifices 34 as well as with respect to themselves. Consequently, each slot 50 in one of the rear wall segments 40 opens into the combustion chamber 22 between adjacent orifices 34 and opposite to a solid bight portion 44 on the opposite wall segment 36. This staggering of the slots 50 in the opposed rear wall segments 36 generates a vortex about each one of the orifices 34 when air is introduced into the combustion chamber 22 through those slots 50 (FIG. 6).

Finally, the rearmost side flanges 42 on the rear wall segments 36 are somewhat wider than the remaining side flanges 42 and abut against the forwardly presented face of the manifold 20 on each side of the ridgelike embossment 32 thereon (FIG. 3), so that the embossment 32 is in effect disposed between the rear ends of the combustion chamber walls 16. Those flanges 42, moreover, extend laterally beyond the side faces of the manifold 20 where they receive stove bolts 52 which pass along the sides of the manifold 20 and through a baffle plate 54 abutting the rearwardly presented face of the manifold 20. By means of this construction, the manifold 20 is held securely against the rearmost side flanges 42 on the combustion chamber walls 16 and 18.

The edges of the sidewalls 12 and 14 are turned inwardly in the formation of mounting flanges 56 and mounting tabs 58 (FIGS. 3 and 5) the former of which are presented outwardly from the clamping plate 54 and manifold 20 as well as from the outer edges of the side flanges 42, excepting the foremost side flange 42 with which the mounting flanges 56 align. The mounting tabs 58, on the other hand, are oblique to the mounting flanges 56 and are located to the rear of the manifold 20. The mounting flanges 56 and tabs 58 are clamped to outer walls 60 and 62 which are presented outwardly from the combustion chamber walls 16 and 18, respectively, in the formation of air supply chambers 64. At their forward ends the outer walls 60 and 62 are provided with inwardly turned front flanges 66 which underlie the foremost side flanges 42 on the combustion chamber walls 16 and 18. At their opposite ends the walls 60 and 62 turn inwardly, forming oblique portions 68 which are connected with tabs 58, and beyond the tabs 58 the oblique portions 68 merge into inwardly extending lips 70 which are located in spaced parallel relation to one another and further terminate prior to the clamping plate 54 at the rear of the manifold 20 in the formation of an inlet 65. The metering air inlet 65 opens upstream into the airstream of the duct 4 and diverts a portion of the air from the airstream into the air supply chambers 64.

The parts 60, 68, and 70 form metering air inlet 65 and the chamber defined by baffle plate 54 and the parts 60, 68 and 70 acts to reduce turbulent intake air to a uniform smooth flow of air for combustion. The lip 70 preferably is formed as a separate part and includes a slot 71 through which a screw 71A fastens the lip 70 to the portions 68. Thus the opening 65 can be adjusted to meter various amounts of combustion airflow into the burner.

The sidewall 12 is further fitted with a pair of threaded sockets 72 and 74, the former of which is located centrally of the ends of the rear wall segments 36, and threaded into that

socket 72 is a spark plug 76 having its spark gap located within the combustion chamber 22. The other threaded socket 74 carries a conventional flame probe 78 which also projects into the combustion chamber 22 beyond the plug 76 for sensing the presence or absence of a flame in the chamber 22.

The gas supply pipe 10 is connected through suitable valving (not shown) to a source of natural gas or some other combustible gas, and that valving has the capability of controlling the amount of gas flowing through the pipe 10 into the manifold 20. The valving also contains a shut-off connected with the flame probe 78 for shutting off the flow of gas should the flame be extinguished. Finally, the spark plug 76 is connected to a suitable electrical source capable of supplying sufficient voltage to cause a spark to jump across the gap of the plug 76. Of course, the shut-off valve should not block the flow of gas to the supply pipe 10 when a high voltage potential is being impressed across the gap of the plug 76 so that a combustible gas-air mixture will be in the chamber when the spark is produced.

