

May 14, 1968

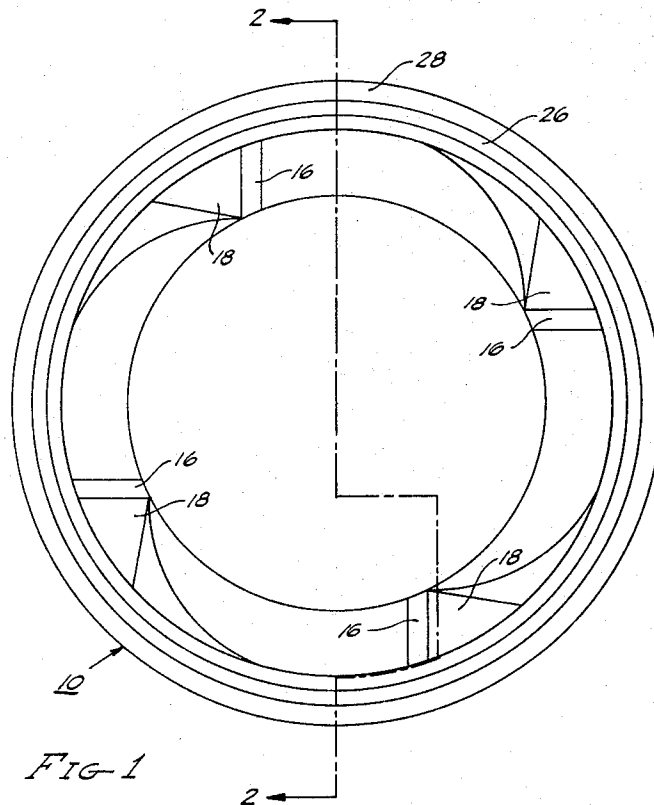
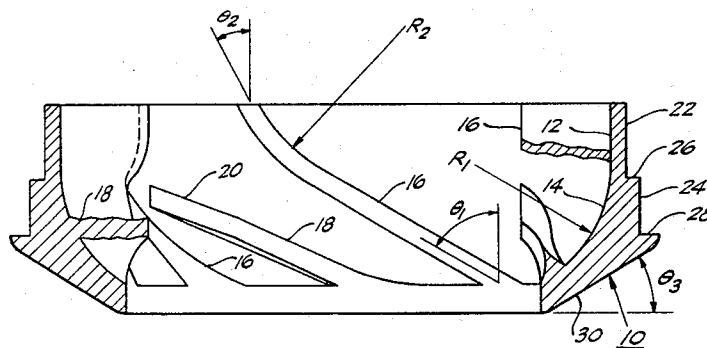
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3,383,052

