

July 17, 1962

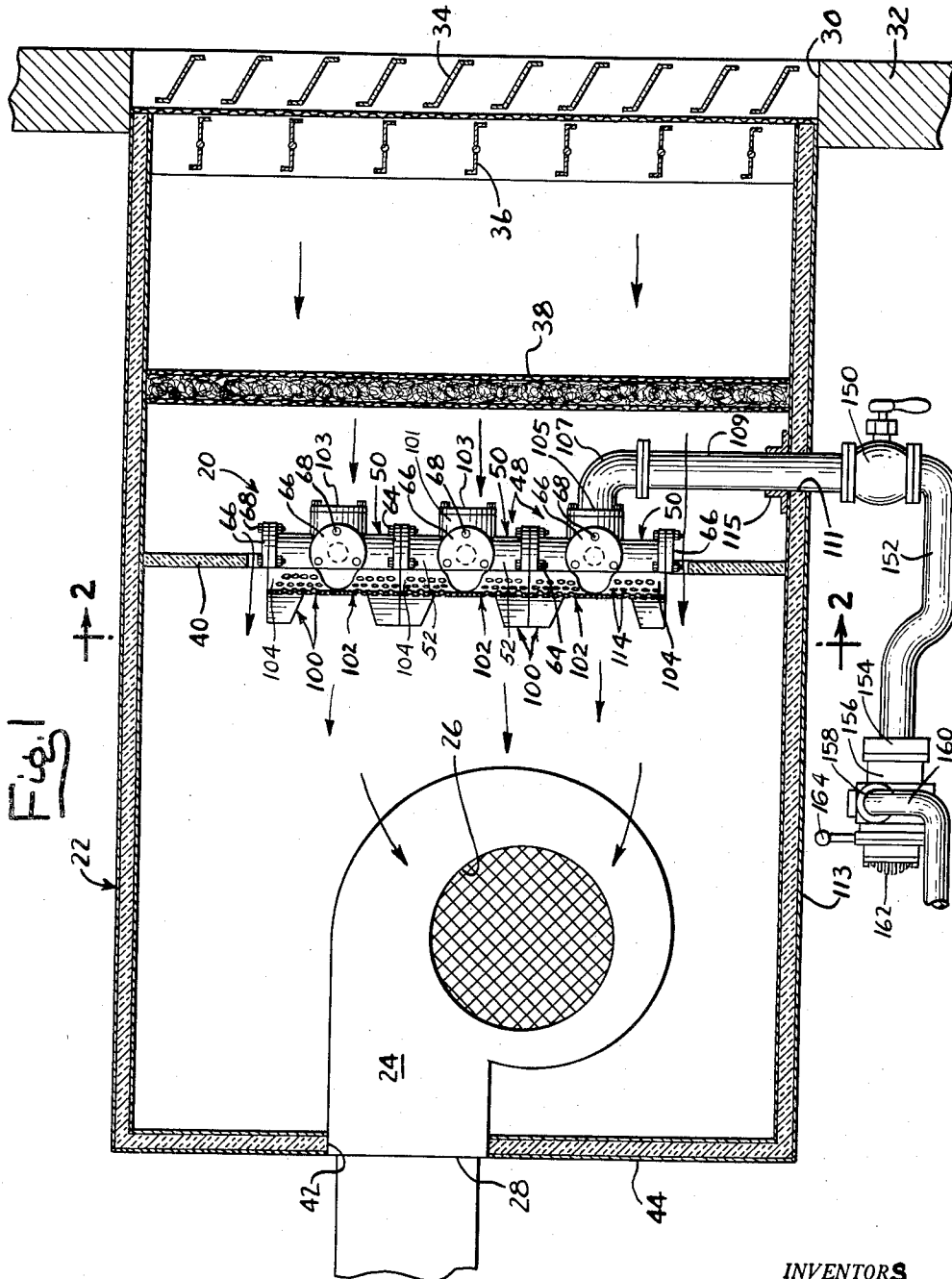
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3,044,754

BURNER CONSTRUCTION

Filed Oct. 18, 1960

6 Sheets-Sheet 1



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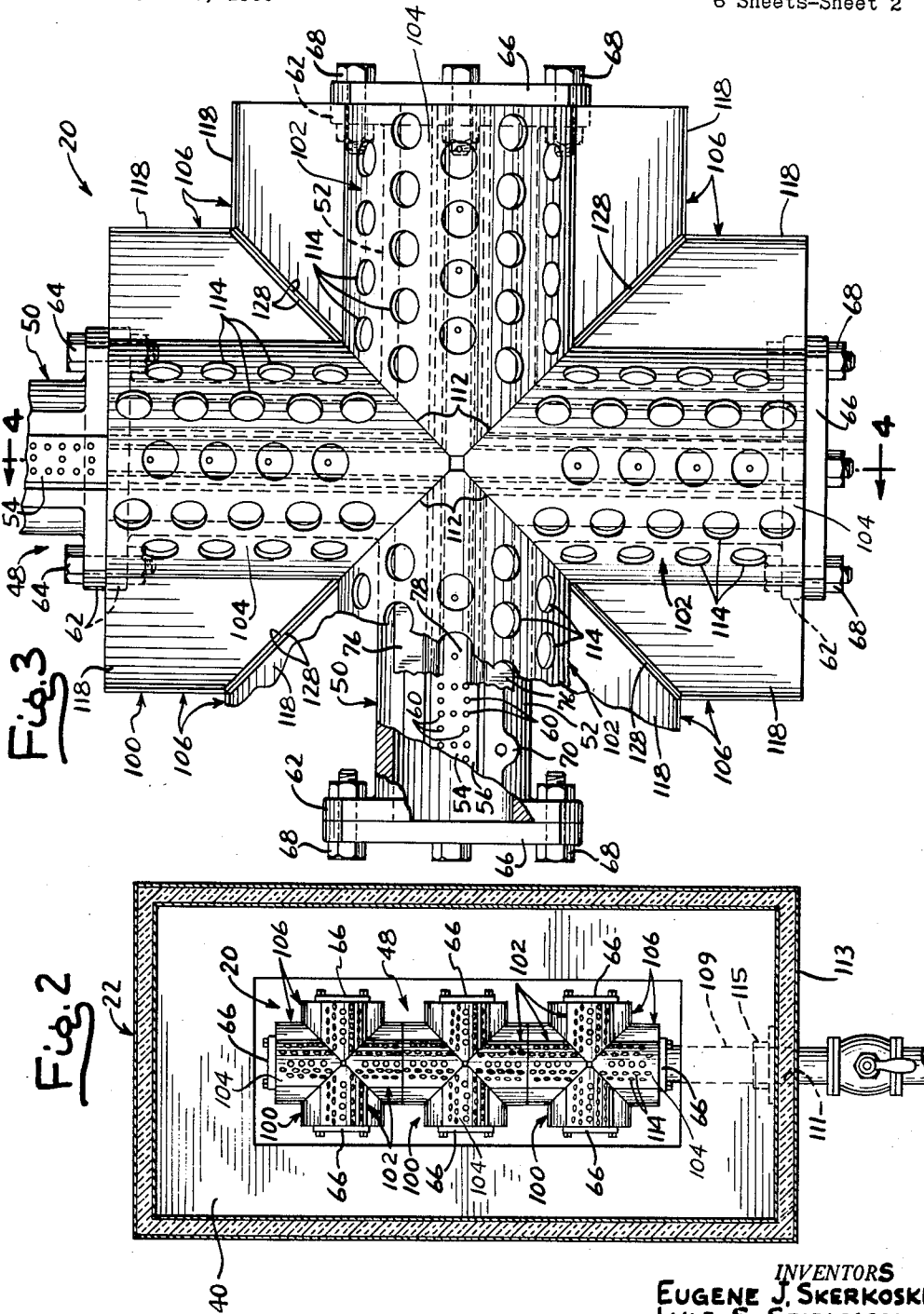
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BURNER CONSTRUCTION