OPERATION

To ignite the burner 2, a high-electrical potential is impressed across the gap of the spark plug 76 while at the same time a combustible gas is introduced into the manifold 20 through the supply pipe 10. That gas flows into the channel 24 and is discharged into the combustion chamber 22 through the orifices 34. The combustion air for the combustible gas introduced into the combustion chamber 22 is derived from the airstream flowing in the duct 4. In particular, the air inlet 65, being disposed in the airstream, diverts a portion of the airstream into the air supply chambers 64. Since the air can only escape from the chambers 64 through the relatively small area of the slots 50, stagnation occurs within the chambers 64 with a corresponding increase in pressure. Accordingly, the pressure of the air within the air supply chambers 64 is somewhat greater than the pressure existing in the combustion chamber 22, and by reason of this fact, the combustion air from the chambers 64 discharges into the combustion chamber 22 through the slots 50.

Inasmuch as the slots 50 in the opposed rear wall segments 36 are staggered with respect to one another and are further interposed between the orifices 34, the combustion air entering the combustion chamber 22 immediately forwardly of the manifold 20 creates elongated gentle vortices around the orifices 34 (FIG. 6). More specifically, the combustion air following into the chamber 22 through a particular slot 50 in one of the rear wall segments 36 passes between two orifices 34 and strikes the bight portion of the opposite wall segment 36, and in so doing the air diffuses laterally in both directions and joins the airstreams following into the chamber 22 from the two adjacent slots 50 in that opposite wall segment 36. This effect is repeated at each slot 50 in the rear wall segments 36 and continues along the entire length of the ridgelike embossment 32 on the manifold 20. The combustible gas is directed by the orifices 34 into the centers of these elongated vortices and is immediately drawn into the vortices where the gas is gently and uniformly mixed with the combustion air. More combustion air is introduced into the combustion chamber 22 through the slots 50 in the intermediate and forward wall segments 40 and 38 and this discharge of air creates turbulence in the chamber 22 and insures complete mixing of the combustible gas and the combustion air.

The spark across the gap of the spark plug 76 remains long enough to ignite the mixture of combustible gas and combustion air after which the spark plug 76 is deenergized since the resulting flame in the combustion chamber 22 is self-sustaining. Should the flame, for some reason, become extinguished, the flame probe 78 will sense the absence of a flame and will halt the flow of the combustible gas into the manifold 20.

Since the outwardly facing sides of the combustion chamber walls 16 and 18 are not exposed to the free-flowing airstream

in the duct 4 as is true of some burners of current manufacture, but on the contrary are exposed to the relatively stagnant air in the combustion air supply plenums 64, the combustion air enters the combustion chamber 22 at moderate uniform velocities, even when the velocity of the airstream within the duct 4 remains high. Consequently, the flame within the combustion chamber immediately forward of the manifold 20. The flame burns completely within the combustion chamber 22 so no additional combustion air is needed beyond the end of the combustion chamber when the airstream in the duct reaches high velocities as is true of those burners of current manufacture which have their apertured combustion chamber walls exposed to the free flowing airstream. Since the position of the flame remains substantially fixed within the combustion chamber 22 irrespective of the velocity of the airstream, only one spark plug 76 and flame probe 78 are necessary.

The burner 2 may be operated over a wide range of gas flow rates, and consequently, has a high turn-down capability. When the flow rate of the combustible gas out of the orifices 34 is low, the flame will be relatively small and confined generally to the area of the combustion chamber 22 bounded by the rear wall segments 36. The vortex effect is still maintained since the staggered slots 50 are in the opposed rear wall segments 36 which are located immediately forwardly of the manifold 20. The excess combustion air escapes into the free-flowing airstream through the slots 50 in the intermediate and front wall segments 40 and 38 which are located ahead of the flame in this instance.

When the gas flow rate is increased, the length of the flame increases and the additional combustion air required for the additional gas is supplied through the slots 50 in the intermediate and front wall segments 40 and 38. Even at high-gas flow rates, the rear terminus of the flame remains adjacent to the ridgelike embossment 32 on the manifold 20. In any event, the combustion air is gently and uniformly mixed with the combustible gases so that the ensuing combustion is complete and produces only minimal traces of carbon monoxide.

By reason of the fact that the structural continuity of the extended combustion chamber walls 16 and 18 is maintained through the side flanges 42 of their wall segments 36, 38 and 40, the tight portions 44 of the wall segment 36, 38 and 40, which portions actually form the surfaces bounding the combustion chamber 22, are not subjected to the extreme stresses which would otherwise be produced due to temperature differentials in the wall. Thus, the tight portions 44 are, in effect, isolated from the one another and can be maintained at different temperatures without inducing extreme structural stresses in the walls 16 and 18. Accordingly, fatigue cracks will not emanate from the slots 50, even after extended periods of use and repeated firings and shutdowns. The thermal expansion which does occur is along the side flanges 42 and inasmuch as these flanges 42 are relatively narrow, the chances of a large temperature differential and corresponding stresses across one are indeed remote. The presence of the slots 50 further retards warpage of the walls 16 and 18.