BURNER END CONE HAVING TWO DIFFERENT TYPES OF VANES

Filed June 28, 1966

2 Sheets-Sheet 1



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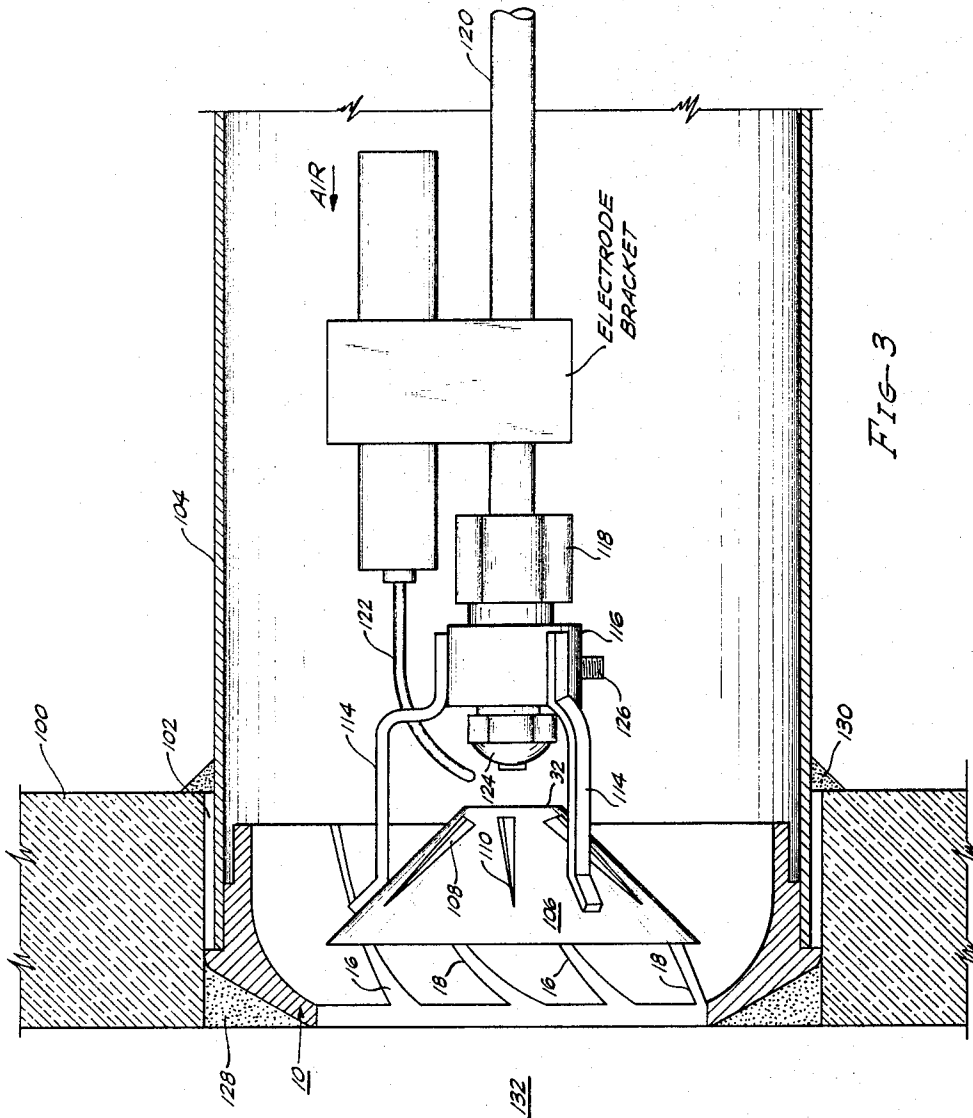


FIG-3

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1

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BURNER END CONE HAVING TWO DIFFERENT TYPES OF VANES

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Filed June 28, 1966, Ser. No. 561,218

15 Claims. (Cl. 239—490)

This invention relates to an improved burner for combusting hydrocarbon fuels, and more particularly, to an improved burner end cone which affords reduced restriction to air flow and higher maximum firing rates without loss of combustion performance.

It is well known to those skilled in the combustion art that the mechanical features of burners used in the combustion of hydrocarbon fuels are important factors in attaining smoke-free combustion at minimum excess air, the measure of a burner's ability to effect smoke-free combustion at minimum excess air being designated the "combustion performance." Accordingly, various burner designs have been proposed for the combustion of these fuels. Although it has been possible to modify burner head assemblies to achieve high combustion performance, it has not always been possible to construct a highly efficient apparatus which is mechanically simple in design, relatively low cost, and able to perform at a reasonably low noise level. One burner assembly realizing these important criteria is proposed in our copending application Ser. No. 388,250, filed Aug. 7, 1964, now matured into U.S. Patent No. 3,361,365. This burner comprises a hollow conical air shield disposed within a convergent end cone having angularly pitched vanes on its interior surface to impart rotational motion to fluids passing therethrough. Combustion air passes into the combustion zone through both the annular area between the air shield and the end cone and through the hollow air shield. Atomized fuel is ejected into the air stream passing through the air shield. An additional portion of air passes from the annular area into the interior of the air shield through a plurality of triangular shaped slots in the air shield. Fluid guide means on the exterior surface of the air shield adjacent these slots impart rotational motion to the air passing into the interior of the air shield through the slots similar to that imparted to the air passing through the vaned annulus.

While the foregoing burner assembly, and other conventional burners of the choke type, wherein a substantial portion of the combustion air passes through an annular area between an end cone and an air shield, are highly effective combustion devices; they are generally limited in firing rate because of reduced combustion air capacity. Further, although the vanes and other flow directing devices placed in the air passages to produce turbulence and impart rotary motion to the combustants are conducive of high combustion performance, they constitute additional restrictions to the flow of combustion air into the combustion zone. Thus, for an equal size air tube, these high performance burners have substantially reduced firing capacity because of the limited combustion air capacity. In new construction, this capacity restriction can usually be overcome at some additional expense by the use of larger combustion air blowers, or by increasing the number of burners installed. However, these changes have become extremely costly where annular flow burners are installed in existing furnaces. Modification of the end cone vane and air shield construction to afford higher air capacity has heretofore usually resulted in an undesirable reduction in combustion performance.

Accordingly, it is an object of the present invention to provide an improved burner having high combustion per-

2

formance and reduced air flow restriction. Another object is to provide an end cone of improved design for use with an annular air flow burner. Still another object is to provide a burner end cone having a high air capacity which imparts rotative motion to fluids passing there-through. These and other objects of the present invention will become apparent to those skilled in the art from the following detailed description and by reference to the accompanying drawings, of which:

FIGURE 1 is an end view of the burner end cone of the present invention as seen from the fluid inlet end.

FIGURE 2 is a side view of the burner end cone in cross-section taken along the line 2—2 of FIGURE 1.

FIGURE 3 is an elevation view partially in cross-section showing an annular flow burner assembly mounted in a horizontal position and employing the end cone of this invention.

Briefly described, the present invention contemplates an improved burner end cone for installation at the discharge end of a burner air tube. The end cone comprises a short annular body member having a central fluid passage extending its length communicating with an open fluid inlet at one end and a fluid outlet of reduced size at the opposite end. The interior surface of the end cone which defines the central fluid passage is preferably shaped to provide a smooth transition from the inlet opening to the smaller diameter outlet opening and is provided with a plurality of curvilinear vanes or ribs protruding inwardly therefrom. These vanes are spaced about the inside periphery of the annular body and are oriented at an angle from the axis of the body. The pitch of the vanes is reduced near the inlet end of the cone so as to offer less restriction to fluid flow in this critical area. Alternate vanes extend the length of the member from the inlet opening to the outlet opening. Disposed between each of these vanes and generally at the same angle from the axis of the body are shorter vanes extending from a point intermediate the length of the body to the outlet opening. These curvilinear vanes protruding from the interior surface of the annular body impart rotational motion to the fluids passing through the end cone and discharging therefrom without excessively restricting the flow of these fluids. The end cone can be conveniently adapted to fit various standard size burner tubes.

Referring to FIGURES 1 and 2 in greater detail, the end cone comprises annular body 10 of unitary structure which is generally symmetrical about a central axis and which is adapted for mounting at the outlet end of a burner air tube in a manner to be subsequently more fully described. Annular body 10 is of relatively short length and has open ends to accommodate the passage of fluids through the center flow area. Fluids are received into the end cone through one open end of the annular structure, pass the length of the body, and are discharged at the opposite outlet end. The outlet opening of the end cone is of smaller size than the inlet opening so as to afford a nozzle-like fluid passage. Although the size of the center flow passage can be varied as necessary to accommodate increased burner capacity, the various end cone dimensions are preferably maintained within relative proportions to achieve optimum performance. Thus, although the fluid inlet opening can be of any appropriate size, it is preferred that the cross-sectional area of the fluid outlet opening be maintained between about 50 and 65 percent of the area of the inlet opening. For example, in a conventional domestic unit the end cone inlet can be a circular opening having a diameter of 3½ inches which is equivalent to a cross-sectional area of 10.32 square inches. Accordingly, the area of the outlet opening for an inlet of this size is preferably between about 5.15 and 6.7 square inches, which corresponds to a circular

opening having a diameter between about 2.56 and 2.93 inches. One especially preferred burner cone has an inlet opening $3\frac{3}{8}$ inches in diameter (10.32 square inches flow area) and an outlet opening $2\frac{3}{4}$ inches in diameter (5.93 square inches in flow area).

In the illustrated device preferred in many applications, a short section 12 of body 10 adjacent the inlet is substantially in the form of a right cylinder of constant inside diameter. The cylinder is then uniformly reduced in inside diameter in adjacent section 14 to provide a smooth transition from the larger diameter of section 12 to the smaller diameter of the outlet opening. Transition section 14 is preferably formed by inturning the cylinder wall in the transition zone through a curvature of radius R_1 . Radius of curvature R_1 is desirably maintained between about 40 and about 60 percent of the radius of the cylinder inlet opening. Thus, the radius of curvature of transition section 14 of the aforementioned $3\frac{3}{8}$ inch end cone is preferably between about 0.73 and 1.09 inches. Optimum performance can usually be obtained in a cone of this size if radius R_1 is between about $\frac{7}{8}$ and 1 inch. The overall length of the cone, as determined by the distance between the transverse inlet and outlet faces at either end of annular body 10, is preferably less than about 50 percent of the diameter of the inlet opening and greater than about 30 percent of this dimension. An overall cone length of $1\frac{3}{32}$ inches has been found satisfactory with the previously mentioned $3\frac{3}{8}$ inch end cone.

Rotary motion is supplied to the fluid passing through annular body 10 by a plurality of curvilinear vanes on the interior surface of the cone which can be conveniently formed integrally with the body structure, or alternatively, permanently affixed thereto as by welding, brazing, or the like. These vanes comprise elongated protrusions extending from the interior surface of the body wall into the fluid flow passage. The vanes are spaced about the inside periphery of the end cone and oriented thereon at an angle from the axis of the body so as to provide a desired degree of rotary motion to the fluids discharged from the end cone. The angle of the vanes from a line parallel with the axis of the annular body largely determines the magnitude of the rotary motion imparted to the fluids. This angle of inclination, or pitch, is illustrated by the angle θ_1 . Alternate vanes 16 extend the length of body 10, commencing at the inlet opening at one end of the body, and terminating at the outlet opening at the opposite end thereof. Vanes 16 are smoothly curved toward the inlet into a configuration more parallel with the axis of the body and with the direction of flow of the fluids entering the end cone. This curvature is typically illustrated by the radius R_2 , which is preferably also between about 40 and 60 percent of the radius of the inlet opening. In an end cone of the size for use in a small burner for the usual domestic furnace, radius R_2 is typically between about $\frac{7}{8}$ inch and about $1\frac{1}{4}$ inches, the preferred radius of curvatures depending on the diameter of the inlet opening.

Interspaced between alternate full vanes 16 are partial vanes 18 which commence at an intermediate point on the interior surface of the end cone wall and extend to the outlet opening. Partial vanes 18 are inclined at the same angle θ_1 as full vanes 16. It is preferred that partial vanes 18 are tapered, such as at 20, to avoid a sharp protrusion projecting upwardly into the flow area. Thus, the height of vane 18 gradually increases over the length of section 20 to a maximum equivalent to the height of vanes 16.

In a preferred modification of this invention, flow directing vanes 16 and 18 have a constant pitch, or angle of inclination θ_1 over a substantial portion of their length of between about 45 degrees and about 75 degrees from a line parallel with the axis of the annular body. For most applications, the optimum angle of inclination θ_1 for this constant pitch section is about 60 degrees. As previously disclosed, the angle of inclination of vanes 16 is gradually

reduced adjacent the inlet opening so as to afford these vanes a more nearly axial orientation at the fluid inlet. The angle of inclination is preferably reduced to an angle θ_2 of less than about 35 degrees. Satisfactory operation is usually obtainable at angles θ_2 of about 25 degrees, although even smaller angles are sometimes preferred. Vanes can be pitched for either clockwise or counter-clockwise rotation, clockwise rotation being usually preferred.

Flow directing vanes 16 and 18 are generally of rectangular cross-section and project outwardly from the interior surface of annular body 10. In a preferred embodiment, the radial projection of vanes 16 and 18 into the flow area is limited so as to provide an unrestricted central flow area through body 10 of a diameter approximately equal to the diameter of the fluid outlet opening. In a further preferred embodiment, vanes 16 and 18 project radially outwardly from the interior wall of body 10 a variable distance to an imaginary right cylinder formed by the projection of the outlet opening the length of body 10 coaxially therewith. Thus, the height of vanes 16 and 18, excepting for tapered section 20 of vanes 18, extend outwardly a variable distance from the interior wall of transition section 14, and a substantially constant distance from the interior wall in cylindrical section 12.

Superior flow characteristics are obtained with vanes having a sharp radial projection outwardly from the interior surface of body 10 without fillets or rounded corners at the base of the vane.

Although the end cone of this invention can have any number of flow directing vanes on its interior surface, as necessary to impart the desired degree of rotational motion to the fluids exiting therefrom, superior results are obtained with a device having between about four and twelve vanes. The preferred device illustrated in FIGURES 1 and 2 is provided with four full vanes 16 uniformly spaced about the circumference of the cylindrical end cone at 90 degree intervals, and with four partial vanes 18 uniformly spaced thereabout at 90 degree intervals offset 45 degrees from flow directing vanes 16. Because of the pitch of these vanes, their position about the periphery of body 10 will vary depending on the axial displacement, however, the vanes are maintained in the same relative position throughout the length of the annular member. Thus, at any transverse section of the illustrated preferred device, vanes 16 will be spaced 90 degrees about the interior surface of the cone and vanes 18 will be spaced 90 degrees apart offset 45 degrees from vanes 16.

The external configuration of body 10 can be adapted to the particular air tube with which it is to be employed. Since many domestic heating furnaces are constructed with either standard $3\frac{3}{8}$ inch or 4 inch I.D. air tubes, it is often preferred to construct the end cone so that it can be conveniently adapted to either of these dimensions. A preferred embodiment of end cone adaptable to various different size air tubes can be constructed by increasing the outside diameter of the cylinder in steps. In the illustrated device, body 10 is constructed with two different outside dimensions to mate with two different size air tubes. Section 22 is constructed with a reduced diameter which is increased at section 24. Both surfaces 22 and 24 can be tapered toward the inlet end to provide draft for casting. When the burner cone is installed on the air tube, radial face 26 or 28 will mate with the end of the air tube, depending on the size of the particular air tube. Tip surface 30 of body 10 can be beveled an amount indicated by angle θ_3 , as illustrated, to facilitate casting, utility, appearance, and caulking at the furnace wall on installation. Bevel angle θ_3 can have a value of between about 25 and about 45 degrees, and preferably is about 33 degrees.

The end cone of this invention can be conveniently fabricated from various metals or metal alloys by casting the device in the desired shape, or by boring and milling the

vaned end cone from a solid block of metal by conventional metal working techniques. In an alternative method of fabrication, a rough casting can be made having the general shape of the end cone, which is then finished by machining to final dimensions.

The installation of the end cone of this invention in an annular flow burner head assembly, such as that disclosed in our aforementioned U. S. Patent No. 3,361,365, is illustrated in FIGURE 3. The burner head assembly is installed in a suitable aperture 102 in combustion chamber wall 100, with the outlet of the assembly directed toward the interior of the combustion chamber. The burner head assembly does not extend any appreciable distance into the combustion chamber, the outlet face of the end cone preferably being installed flush with the inside surface of wall 100. The burner head assembly comprises air tube 104 having secured to the end thereof an end cone substantially in accordance with the device illustrated in FIGURES 1 and 2.

Disposed inside annular body 10 of the end cone is hollow air shield 106 having a truncated conical configuration or being cup-like in appearance with the largest diameter of the air shield being substantially equal to the diameter of the end cone outlet. Air shield 106 is slidably disposed within the end cone with the larger end thereof entering through the larger end of the end cone and movable toward the smaller end thereof. Air shield 106 has a number of equally spaced triangular-shaped slots 108 in the conical wall thereof communicating the exterior of air shield 106 to the interior thereof. The slots or apertures 108 are tangential to the smallest diameter of air shield 106 and have shapes similar to right spherical triangles. The greatest width of the slots is adjacent the smallest diameter of air shield 106. These slots extend a substantial distance toward the largest or flared end of the air shield and are of such size so as to permit a sufficient amount of combustion supporting fluid and fuel to be passed therethrough into the interior of the air shield for effective combustion. The tapered slots 108 have a maximum width of approximately $\frac{1}{8}$ inch to $\frac{3}{8}$ inch and taper to a point near the flared end of the air shield. The length of the slot may be of any size, i.e., coextensive with the length of air shield 106, and is limited only by air shield structural considerations. That is if either the tapered end or widest end of the tapered slot is too near the largest or smallest end of the air shield respectively, flexibility and structural weakness will result in the air shield. The size of slots 108 should preferably allow between about 4 percent and 30 percent of the amount of air needed for combustion to flow there-through.

Juxtaposed to slots 108 are fluid guide means 110 projecting outwardly from the exterior surface of the air shield. Guide means or fins 110 have a spiral shape or louver configuration substantially corresponding to the contour of the exterior surface of the air shield so that fluids passing over the exterior surface of air shield 106 will be partially diverted through slots 108 and enter the interior of the air shield with a rotary motion, the rotation of these fluids being substantially the same as the rotational movement given the air passing through the annulus. The fin or guide means are coextending in length with the slots and have a projection height of about $\frac{1}{16}$ to $\frac{3}{8}$ inch with a preferred height of about $\frac{3}{32}$ inch for the normal domestic burner. Ordinarily, the projection height will generally approach the same dimension as the greatest width of slot 108. Air shield 106 is fashioned of a relatively thin corrosion resistant metal such as stainless steel of about 14 to 28 gage and has a substantially smooth interior and exterior surface except for projecting fins or guides 110. While the slots may be punched out of the air shield and separately spirally shaped fins or air guide means secured adjacent the slot on the exterior surface of the air shield, it is preferred to make two cuts in the air shield with the subsequent bending out of that portion of the conical wall congruent with the slot to form the louver design.

It is preferred to space the slots at intervals of about 60 degrees around the periphery of the shield, but smaller or greater spacings can be used. One end of support means 114, preferably formed of bent metal rods is secured to the exterior surface of the air shield as by spot welding or silver brazing. The other end of supporting members 114 are secured to coupling 116 adapted to be slidably disposed on nozzle adapter 118 or fuel pipe 120. The supporting members 114 may be of any shape so long as they are fashioned to provide ample clearance for ignition electrode 122 and atomizing nozzle 124. Sufficient clearance between nozzle 124 and nozzle adapter 118 is provided so that coupling 116 is movable axially thereof thereby allowing air shield 106 to be freely slideable within end cone 10. Coupling 116, after setting, is held in fixed position at any predetermined position by means of set screw 126. Alternatively, and preferably, the distance between the back end of the air shield and the nozzle orifice is fixed and placement of the air shield within the annulus is accomplished by moving the nozzle, nozzle adapter, and air shield as a unitary structure thereby maintaining a pre-selected fixed distance between the nozzle orifice and the air shield. This distance is set to obtain satisfactory flame patterns and performance. Although a preferred method of mounting the air shield has been illustrated, the air shield may be supported within end cone 10 by other means, as by supporting means secured to the air tube, nozzle, oil supply conduit, end cone, etc.