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6 Sheets-Sheet 2



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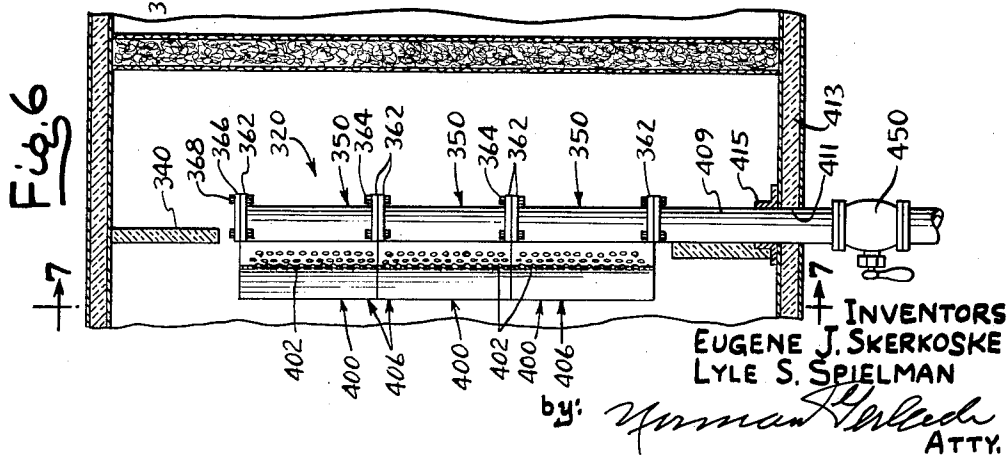
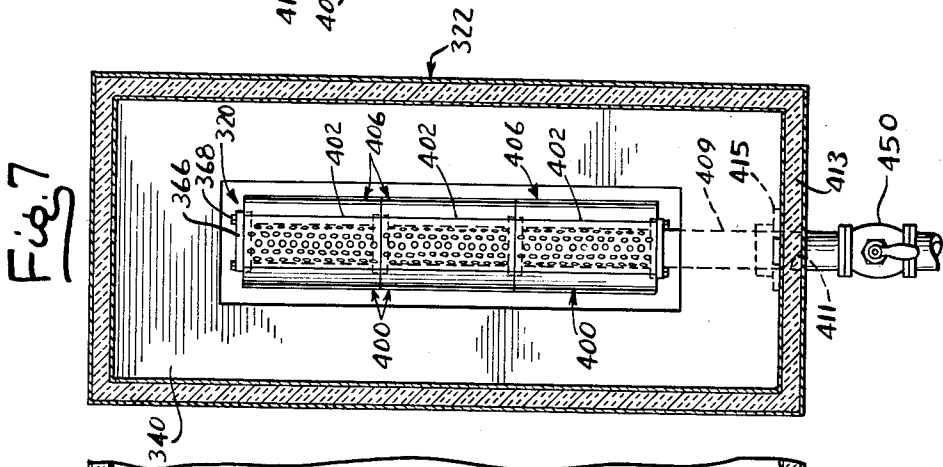
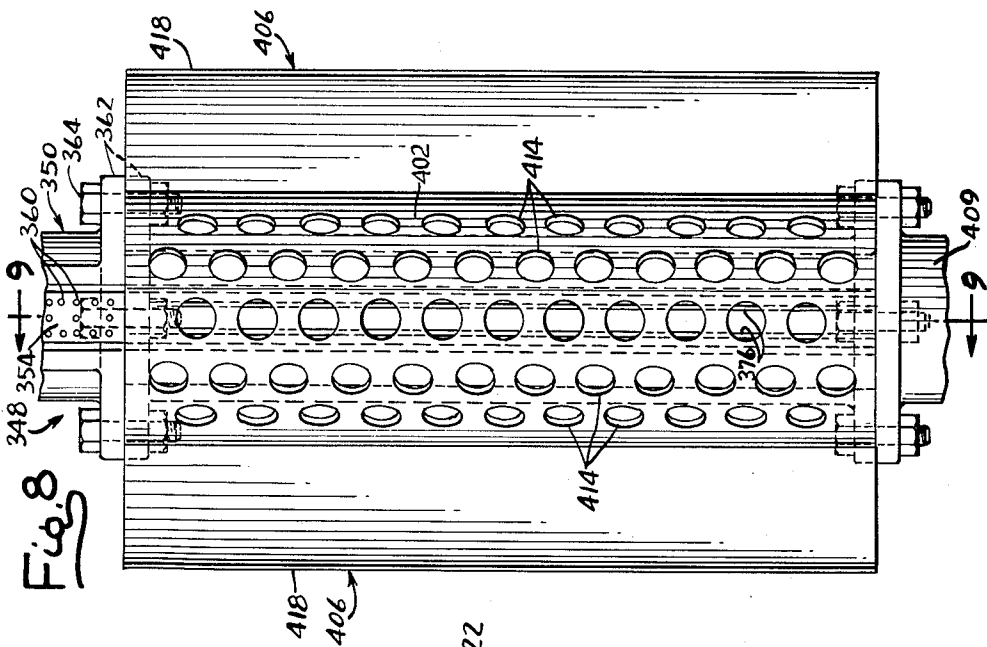
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BURNER CONSTRUCTION