Thus it is seen that the foregoing invention achieves the objects and advantages sought therefor which include the following:

1. A multistage burner with mixing of air and gas allowing combustion and burning at the point where the gas enters the burner within the first stage (the base of the jets) at all gas flow rates and additional combustion air being added to the fire in the later stages for higher fires.
2. A smooth flow of metered combustion air using an adjustable metering device and plenum.
3. The fan being located immediately before the burner resulting in a compact construction while still maintaining good burning characteristics.
4. Complete combustion within the burner so that combustion air from the duct is not required beyond the end of the burner at high fire.
5. The use of slots in all stages for strength and burning characteristics and to eliminate expansion and contraction problems.

6. Adjustment of the flame by varying the amount of gas entering the burner.

7. The provision of a unit in which the fan and burner can be mounted in a cabinet for a horizontal straight through design or with a downturn to form an air curtain construction.

This invention is intended to cover all changes and modifications of the example of the invention herein chosen for purposes of the disclosure which do not constitute departures from the spirit and scope of the invention.

What is claimed is:

1. A burner comprising a pair of opposed walls defining a combustion chamber, each of the opposed walls including an equal number of wall segments with corresponding wall segments of the two walls being of equal size and located directly across the combustion chamber from one another, each of the wall segments having face portions and connecting means located at the sides of the face portions, the connecting means of adjacent wall segments being secured to one another such that the face portions of the connected wall segments form a generally continuous surface which is presented toward the combustion chamber, the wall segments being provided with slots for admitting air to the combustion chamber, the slots extending across the face portions of their respective wall segments and the slots in adjacent wall segments being staggered relative to one another so that a slot is not continued beyond a wall segment in which it is located; and a manifold at one end of the opposed walls and located adjacent to one of the wall segments for each of the walls, the manifold having longitudinally spaced orifices which open into the combustion chamber for introducing a combustible gas into the combustion chamber; the slots of the two wall segments located adjacent to the manifold being staggered relative to each other and relative to the orifices of the manifold so that air entering the combustion chamber through those slots creates vortices about the combustible gas as that gas is introduced into the combustion chamber through the orifices.

2. A burner comprising a manifold connected to a source of combustible gas and having a plurality of orifices through which the combustible gas is discharged from the manifold, the orifices being spaced generally one after another; and a pair of opposed walls extending away from the manifold and partially defining a combustion chamber into which the orifices open so that the combustible gas is introduced into the combustion chamber, each wall comprising a plurality of wall segments arranged side-by-side and each wall segment including a face portion presented toward the combustion chamber and a connecting portion connected to the face portion along at least each side thereof which is adjacent to another wall segment, each connecting portion being presented at an angle with respect to the face portion to which it is connected and projecting away from the face portion, the connecting portions of adjacent wall segments being joined together so that the opposed walls are unitary, the wall segments having apertures in the face portions thereof for admitting air to the combustion chamber, each aperture extending from one side of the wall segment in which it is located to the other side of that wall segment and terminating at a connecting portion, whereby the face portions of the wall segments are not subjected to extreme stresses when a temperature differential exists in the walls.

3. A burner according to claim 2 wherein the connecting portions are formed integral with the face portions and project outwardly away from the combustion chamber.

4. A burner according to claim 3 wherein the face portions for adjacent wall segments are flush.

5. A burner according to claim 3 wherein the wall segments extend in the same general direction as the manifold so that the wall segments for each wall are arranged one after another away from the manifold.

6. A burner according to claim 5 wherein the apertures are slots.

7. A burner according to claim 6 wherein the slots in the face portions of the two wall segments located closest to the manifold are staggered with respect to each other and also

with respect to the orifices of the manifold, whereby the air admitted into the combustion chamber through those slots creates vortices about the combustible gas as that gas is introduced into the combustion chamber through the orifices.