Packing or caulking material 128 and 130 is provided around end cone 10 and air tube 104, respectively, at the combustion chamber wall so that atmospheric air will not be drawn into combustion zone 132.

In operation, air is forced through air tube 104, by means not shown, toward the combustion chamber. Depending upon the position of air shield 106 within annular body 10, a portion of the air necessary for combustion passes through the annular flow area between body 10 and air shield 106 and is introduced into combustion zone 132 in turbulent fashion, rotational movement being given the air by vanes 16 and 18. Another portion of the combustion air will impinge upon the exterior surface of air shield 106 and will be diverted by fins 110 through slots 108 into the interior in similar rotational manner as the air passing through the annulus. Another portion of air will be admitted through the open back of air shield 28 along with atomized fuel delivered under pressure through fuel pipe 120 and atomizing nozzle 124.

The end cone of the present invention, in combination with an annular burner of the type disclosed in our aforementioned U.S. Patent No. 3,361,365, results in a substantially increased combustion air capacity and a corresponding increase in firing rate. Air flow and firing rates can be increased as much as 50 percent, or more, without loss of combustion performance. For example, a burner assembly of the previous disclosed type having a $3\frac{3}{4}$ inch inlet and eight 60 degree full length vanes was tested at a maximum air flow of 163.5 lb./hr. and a maximum oil firing rate of 1.41 gallon per hour at 11.0 percent excess air at #2 smoke. "Excess air" is defined as that air in excess of the amount theoretically required to completely burn the fuel. The same burner having a $3\frac{3}{4}$ inch end cone with four full length 60 degree pitch vanes curved to 25 degrees at the inlet and four partial vanes interspaced therebetween, in accordance with the preferred device illustrated in FIGURES 1 and 2, exhibited a maximum air flow of 232.0 lb./hr. and a maximum firing rate of 2.0 gallons per hour at 11.0 percent excess air at #2 smoke.

While particular embodiments of the invention have been described, it will be understood, of course, that the invention is not limited thereto since many modifications can be made, and it is intended to include within the invention any such modification as fall within the scope of the claims.

The invention having thus been described, we claim:

1. A burner end cone comprising an annular body member having a fluid inlet opening at one end, a fluid

outlet opening of reduced size at the opposite end, and an internal flow passage extending the length of said body member communicating said inlet with said outlet; a plurality of first flow directing vanes protruding from the interior surface of said body member into said flow passage and extending the length of said body member from said inlet opening to said outlet opening, said vanes being angularly displaced from a line parallel with the center axis of said body member; and a plurality of second flow directing partial vanes protruding from the interior surface of said body member, said second vanes being alternately disposed between said first vanes and extending from a point on the interior surface of said body member intermediate said ends to said fluid outlet.

2. The article defined in claim 1 wherein said annular body member comprises a hollow right cylinder having an inturned section of continuously decreasing inside diameter adjacent said outlet opening which defines an interior surface affording a smooth transition from the inside diameter of the right cylinder to that of said outlet opening.

3. The article defined in claim 1 wherein the outside diameter of said annular body is reduced adjacent said fluid outlet.

4. The article defined in claim 1 wherein said first flow directing vanes and said second flow directing partial vanes are of substantially rectangular cross-section.

5. The article defined in claim 1 wherein said second partial vanes are of increasing radial height over the portion of their length most removed from said fluid outlet so as to be tapered toward said fluid inlet.

6. The article defined in claim 1 wherein said first and said second flow directing vanes are disposed from a line parallel with the axis of said cylinder at an angular pitch of between about 45 degrees and about 75 degrees.

7. The article defined in claim 1 wherein the angle of pitch of said first flow directing vanes is gradually decreased to an angle of less than about 35 degrees adjacent said fluid inlet so as to afford said vanes a more nearly axial orientation at said fluid inlet.

8. The article defined in claim 1 wherein said first and said second flow directing vanes are uniformly spaced about the circumference of said annular body member.

9. The article defined in claim 1 wherein four of said first flow directing vanes are uniformly spaced about the circumference of said annular body member at 90 degree intervals and wherein four of said second flow directing partial vanes are uniformly spaced about the circumference of said annular body member at 90 degree intervals offset 45 degrees from said first flow directing vanes.

10. The article defined in claim 1 wherein said annular body member has a first exterior circumferential surface adjacent said fluid inlet terminating at a radial face extending outwardly from said first surface and an adjacent circumferential surface of greater diameter than said first surface and terminating at a second radial face extending outwardly from said second surface.

11. The article of claim 1 wherein said annular body member, said first flow directing vanes and said second flow directing partial vanes are of a unitary construction.

12. An end cone for a burner air tube, which comprises a hollow cylindrical member having a fluid inlet opening at one end and a fluid outlet opening of reduced diameter at the opposite end, said cylinder comprising a right cylindrical section adjacent said fluid inlet having an inside diameter substantially equal to said fluid inlet opening, and a concentric inturned cylindrical section adjacent said right cylindrical section which defines an interior surface having a smooth transition from the diameter of said right cylinder to that of said outlet opening, and wherein the outside diameter of said inturned cylindrical section is reduced adjacent said fluid outlet; a plurality of first

flow directing vanes uniformly spaced about the circumference of said cylinder protruding from the interior surface of said cylinder, said vanes extending the length of said cylinder from said inlet opening to said outlet opening, said vanes being disposed from a line parallel with the center axis of said cylinder at an angular pitch of between about 45 degrees and about 75 degrees over a substantial portion of their length and wherein the angle of pitch of said vanes is gradually decreased to an angle of less than about 35 degrees adjacent said fluid inlet; and a plurality of second flow directing partial vanes protruding from the interior surface of said hollow cylinder, said second vanes being alternately disposed between said first vanes and extending from a point on the interior surface of said cylinder intermediate said ends to said fluid outlet, said second partial vanes increasing in height over the portion of their length most removed from said fluid outlet so as to be tapered toward said fluid inlet.

13. The article defined in claim 12 wherein four of said first flow directing vanes are uniformly spaced about the circumference of said hollow cylinder at 90 degree intervals and wherein four of said second flow directing partial vanes are uniformly spaced about the circumference of said hollow cylinder at 90 degree intervals offset 45 degrees from said first flow directing vanes, said first and second vanes having an angular pitch of about 60 degrees and wherein said first flow directing vanes are gradually curved to a pitch of about 25 degrees adjacent said inlet.

14. The article defined in claim 12 wherein said hollow cylinder has a first exterior circumferential surface adjacent said fluid inlet terminating at a radial face extending outwardly from said first surface and an adjacent circumferential section of greater diameter than said first surface and terminating at a second radial face extending outwardly from said second surface.

15. A burner of the type wherein an air tube is provided with a hollow cylindrical end cone having a fluid outlet of reduced diameter, an air shield concentrically disposed within said end cone so as to define an annular flow area between the outer periphery of said air shield and the inner surface of said end cone, and wherein said end cone is provided with angularly disposed vanes on its interior surface to impart rotational motion to the fluids passing therethrough, the improvement which comprises:

first vanes protruding from the interior surface of said end cone and extending the length of said end cone, said vanes being disposed from a line parallel with the center axis of said end cone at an angular pitch of between about 45 degrees and about 75 degrees over a substantial portion of their length and wherein the angle of pitch of said vanes is gradually decreased to an angle of less than about 35 degrees adjacent the inlet of said end cone; and

second vanes protruding from the interior surface of said end cone, said second vanes being alternately disposed between said first vanes substantially parallel therewith and extending less than the full length of said end cone terminating at said outlet end.

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