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6 Sheets-Sheet 4



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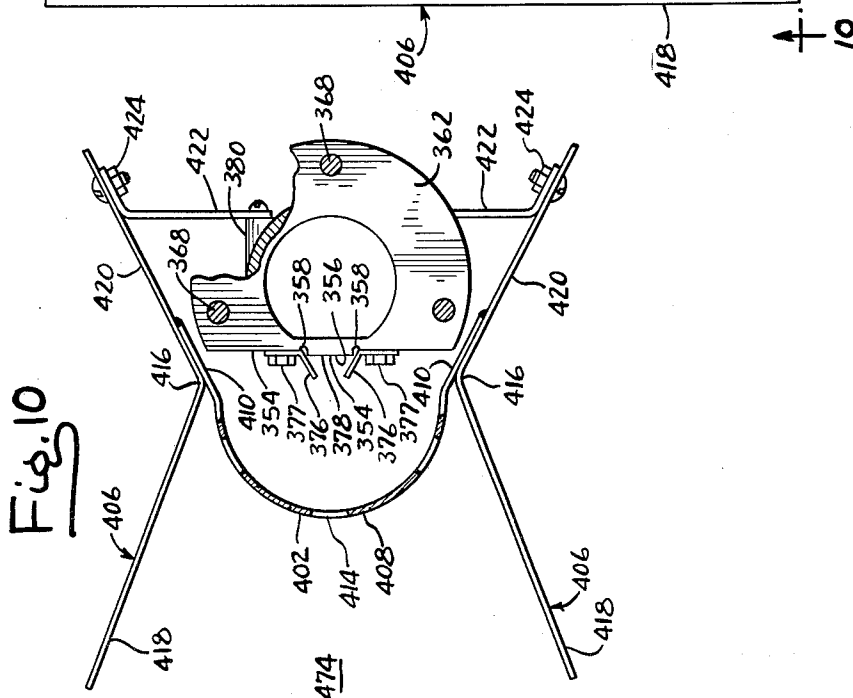
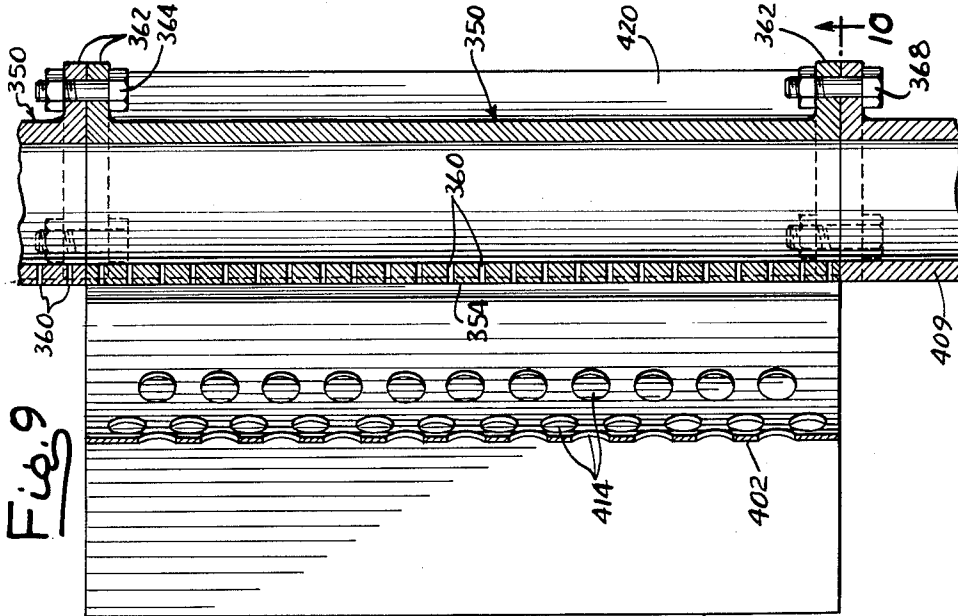
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BURNER CONSTRUCTION

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6 Sheets-Sheet 5



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BURNER CONSTRUCTION

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6 Sheets-Sheet 6

Fig. 11

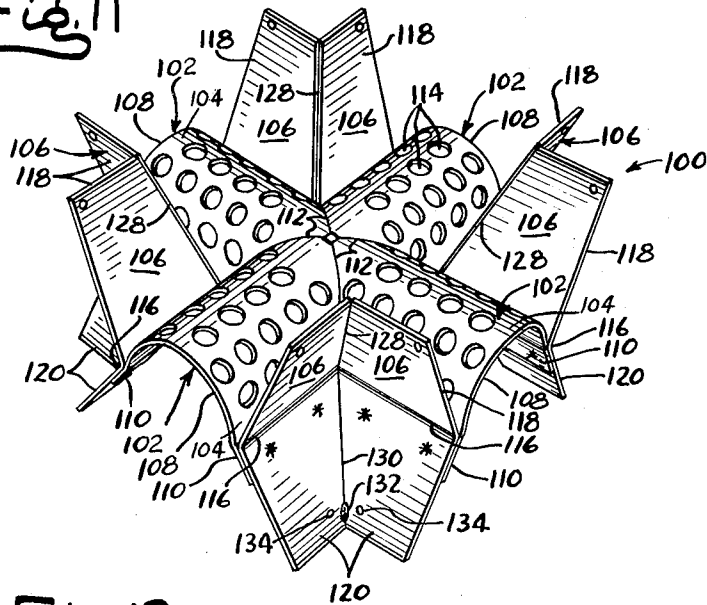
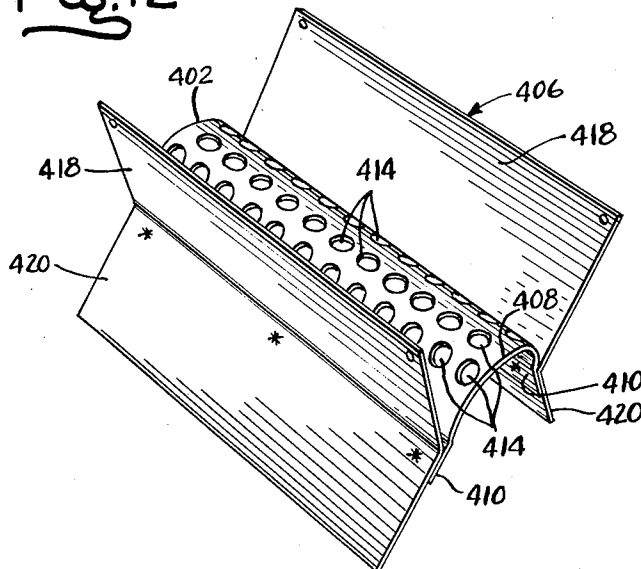