8. A burner according to claim 2 wherein each of the wall segments is provided with a flange formed integral with its face portion along the sides thereof and turned outwardly away from the combustion chamber; wherein the flanges along the juxtaposed sides of adjacent wall segments are joined and constitute the connecting portions; and wherein the apertures are slots which terminate in the flanges.

9. A burner according to claim 6 wherein the connecting portions on the wall segments are outwardly turned flanges extending along the sides of the face portions; and wherein the slots extend at least to the flanges.

10. A burner according to claim 7 wherein the slots in adjacent wall segments are staggered relative to one another so that a slot is not continued beyond the wall segment in which it is located.

11. A burner according to claim 1 wherein the opposing walls diverge away from the manifold and are connected at their sides by sidewalls.

12. A burner according to claim 8 wherein the slots terminate at enlarged cutouts formed in the side flanges of the wall segments.

13. A burner according to claim 2 wherein the burner is disposed within an airstream with its combustion chamber opening downstream; wherein a closure encloses the outwardly presented faces of the opposed sidewalls and form combustion air supply plenums therewith; and wherein the air supply plenum are supplied with air from the airstream through at least one air-metering means which opens upstream in the airstream.

14. In a duct through which a moving stream of air flows; an improved burner for heating the air flowing in the duct; said burner comprising a manifold connected to a source of combustible gas and having orifices through which the combustible gas is discharged from the manifold; opposed combustion chamber walls extending away from the manifold and defining a combustion chamber having one end located downstream from the other end relative to the stream of air flowing in the duct, the opposed combustion chamber walls at the upstream end of the combustion chamber being presented adjacent to the manifold on opposite sides of the manifold orifices so that the orifices open into the combustion chamber, the downstream end of the combustion chamber opening into the duct and facing downstream therein, the combustion chamber walls having apertures therein; outer walls presented outwardly from the combustion chamber walls and forming a clo-

sure therewith which defines a supply plenum, the supply plenum communicating with the combustion chamber through the apertures in the combustion chamber walls; and inlet means associated with the outer walls and defining an opening which faces upstream in the duct and is exposed directly to the airstream therein so that the air flowing in the duct will enter the opening, the opening communicating with the air supply plenum, whereby the air which enters the opening passes into the plenum from which it is discharged into the combustion chamber through the apertures on the combustion chamber walls, the aperture being elongated slots extending in the same general direction that the combustible gas is introduced into the combustion chamber, and at least some of the slots in one wall being staggered with respect to slots in the opposite wall; the orifices being arranged in longitudinally spaced relation along the manifold; the slots which are located in those portions of the opposed combustion chamber walls which are adjacent to the orifices being staggered with respect to the orifices so that elongated vortices are induced about the axes of the orifices.

15. In a duct through which a moving stream of air flows; an improved burner for heating the air flowing in the duct; said burner comprising a manifold connected to a source of combustible gas and having orifices through which the combustible gas is discharged from the manifold; opposed combustion chamber walls extending away from the manifold and defining a combustion chamber having one end located downstream from the other end relative to the stream of air flowing in the duct, the opposed combustion chamber walls at the upstream end of the combustion chamber being presented adjacent to the manifold on opposite sides of the manifold orifices so that the orifices open into the combustion chamber, the downstream end of the combustion chamber opening into the duct and facing downstream therein, the combustion chamber walls having apertures therein; outer walls presented outwardly from the combustion chamber walls and forming a closure therewith which defines a supply plenum, the supply plenum communicating with the combustion chamber through the apertures in the combustion chamber walls; and inlet means associated with the outer walls and defining an opening which faces upstream in the duct and is exposed directly to the airstream therein so that the air flowing in the duct will enter the opening, the opening communicating with the air supply plenum, whereby the air which enters the opening passes into the plenum from which it is discharged into the combustion chamber through the apertures on the combustion chamber walls, wherein the inlet means comprises at least one member which is shiftable relative to the outer walls so that the size of the inlet opening can be varied.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,630,499 Dated December 28, 1971

Inventor(s) Frederick A. Kramer, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 56 "4" should be "5"

Column 5, line 6, "remains" should be inserted before "within"

Column 5, line 47, cancel "the"

Column 8, line 18 add "to each other; and the staggered slots also being staggered with respect"

Signed and sealed this 11th day of July 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents