April 2, 1957 | J. J. WOLFERSPERGER | 2,787,318

BURNER WITH TANGENTIAL AIR ADMISSION AND RESTRICTED THROAT

Filed Nov. 4, 1949 | 2 Sheets-Sheet 1

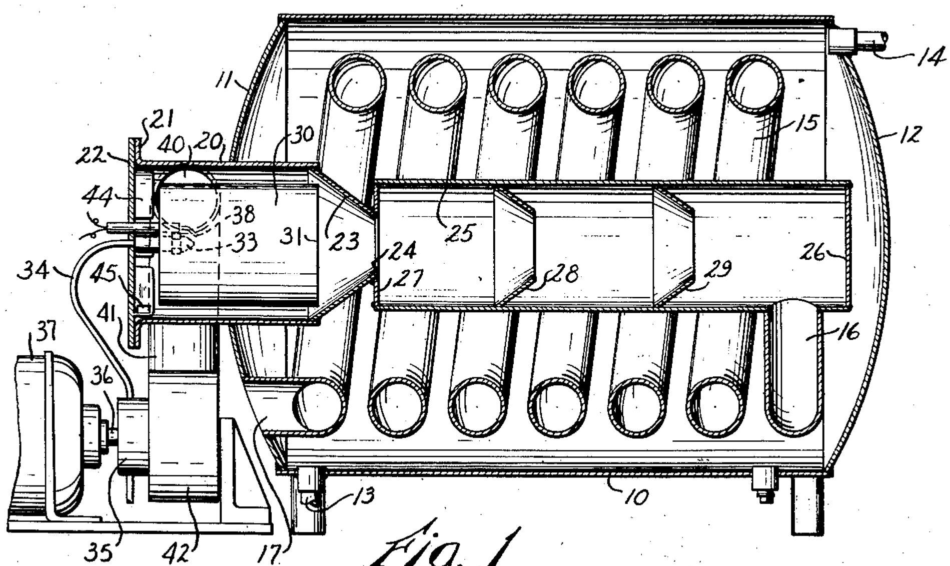

Fig. 1

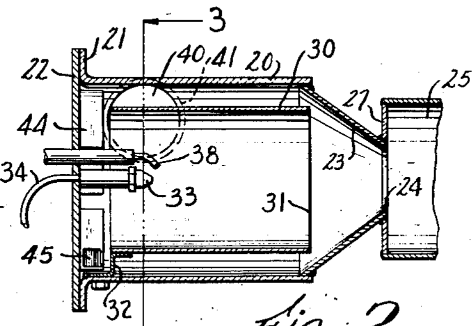

Fig. 2

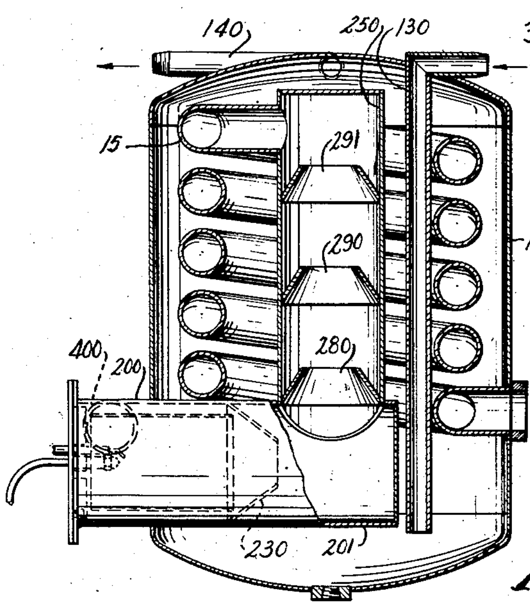

Fig. 5

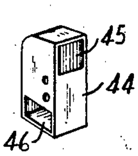

Fig. 4

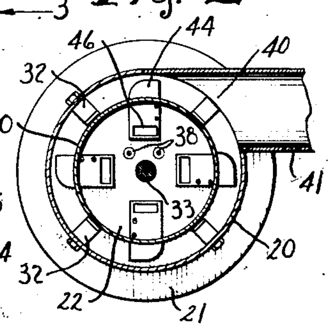

Fig. 3

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BURNER WITH TANGENTIAL AIR ADMISSION AND RESTRICTED THROAT

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2 Sheets-Sheet 2

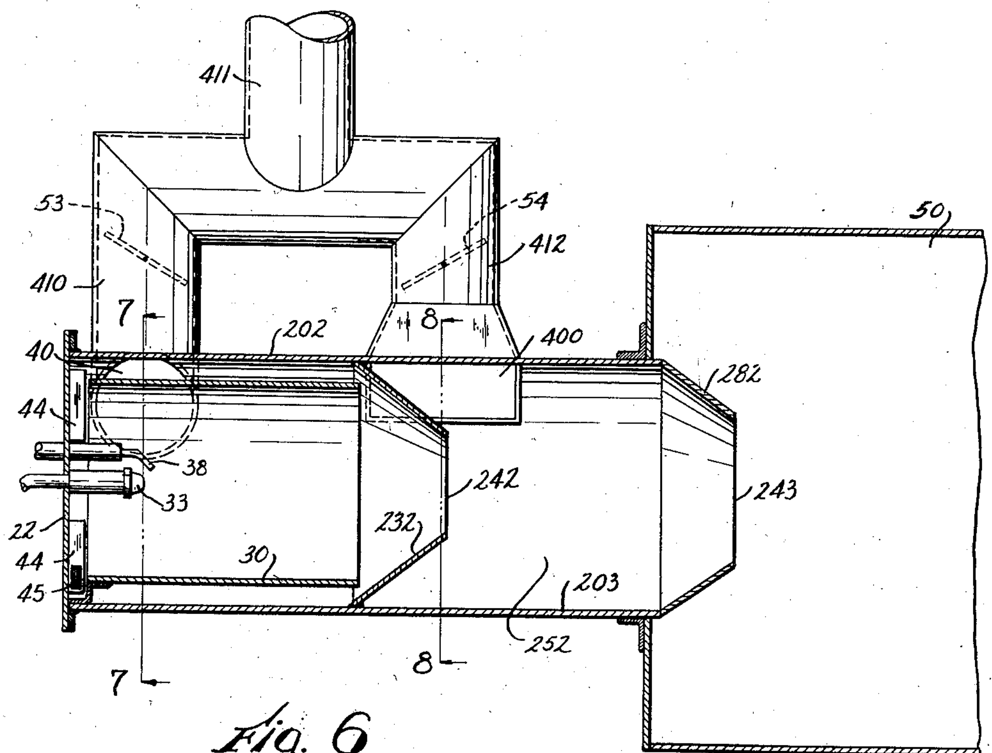

Fig. 6

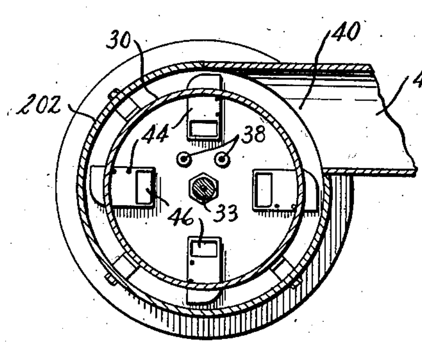

Fig. 7

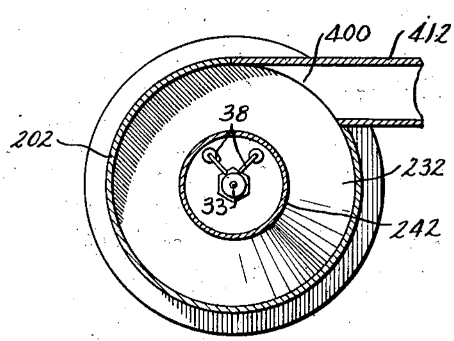

Fig. 8

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BURNER WITH TANGENTIAL AIR ADMISSION AND RESTRICTED THROAT

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Application November 4, 1949, Serial No. 125,582

9 Claims. (Cl. 158—1.5)

This invention relates to a burner with tangential air admission and restricted throat.

The present application is a companion to my application Ser. No. 636,781, entitled Pressure Type Burner and Method of Burning Fuel, and filed December 22, 1945, now Patent No. 2,499,207, dated February 28, 1950. An object of the present invention is to reduce the space required for a burner of the type disclosed in my companion application above identified and to promote the rapidity of combustion while protecting metal parts from unduly high temperatures.

It is a further and important object of the invention to produce a hotter flame than is achieved in the device of my companion application, or in any comparable burner.

Further objects of the invention include a reduction in cost of manufacture; a simplification in the burner structure; an improved air control for eliminating carbon deposits; and an improved means for adding large quantities of diluting air to the products of combustion without interfering with complete combustion.

In the drawings:

Fig. 1 is a view in axial section through an improved burner embodying the present invention as the burner appears when installed in a boiler.

Fig. 2 is an enlarged axial sectional view through the mixing chamber of my improved burner.

Fig. 3 is a view in transverse section on the line 3—3 of Fig. 2.

Fig. 4 is a detail view in perspective of one of the air transferring conduits used in the device of Figs. 1 to 3.

Fig. 5 is a view partially in side elevation and partially in vertical, axial section showing my improved burner installed in an upright boiler.

Fig. 6 is a view in axial section showing a modified embodiment of my burner as it appears when used as a torch.

Fig. 7 is a view taken in cross section on the line 7—7 of Fig. 6.

Fig. 8 is a view taken in cross section on the line 8—8 of Fig. 6.

The boiler **10** comprises a generally cylindrical side wall and convex heads **11** and **12** with water inlet at **13** and water or steam outlets at **14**. Within the boiler shell is a helical fire tube **15** having an inlet portion **16** for receiving gases from the multiple chamber burner hereinafter to be described, the opposite end of the helix having a flue opening at **17** through the head **11** for the discharge of products of combustion.

Mounted in the head **11** is a tubular mixing chamber **20** flanged at **21** to receive the end plate **22**. At the inner end of the tubular mixing chamber **20** is a conical partition wall **23** terminating in the restricted orifice **24** which communicates with a combustion chamber **25** having the form of an elongated tube of large cross section closed at **26** in its remote end and communicating laterally with the inlet **16** of fire tube **15**. An annular closure **27** at the lefthand end of such tube as viewed in Figs. 1 and 2, is welded or otherwise secured to the conical member **23** about the restricted orifice **24**. The combustion chamber **25** is desirably subdivided into a number of separate compartments by frusto-conical partitions or baffles **28** and **29**, each of which provides restricted communication between the successive compartments. The frusto-conical baffles are desirably spaced at intervals of one to two diameters of the combustion chamber **25** wherein they are mounted. Their use is made practical by the fact that the combustion chamber tube **25** is immersed in the water of the boiler and hence delivers heat sufficiently rapidly into the water to carry off from the baffles the heat which would otherwise destroy them. The baffles are desirably welded throughout their peripheries to the tube **25** to promote heat delivery from the baffles to the tube **25** and thence to the water of the boiler.

Within the mixing chamber sleeve **20** is a baffle sleeve **30** having its end portion **31** in immediate proximity to the frusto-conically tapered terminal wall **23** which partitions the mixing chamber from the combustion chamber. The baffle sleeve **30** may be supported by brackets **32** (Fig. 2) or otherwise. Centrally within the sleeve **30** is the fuel atomizing nozzle **33** supplied with fuel through pipe **34** from the fuel pump **35** which is driven by the armature shaft **36** of motor **37**. Immediately adjacent the nozzle tip is the igniter **38** which may be of any suitable type.

Opening tangentially at **40** into the chamber **20** is the air supply pipe **41** leading from a blower **42** aligned with, and driven by, the armature shaft **36**. A large body of air delivered tangentially into chamber **20** creates a vortex in such chamber.

The fittings **44** which are conveniently mounted on the end wall or closure plate **22** of chamber **20**, and one of which is separately illustrated in Fig. 4, comprise baffle means desirably in the form of conduits having inlet openings **45** in the path of a whirling mass of air which is confined between the tubular outer wall of chamber **20** and the exterior surface of the tubular baffle sleeve **30** therein. Thus each of the inlet openings **45** constitutes a scoop through which air is caused to enter the fitting **44**, issuing from the outlet opening **46** thereof in a direction which is axial of sleeve **30**. In practice, I find it desirable to transfer in this manner to the interior of sleeve **30** about one-sixth of the air admitted to chamber **20** through the tangential inlet opening **40**.

In previous burner designs, there has tended to be a surplus of air moving through the baffle sleeve **30** past the nozzle. Thus it was necessary to somewhat restrict the flow and, in order to rectify or straighten the flow, a considerable space has had to be provided between the nozzle and the end wall of the mixing chamber. In the present device there would be, but for the scoops or deflectors **44**, a deficiency of air within the tubular baffle. Therefore, the scoops or their equivalent are needed to provide adequate primary air about the nozzle. Such primary air should be barely sufficient to support stable combustion, but, as disclosed in the companion application above identified, should not be more than the amount necessary for this purpose. I have found that these scoops constitute an extremely simple means of supplying exactly the right amount of air and sufficiently rectifying its flow axially of the sleeve so that the nozzle can be mounted directly on the closure plate **22** as shown. This reduces the overall length of the burner very materially below what has previously been deemed necessary. Yet no carbon or tar deposits occur.

It will be noted that the tangential inlet port is sufficiently large so that a substantial part of the air admitted therethrough is blown against the side of the baffle sleeve **30**, which lies across the path of such air and is cooled thereby.

The method of operation is the same as that described in the companion application above identified, but important advantages are realized in the present burner. The forward or axial velocity of the spiralling air in chamber **20** is necessarily the same for a given burner capacity as in the previous device (the same amount of air being required to be delivered for complete combustion) but the very much longer path which is necessarily followed by air flowing spirally, requires the actual velocity of the air to be greatly in excess of the velocity it would have if it were moving solely in an axial direction. Consequently, when the high velocity secondary air encounters the frusto-conical wall **23** and moves toward the restricted orifice **24**, even greater turbulence results than was achieved by that orifice without the tangential flow.

Secondly, it being an object of the invention disclosed in my former application, as well as the present device, to keep the secondary air separate from the mixture of fuel and primary air which has been ignited at the burner, until sudden and turbulent mixing occurs at the orifice, it is found that the rapid vortex movement of the relatively colder secondary air assists in maintaining the secondary air in the form of an annular stratum outside of the slowly burning mixture.

In the third place, the considerations above noted produce at the orifice a flame which is between 500° and 1000° F. hotter than that previously achieved, even in the burner of my companion application, wherein the flame produced was exceptionally hot.

In the fourth place, the superior mixing achieved in the throat as a result of the considerations noted makes it possible to increase the diameter of the throat or orifice **24** as compared with a throat or orifice used in the straight flow burner of the companion application, this, in turn, permitting a reduction in air pressure to only one-third or one-fourth that required in the straight flow burner at any specified rating.

Finally, the use of the scoop fittings **44** not only permits the entire mixing chamber to be shortened, as above noted, but eliminates baffles and the like while securing improved results.

Apart from those changes and improvements in the mixing chamber, further advantages are achieved by the baffles **28** and **29** in the combustion chamber which, by abruptly varying the rate of flow of the gases, promote turbulence and heat exchange.

The device of Fig. 5 is closely comparable to that already described but the water jacket **100** is vertical with its inlet pipe **130** extending downwardly from its top and its outlet pipe **140** opening from its top. The mixing chamber tube **200** is set into the side wall of the boiler. Internally, its organization is the same as that already described, its tangential inlet being shown at **400**. In this construction, the first compartment of the combustion chamber comprises an extension **201** of the mixing chamber tube, the tapered wall **230** being merely a baffle in such tube. The combustion chamber tube **250** constitutes a lateral extension upwardly from the compartment **201** and it is provided with a series of conical baffles **280**, **290** and **291**. The fire tube **15** may be identical with that already described. The operation is essentially the same as that already described.

In the device shown in Figs. 6, 7 and 8, a modified arrangement is desirable because, unlike those previously shown, the combustion chamber is not immersed in boiler water and therefore its walls and baffles require protection from the intense heat. At the same time, in many installations, such as forage crop driers, it is important to reduce the temperature of the products of combustion where the hot gases are used in contact with the material being dried. In other devices, such as gravel driers and the like, it is immaterial whether products of combustion are reduced in temperature since their contact with the gravel or other work will do no harm.

The device of Fig. 6 resembles that of Fig. 5 to the extent that the tube **202** which constitutes the wall of the mixing chamber is extended at **203** to provide a combustion chamber **252**. The frusto-conical baffle **232** provides a restricted orifice **242** between the mixing chamber and the combustion chamber. A similar frusto-conical baffle at **282** provides a restricted orifice **243** through which the hot gases enter into a drum **50** wherein is contained the material to be dried, whatever that material may be.

As in the constructions previously disclosed, there is a baffle sleeve **30** within the mixing chamber, and the fuel nozzle **33** is mounted near the back end of sleeve **30**. The nozzle **33** and igniter **38** are conveniently mounted directly on the closure plate **22**. Such plate also carries the scoop fittings **44** which pick up the air moving spirally in chamber **202** and convey such air centrally and release it axially of sleeve **30** to provide primary air for the fuel issuing from nozzle **33**.

The air is admitted tangentially to chamber **202** through the opening **40** which opens from the pipe **410**. Instead of coming directly from the blower or other air pump, however, the pipe **410** is desirably merely a branch of the pressure pipe **411**, another branch **412** of which leads to a tangential opening at **400** into the combustion chamber **252** externally of the frusto-conical baffle **232**. Each of the branch pipes **410** and **412** is desirably controlled by a damper **53**, **54** so that the air may be divided in any desired proportions between the tangential inlet port **40** of the mixing chamber and the tangential inlet port **400** of the combustion chamber.