Fig. 12



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3,044,754

BURNER CONSTRUCTION

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9 Claims. (Cl. 263—19)

The present invention relates to burner construction and has particular reference to gas burners of the general type which are positioned bodily in an air stream for the purpose of heating the air which passes the burner, such burners being commonly referred to as air stream burners. Air stream burners of this character are widely employed for preheating make-up air which is supplied to inhabitable enclosures, for space heating in general, and also for supplying heated air to drying ovens of various types. In general, such burners may be found useful in connection with a wide variety of industrial processes requiring heated air for drying or heating purposes.

Present day line burners, when interposed in air streams, are possessed of certain functional limitations, principal among which is their limited capacity range. Since, in burners of this type, the flame must be maintained within the path of a moving stream of air at a relatively high velocity, these burners must necessarily be of the premix type, which is to say that the fuel fed thereto to support combustion must be a gaseous combustible mixture, usually gas and air which have been thoroughly premixed prior to conduction to the burner so that, upon release thereof into the moving air stream, no difficulty will be encountered in igniting them. Conventional air stream burners require for efficient combustion that a gas-air ratio of approximately 80% be maintained insofar as the mixture which is fed to the burner is concerned, and that such a ratio be maintained over the entire range of operation of the burner to maintain stable and complete combustion with a reasonably short flame. Such a mixture, moreover, must be supplied at a sufficiently high pressure that backfiring into the burner is precluded.

Air stream burner applications invariably call for large quantities of fuel to heat the air passing the burner and, with conventional burners, large port areas must be maintained to accommodate high fire conditions. With these large port areas and high air to gas ratios in effect, the flame produced thereby under high fire conditions may be unduly long. The presence of a long flame within the moving air stream on the downstream side of the burner is not conducive to complete combustion in that the tip end of the flame is frequently quenched with the result that not all of the gas is consumed and undesirable aldehydes or carbon monoxide may be formed and released into the air stream.

Stated in another way, conventional burners which are interposed in a stream of air to be heated cannot rely upon the air stream itself for the extra amount of air required to support combustion at high firing rates, since insufficient turbulence is initiated in the vicinity of the burner ports to effect the necessary intimacy of gas and air. Therefore the needed air must be contained in the mixture fed to the burner so that conditions conducive to combustion will obtain immediately upon discharge of the mixture into the air stream. Large port areas are required for proper release of the mixture into the air stream and these large port areas produce a long flame as stated above.

The present invention is designed to overcome the above-noted limitation that is attendant upon the construction and use of conventional air stream burners and, toward this end, there is contemplated the provision of

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a novel burner assembly having associated therewith means for effectively breaking up the steady flow of gaseous constituents issuing from the burner ports in the combustion area of the burner and thus making available in this area the excess air which may be needed for combustion purposes so that no compromise as to port areas or as to gas-air ratios need be made to accommodate both high and low fire conditions.

As will become more readily apparent when the nature of the invention is better understood, air stream burners constructed in accordance with the principles of the present invention are capable of burning gas and air mixtures, the ratio of which may be varied from stoichiometric ratios of, for example, twenty-five or more parts of air to one part of gas when using propane, down to one-to-one ratio of air and gas respectively when using natural gas, without at any time producing an unduly long flame so that complete combustion throughout a wide range of firing conditions will at all times be assured, the above exemplary condition being based upon interpositioning of the burner in an air stream having a velocity of approximately two thousand feet per minute or more.

According to the present invention, because it is not necessary to supply all of the air required for combustion as a constituent of the primary mixture fed to the burner (some of the air in the air stream being used for this purpose instead), the burner ports which for any given size can accommodate only a given volume of the mixture, are available for increased gas flow if the mixture is enriched, and therefore a much greater quantity of gas can be burned at high firing rates than has heretofore been possible.

The provision of an air stream burner assembly of the character and possessing the advantages briefly described above being among the principal objects of the present invention, it is an additional object to provide such a burner assembly having associated therewith a novel form of burner shroud including deflecting plates for directing a portion of the air stream into the combustion zone, baffle plates for breaking up the deflected portions of the air stream and securing turbulence and intermixing in the combustion zone, and flame delineating members which serve to contain the flame, so to speak, or confine it in a region of high turbulence until at least such time as sufficient intermixing of all of the gaseous constituents leaving the immediate vicinity of the burner have been sufficiently intermixed to insure complete combustion at a region not too far removed downstream from the burner.

A still further object of the invention, in an air stream burner of this general character, is to provide a sectional arrangement of burner units and shroud units capable of being readily assembled upon one another in various patterns to selectively produce burner assembly designs which will accommodate a wide variety of sizes and shapes of duct-work within which the burner is to be assembled.

With these and other objects in view, which will become more readily apparent as the following description ensues, the invention consists in the novel construction, combination and arrangement of parts shown in the accompanying six sheets of drawings forming a part of this specification.

In these drawings:

FIG. 1 is a side elevational view of a composite sectional burner assembly constructed in accordance with the principles of the present invention and showing the same operatively installed in an air stream, the conduit for the air stream being shown in vertical section;

FIG. 2 is a sectional view taken substantially along the

line 2—2 of FIG. 1 in the direction indicated by the arrows;

FIG. 3 is an enlarged front elevational view of one of the burner sections shown in FIGS. 1 and 2;

FIG. 4 is a sectional view taken substantially along the line 4—4 of FIG. 3;

FIG. 5 is a sectional view taken substantially along the line 5—5 of FIG. 4;

FIG. 6 is a fragmentary sectional view similar to FIG. 1 showing a modified form of composite sectional burner assembly constructed according to the present invention;

FIG. 7 is a sectional view taken substantially along the line 7—7 of FIG. 6;

FIG. 8 is an enlarged elevational view similar to FIG. 3, showing one of the burner sections of FIGS. 6 and 7;

FIG. 9 is a sectional view taken substantially along the line 9—9 of FIG. 8;

FIG. 10 is a sectional view taken substantially along the line 10—10 of FIG. 9;

FIG. 11 is a perspective view of a burner shroud assembly employed in connection with the form of the invention shown in FIG. 1; and

FIG. 12 is a perspective view, similar to FIG. 11, showing a burner shroud assembly employed in connection with the form of the invention shown in FIG. 6.

Referring now to the drawings in detail and in particular to FIGS. 1 and 2, one form of air stream burner assembly constructed according to the principles of the present invention has been designated in its entirety at 20 and it is shown as being operatively installed in a moving air stream (indicated by the arrows in FIG. 1). The air stream is confined in a conduit 22 and is initiated by means of a suction type blower 24 having an inlet opening 26 and a discharge opening 28.

The blower 24 is of conventional design and the conduit 22 illustrated herein is purely exemplary since various other types of conduits presenting a wide variety of cross sectional shapes may be employed for burner-mounting purposes. The conduit 22 selected for illustration herein is rectangular in cross section and it is shown as being operatively mounted in a wall opening 30 provided in a wall structure 32. A suitable grille 34 extends across the opening 30 and adjustable baffles 36 are provided at the inlet end of the conduit. Other adjuncts associated with the conduit 22 are a filter screen 38 which extends transversely across the conduit upstream with respect to the burner assembly 20, and an overlying air-restricting baffle 40 in the general transverse plane of the burner construction. The blower 24 has its discharge opening 28 in register with an opening 42 in the end wall 44 of the conduit and this blower serves to draw air through the conduit and in and around the burner assembly 20 in a manner and for a purpose that will be made clear presently.

Still referring to FIGS. 1 and 2, and additionally to FIGS. 3, 4 and 5, the burner assembly 20 is comprised of a burner proper 48 which, in the illustrated form of the invention shown in these views, is made up of a plurality of individual burner sections or units 50 suitably bolted together to provide the composite burner proper. Each burner section 50 is in the form of a hollow casting of generally X-shaped external configuration (see particularly FIG. 3) and having a series of four radially diverging lateral legs 52 which communicate internally with one another at the central regions of the casting. The various legs 52 are generally cylindrical in transverse cross section except for the provision of a flat forward burner face 54 having a central raised portion or rib 56 (see also FIG. 5) extending therealong. The arcuate extent of each generally cylindrical leg 52 is appreciably in excess of 180°. Shallow narrow troughs 58 are formed on each side of the rib 56 where it joins the otherwise planar front burner face 54. The raised rib 56 is formed with a multiplicity of small spaced burner ports 60 which may assume any desired pattern, the ports herein being ar-

ranged in three parallel straight rows as best seen in FIG. 3 and which extend radially outwardly from the center of the generally X-shaped burner 48.

Each tubular leg 52 has formed thereon at its outer end a bolting flange 62 by means of which a plurality of the sections 50 may be operatively bolted together to construct a burner assembly of any desired configuration, three such sections being secured together in straight line fashion as shown in FIGS. 1 and 2 herein for exemplary purposes, suitable fastening bolt assemblies 64 being employed for the purpose as best seen in the upper regions of FIG. 3. The outer ends of such legs 52 as are not employed for fluid communication purposes are closed by means of end closure plates 66 which are fastened in position over the otherwise open end of the legs by bolt assemblies 68. The wall of each leg 52 is formed with thickened portions 70 having threaded sockets 72 formed therein for reception of fastening screws 77 (FIG. 5) by means of which a pair of flame guiding or orifice strips 76 may be secured in position on the front face of the burner so as to extend lengthwise of each leg 52 on opposite sides of the rib 56. The strips 76 are in the form of obtuse angle pieces and, when in position on the front face 54 of the burner, these strips define therebetween an elongated flame control orifice 78.

On the rear side of each burner section 50 there are formed a pair of thickened bosses 80 having threaded sockets formed therein for reception therein of fastening screws by means of which a burner shroud assembly, which has been designated in its entirety at 100 may be positioned relative to the burner assembly 20 in a manner and for a purpose that will be made clear presently.

Referring now to FIGS. 1, 4 and 5, in addition to the lateral legs 52, each burner unit 50 is formed with a rearwardly extending tubular leg 101 which is centrally disposed relative to the legs 52 or, in other words, extends axially of the unit. The leg 101 is of slightly larger diameter than the diameters of the legs 52 and it constitutes an inlet leg for the gaseous fuel mixture. As seen in FIG. 1, the outer ends of the legs 101 associated with the two upper burner units 50 are closed by closure plates 103 while the leg 101 associated with the lowermost unit 50 is provided with an inlet fitting 105 which communicates with an elbow 107 which, in turn, communicates with a vertical fuel inlet pipe 109. The inlet pipe 109 extends through an opening 111 in the floor 113 of the conduit 22 and is secured therein by a flanged anchoring ring 115.

Referring now particularly to FIGS. 2 to 5 inclusive, the burner shroud assembly 100 is in the form of a composite sheet metal structure consisting of various shroud sections which are capable of being secured together in any suitable manner, as for example by welding, to accommodate a given pattern of burner sections 52, such as the three-unit assembly 20 illustrated herein.

Specifically, the burner shroud assembly 100 involves in its general organization a sheet metal sub-assembly 102 for each burner unit 50. The three sub-assemblies 102 shown in FIG. 1 are identical in construction and therefore a description of one of them will suffice for the others.

Each shroud sub-assembly 102 is comprised of eight principal parts, namely four perforated arcuate trough-like flame holder plates 104 and eight side plates 106. As best seen in FIGS. 3 and 5, each flame holder plate 104 is formed from a flat sheet metal plate which has been bent so as to present an arcuate section 108 with two planar side wings 110 extending outwardly in diverging fashion from the free side edges of the section 108. Each flame holder plate 104 is positioned a short distance in front of one of the radial legs 52 of its respective burner unit 50 with its concave side facing rearwardly toward the burner and with the side wings 110 straddling the leg 52 as shown in FIG. 5. The inner end of each flame holder plate 104 is tapered substantially to a point and

the inner ends of the four flame holder plates are nested together in interfitting relationship as clearly shown in FIG. 3 and in edge-to-edge relationship along arcuate meeting edges 112. The various flame holder plates 104 are provided with relatively large circular openings 114 in the arcuate sections 108 thereof but these openings are omitted in the central region of the T-shaped structure, this latter region being imperforate.

Each side wing 110 of each flame holder plate 104 has secured thereto as a spot welding operation indicated at 115 one of the side plates 106. These side plates 106 are in the form of flat sheet metal blanks which have been bent as at 116 to provide a forward flame-containing wing 118 and a rear air-collecting wing 120, the two wings diverging from each other at a comparatively wide obtuse angle as best seen in FIGS. 4 and 5.

The wings 120 of the various side plates 106 are fastened by means of straps 122 to respective bosses 80 on the adjacent burner section 50, each strap being secured to a wing 120 by nut and bolt assemblies 124 to one of the bosses 80 by means of fastening screws 126, and these wing structures, considered collectively, constitute an air-collecting wing structure for channeling air into the region in front of the burner face 54. As best seen in FIGS. 3 and 11, the eight side plates 106 are disposed in pairs and the flame-containing wings 118 of each pair meet in edge-to-edge fashion along straight edges 128 with the wings extending substantially at right angles to each other. Similarly, the air-collecting wings 120 meet in edge-to-edge fashion along straight edges 130 with these latter wings also extending substantially at right angles to each other. The lower regions of adjacent air collecting wings 120 are welded together as indicated at 132. As seen in FIG. 11, the lower regions of the various air-collecting wings 120 may be provided with prepunched holes 134 for reception therethrough of the fastening assemblies 124 by means of which the straps 122 are secured to the side plates 106. In the assembled relation of the burner proper 48 and the shroud 100, the air-collecting wings 120 straddle the burner proper and extend a short distance rearwardly thereof as best seen in FIG. 5.

Referring again to FIG. 1, in the embodiment of the invention selected for illustration herein, the burner assembly 20 constitutes the sole supporting means for the shroud assembly 100 and the fastening straps 122 constitute the sole attachment means between the shroud and burner assemblies. It is to be distinctly understood however that, if desired, reinforcing or bracing straps, struts and the like may extend between the shroud and the walls of the conduit 22 or the floor thereof.

Still referring to FIG. 1, the fuel inlet conduit 109 communicates with a control valve 150 which in turn communicates with a fuel line 152. The fuel line 152 may be operatively connected to the discharge side 154 of a suitable fuel proportioning device 156 having a gas inlet side 158 leading from a gas supply pipe 160 and having an air inlet side 162. The fuel proportioning device 156 forms no part of the present invention and various types of such devices are available for use in connection with the present burner system. One such device which is suitable for use in connection with the burner assembly 20 has been shown and described in United States Patent No. 2,840,153, dated June 24, 1958, and issued to Donald A. Campbell et al., for "Fuel Proportioning Apparatus." The device 156 is operable under the control of a manipulating handle 164 to vary the ratio of gas and air delivered at the discharge side 154 and fed to the fuel line 152. If desired, the control valve 150 and proportioning device 156 may be operatively connected together by suitable mechanism (not shown) for operation in unison.

In the operation of the above described air stream burner assembly 20 the air passing through the conduit 22 in the direction indicated by the arrows in FIG. 1 flows around the burner proper 48 which is interposed in

the air stream. Some of this air by-passes the entire burner assembly 20 while a portion of it is directed through the burner shroud assembly 100. Regardless of the ratio of the gas and air mixture fed to the burner 48 from the inlet pipe 109, or of the volume of mixture being fed under the control of the valve 150, the rearwardly directed wings 120 of the shroud assembly 100 serve to channel or funnel a portion of the air stream forwardly and inwardly toward the various flame holder plates 104 and into the general area directly in front of the elongated orifice 78 afforded by the orifice strips 76. Because of the fact that the arcuate extent of each generally cylindrical leg 52 is in excess of 180° as best seen in FIGS. 4 and 5, the flow of air around the burner proper follows the general law of aerodynamics so that a partial vacuum is established in front of the burner and the divided air stream which sweeps around the burner converges inwardly at the front of the burner toward the small burner ports 54, picking up the flame jets therefrom and carrying the same forwardly toward the flame holder plate or plates 104.

Under conditions of low fire where a relatively low gas to air ratio is maintained by the proportioning device 156, and where the flow of the gas-air mixture to the burner is materially restricted by the control valve 150, the flame issuing from the small burner ports 50 will remain confined within the chamber-like initial combustion space or chamber designated at 170 in FIGS. 4 and 5. Under extremely low fire conditions, the flame will be confined principally to the elongated orifice region 78 existing in front of the rib 54 and between the two orifice plates 76, the flame exhibiting itself merely as a small dull flame jet in the vicinity of each port 50. As the fire is increased by simultaneously enriching the fuel mixture with additional gas, and by increasing the flow of the mixture through the control valve 150, the flame will spread forwardly into the chamber 170 and gradually fill the same. Under these low fire conditions, the flame is not appreciably affected by the air stream and practically all of the air required for combustion is supplied in the mixture.

Under high fire conditions where a considerably richer mixture is fed from the proportioning device 156 and in considerable volume from the control valve 150, the flame will extend into the area designated at 174 in FIG. 5. The relatively rich mixture will pick up sufficient air from the air stream to complete combustion, the wings 120 serving to channel the air into the chamber 170 and create a certain amount of turbulence in this region. Combustion will be initiated in the chamber 170 and it will be completed in the secondary combustion region 174 where the forwardly extending flame-containing wings 118 provide a wing structure which serves the dual purpose of containing the flame and shielding the same from the slip stream of air so that quenching is effectively prevented. The relatively large holes or openings 114 provided in the various flame holder plates 104 allow the channeled air and such portion of the fuel mixture as is not consumed in the space 170 to pass forwardly into the space 174, together with any products of combustion arising from ignition of gas and air in the space 170. The velocity of these gaseous materials however appreciably restricted so that the flame holder plate serves directly to reduce the velocity flow of gases between the generally tubular structure afforded by the eight side plates 106 while the latter plates themselves shield these gases from direct entrainment in the air slip stream by-passing the burner assembly in the outer regions of the conduit 22. In this manner the creation of an unduly long flame is prevented during high fire conditions and there is little danger of flame tip quenching as previously outlined.

Referring now to FIGS. 6 to 10 inclusive and in particular to FIGS. 6 and 7, a modified form of air stream burner assembly 320 has been illustrated in these views. This burner 320 is shown as being operatively disposed in

a moving air stream as indicated by the arrows in FIG. 6. The air stream is confined in a conduit 322 and it may be initiated by means of a suitable blower (not shown) similar to the blower 24 and similarly positioned relative to the conduit. Only a fragment of the conduit 322 has been shown in FIG. 6 but it will be understood that this conduit may be similar to the conduit 22 and it may be provided with similar adjuncts, only the filter screen 338 being illustrated herein.

Since the disclosure of FIGS. 6 to 10 inclusive is similar to the disclosure of the preceding views, to avoid needless repetition of description similar characters of reference have been applied to the parts in these latter views which have corresponding parts in the former views.

Whereas the burner proper 48 of FIG. 1 is of X-shape configuration, the burner proper 348 of FIG. 6 is of straight line configuration, which is to say that it presents a straight linear axis with no lateral legs. The burner proper is comprised of three elongated tubular burner sections 350 having a cross sectional shape substantially identical with the cross sectional shape of the various legs 52 of the X-shaped burner sections 50. The front face 354 is the same as the front face portions associated with sections 50 and includes the raised rib 356, troughs 358, burner ports 360, and orifice strips 376. The adjacent ends of the three burner sections are communicatively connected together by bolting flanges 362 and bolt assemblies 364. The upper end of the uppermost section is closed by a closure plate 366 having fastening screws 374. The lower end of the lower burner section 250 is provided with an inlet fitting 405 in communication with an inlet pipe 409 connected to a control valve 450 and fuel proportioning device 456 in a manner similar to the inlet pipe 109.

The rear sides of the various burner units 350 are formed with strap-anchoring bosses 380 similar to the bosses 80 and straps 422 serve to connect the burner shroud assembly 400 to the lower regions of the air-collecting wings 420 of the side plates 406. Since the burner units 250 have no lateral legs, only two side plates 406 are required to maintain a single flame holder plate 404 in position in front of the burner face 354 in its proper spaced relationship with respect thereto.

It is to be noted that in connection with the burner proper 348 that the burner is fed from the bottom end thereof and not through the medial region of any one of the three sections 350 as is the case in connection with the various X-shaped sections 50. Burner assemblies constructed according to the principles of the invention as exemplified in FIGS. 6 to 9 inclusive are designed for use primarily in narrow air streams such as may be confined in the conduit 322 of FIG. 7.

It is believed that the description of the operation of the burner assembly 20 of FIGS. 1 to 5 inclusive as previously rendered herein will suffice for the operation of the burner assembly 320 since the shroud assembly 100 is similarly positioned with respect to the burner face 354.

While two forms of the invention involving X-shaped burner sections and shrouds therefor and straight line sections and shrouds respectively have been illustrated herein, it will be understood that the principles of the invention are applicable to other burner section shapes. Among the shapes contemplated are T-shape sections and L-shaped sections. The various sections may be built up or assembled to accommodate the cross sectional shape of the air stream in which they are to be interposed.

The invention is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in the specification as various changes in the details of construction may be resorted to without departing from the spirit of the invention. Only insofar as the invention has particularly been pointed out in the accompanying claims is the same to be limited.

Having thus described the invention what we claim as new and desired to secure by Letters Patent is:

1. Combustion apparatus comprising, in combination, a burner assembly adapted to be positioned bodily within a high velocity air stream and to apply heat to the air issuing from the upstream side of the burner assembly for discharge of the heated air downstream, said burner assembly comprising a burner proper and a burner shroud, the burner proper being in the form of a tubular casting having a forward burner face directed downstream and provided with a multiplicity of spaced relatively small burner ports therein in communication with the interior of the casting for producing a corresponding number of forwardly directed flame jets, said burner shroud comprising a sheet metal structure including a flame holder plate positioned forwardly of the burner face and spaced therefrom, said flame holder plate and burner face defining therebetween an initial combustion space, said flame holder plate being formed with a series of relatively large spaced apart holes therethrough, and an air-collecting wing structure extending rearwardly from the marginal regions of the flame holder plate and presenting converging air-deflecting surfaces which are adapted to extend at an incline to the longitudinal axis of the air stream and which straddle the burner face on opposite sides thereof and are adapted for channeling a portion of the air of said air stream into said initial combustion space, and a flame-containing wing structure extending forwardly from the marginal regions of the flame holder plate and presenting diverging flame-confining surfaces which, in combination with the plate, establish a secondary combustion space, means for supplying a mixture of gas and air to the interior of the burner casting for discharge through the burner ports into said initial combustion space, and means for regulating the quantity of such mixture supplied to the burner casting whereby when a relatively small quantity of the mixture is fed to the burner casting under low fire conditions combustion will be confined mainly to said initial combustion space and whereby when a relatively large quantity of fuel is fed to the burner casting under high fire conditions, combustion will take place additionally in the region of the air stream forwardly of the flame holder plate and within said secondary combustion space.

2. Combustion apparatus comprising, in combination, a burner assembly adapted to be positioned bodily within a high velocity air stream and to apply heat to the air issuing from the upstream side of the burner assembly for discharge of the heated air downstream, said burner assembly comprising a burner proper and a burner shroud, the burner proper being in the form of a hollow casting including tubular legs which diverge radially outwardly from one another in spider-like fashion and which communicate internally at their inner ends, each of said legs having a forward burner face adapted to be directed downstream and provided with at least one straight longitudinally extending row of relatively small burner ports therein in communication with the interior of the leg, said burner shroud being in the form of a sheet metal structure including an elongated curved trough-like flame holder plate for each leg, positioned in front of the leg and spaced therefrom with its concave side facing rearwardly toward the leg, each flame holder plate being provided with a series of relatively large spaced apart holes therethrough and distributed substantially equally throughout the entire area of the plate, said flame holder plates and the burner faces of the legs which they respectively oppose defining therebetween an initial combustion space, and means for supplying a mixture of gas and air to the interior of the burner casting for discharge through the burner ports into said initial combustion space.

3. Combustion apparatus as set forth in claim 2 and including, additionally, means for regulating the quantity of the gas-air mixture supplied to the burner casting whereby, when a relatively small quantity of the mix-

ture is fed under low fire conditions combustion will be confined mainly to said initial combustion space, and whereby when a relatively large quantity of the mixture is fed under high fire conditions combustion will take place additionally in the region of the air stream forwardly of the flame holder plates.

4. Combustion apparatus comprising, in combination, a burner assembly adapted to be positioned bodily within a high velocity air stream and to apply heat to the air issuing from the upstream side of the burner assembly for discharge of the heated air downstream, said burner assembly comprising a burner proper and a burner shroud, the burner proper being in the form of a hollow casting including tubular legs which diverge radially outwardly from one another in spider-like fashion and which communicate internally at their inner ends, each of said legs having a forward burner face adapted to be directed downstream and provided with at least one straight longitudinally extending row of relatively small burner ports therein in communication with the interior of the leg, said burner shroud being in the form of a sheet metal structure including an elongated curved trough-like flame holder plate for each leg, positioned in front of the leg and spaced therefrom with its concave side facing rearwardly toward the leg, each flame holder plate being provided with a series of relatively large spaced apart holes therethrough and distributed substantially equally throughout the entire area of the plate, said flame holder plates and the burner faces of the legs which they respectively oppose defining therebetween an initial combustion space, a pair of diverging air-collecting wings extending rearwardly from the marginal edges respectively of each flame holder plate adapted to channel a portion of the air of said air stream into said initial combustion space, and means for supplying a mixture of gas and air to the interior of the burner casting for discharge through the burner ports into said initial combustion space.

5. Combustion apparatus as set forth in claim 4 and including, additionally, means for regulating the quantity of the gas-air mixture supplied to the burner casting whereby, when a relatively small quantity of the mixture is fed under low fire conditions combustion will be confined mainly to said initial combustion space, and whereby when a relatively large quantity of the mixture is fed under high fire conditions combustion will take place additionally in the region of the air stream forwardly of the flame holder plates.

6. Combustion apparatus comprising, in combination, a burner assembly adapted to be positioned bodily within a high velocity air stream and to apply heat to the air issuing from the upstream side of the burner assembly for discharge of the heated air downstream, said burner assembly comprising a burner proper and a burner shroud, the burner proper being in the form of a hollow casting including tubular legs which diverge radially outwardly from one another in spider-like fashion and which communicate internally at their inner ends, each of said legs having a forward burner face adapted to be directed downstream and provided with at least one straight longitudinally extending row of relatively small burner ports therein in communication with the interior of the leg, said burner shroud being in the form of a sheet metal structure including an elongated curved trough-like flame holder plate for each leg, positioned in front of the leg and spaced therefrom with its concave side facing rearwardly toward the leg, each flame holder plate being provided with a series of relatively large spaced apart holes therethrough and distributed substantially equally throughout the entire area of the plate, said flame holder plates and the burner faces of the legs which they respectively oppose defining therebetween an initial combustion space, a pair of diverging air-collecting wings extending rearwardly from the marginal edges respectively of each

flame holder plate adapted to channel a portion of the air of said air stream into said initial combustion space, a pair of diverging flame-containing wings extending forwardly from the marginal edges of each flame holder plate respectively and defining therebetween a secondary combustion space forwardly of the flame holder plate, and means for supplying a mixture of gas and air to the interior of the burner casting for discharge through the burner ports into said initial combustion space.

7. Combustion apparatus as set forth in claim 6 and including, additionally, means for regulating the quantity of the gas-air mixture supplied to the burner casting whereby, when a relatively small quantity of the mixture is fed under low fire conditions, combustion will be confined mainly to said initial combustion space, and whereby when a relatively large quantity of the mixture is fed under high fire conditions combustion will take place additionally in the region of the air stream forwardly of the flame holder plates.

8. Combustion apparatus comprising, in combination, a burner assembly adapted to be positioned bodily within a high velocity air stream and to apply heat to the air issuing from the upstream side of the burner assembly for discharge of the heated air downstream, said burner assembly comprising a burner proper and a burner shroud, the burner proper being in the form of a hollow casting of X-shape design in overall configuration and four tubular legs which diverge radially outwardly from one another in spider-like fashion at right angles to one another and which communicate internally at their inner ends, each of said legs having a forward burner face adapted to be directed downstream and provided with at least one straight longitudinally extending row of relatively small burner ports therein in communication with the interior of the leg, said burner shroud being in the form of a sheet metal structure including an elongated curved trough-like flame holder plate for each leg, positioned in front of the leg and spaced therefrom with its concave side facing rearwardly toward the leg, each flame holder plate being provided with a series of relatively large spaced apart holes therethrough and distributed substantially equally throughout the entire area of the plate, said flame holder plates and the burner faces of the legs which they respectively oppose defining therebetween an initial combustion space, a pair of diverging air-collecting wings extending rearwardly from the marginal edges respectively of each flame holder plate adapted to channel a portion of the air of said air stream into said initial combustion space, a pair of diverging flame-containing wings extending forwardly from the marginal edges of each flame holder plate respectively and defining therebetween a secondary combustion space forwardly of the flame holder plate, and means for supplying a mixture of gas and air to the interior of the burner casting for discharge through the burner ports into said initial combustion space.

9. Combustion apparatus as set forth in claim 1 and wherein the tubular casting of the burner proper is generally semi-cylindrical and appreciably in excess of 180° in arcuate extent, the forward burner face of said casting is substantially flat, and the flame holder plate is curved and presents its concave side rearwardly toward the flat burner face.

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