By suitable regulation of the dampers, any desired operation of the burner within its capacity may be achieved. Where maximum temperatures are desired, and where the supply of air available greatly exceeds that needed for complete combustion, the dampers may both be closed to such an extent that the total air admitted through both of them will not substantially exceed the amount required for complete combustion. This air may be divided in equal quantities between the two tangential inlet ports, or as low as ⅓ through the first inlet port. In either case, for reasons above noted, the tangential flow of the air cooperates with the abruptly restricted orifice to produce an intensely hot flame. In my former burner, I have found that where the air supplied is approximately the exact amount needed for complete combustion, the length of the flame extending from the burner will approximately equal the overall length of the burner. With such a burner mounted on the head of a drier drum, this results in the flame projecting for a considerable distance into the drum. The present device with its two chambers is substantially identical in length as the former burner, but, by reason of the tangential inlets and two chambers, combustion is practically completed in the second chamber and practically no flame protrudes from its outlet throat. Thus no flame will extend therefrom into a drying drum, so that a shorter drum may be used, or the same drum could dry more material.

However, a large reduction in the temperature of the products of combustion may be achieved by supplying excess air. For this purpose, the dampers **53** and **54** may be opened beyond the requirements for complete combustion to supply air which will dilute the products of combustion and partake of their heat so that the gases delivered into the drying chamber **50** will be greatly increased in volume but correspondingly reduced in temperature. This is particularly desirable for the drying of edible produce and brewery grains and the like by direct contact with the gases. I have found that due to the spiral flow resulting from the tangentially disposed inlets, it is possible to introduce up to 300% excess of air into the mixing chamber and another 300% excess into the combustion chamber over and above the air required for complete combustion, without in any way interfering with the achievement of complete combustion, free of soot or tar. Thus the flow of gases can be multiplied six-fold.

A very important advantage of the admission of air through the tangential orifice **400** consists in the cooling of the frusto-conical baffle or partition **232** which provides the restricted opening **242** whereby mixing and combustion are abruptly perfected. It will be remembered that in the devices originally disclosed, this frusto-conical wall was immersed in the water of a boiler, whereby its excess heat could be carried off directly into the water. I have found the admission of air around its external face to be an important factor in keeping this baffle at a reasonable operating range of temperatures where it is deprived of contact with the liquid. The tangential inlet at **400** also maintains a stratified body of cooler air around the entire inner surface of the combustion chamber **252**, thereby protecting the combustion chamber wall and baffle **282** from excessive heat.

I claim:

1. A burner comprising the combination with a fuel nozzle, of a tubular chamber wall substantially concentric therewith and having a tangential air inlet, a sleeve spaced within such wall and encircling the nozzle, and a restricted throat comprising a conically tapered and centrally apertured terminal wall for said chamber spaced from the sleeve at the end of the chamber toward which said nozzle is directed, the aperture being materially smaller in cross section than the sleeve, the other end of the chamber being provided with a closure behind the nozzle, the said sleeve having an inlet opening within said chamber and adjacent said closure for the admission from the outer part of said chamber of primary air for the fuel from said nozzle, said closure comprising a plate upon which the nozzle is supported and from which the end of said sleeve is spaced, said plate being provided with baffle means having a generally radial extent and having air scoop means to deflect into the interior of the sleeve, air moving in a vortex resulting from its tangential delivery into the space between the sleeve and the chamber wall.

2. A device of the character described comprising the combination with a generally cylindrical tubular chamber wall having a rear closure plate at one end and a restricted throat comprising a frusto-conically tapered wall with a central aperture at its other end, the tubular chamber wall having a tangentially disposed inlet, a nozzle mounted on the closure plate and directed centrally of said tubular chamber wall toward the aperture of the frusto-conically tapered wall, and a sleeve of larger diameter than said aperture and spaced from the closure plate and encircling the nozzle between the nozzle and the tubular chamber wall and terminating short of the frusto-conically tapered wall, said sleeve being disposed across a substantial portion of the cross sectional area of the tangential inlet port aforesaid whereby air admitted therethrough to the space between the sleeve and the tubular chamber wall is directed in substantial part against the side of the sleeve, in further combination with conduit means mounted on the closure plate and having laterally disposed inlet ports in the path of air encircling the sleeve, and axially disposed outlet ports between the sleeve and the nozzle.

3. A burner of the character described comprising a tubular chamber wall having a tangential inlet, a nozzle disposed substantially axially of the wall, a closure across the end of the wall behind the nozzle, and at least one deflector fitting mounted on the closure and comprising an air scoop disposed adjacent said wall in a position to deflect toward the nozzle air circulated by said tangential inlet about the inner periphery of the wall, said fitting having a tangential inlet and a delivery portion directed axially from said closure along the axis of said tubular wall for delivery of primary air axially about the nozzle.

4. A burner of the character described comprising the combination with wall means defining a succession of communicating chambers, each of which has a frusto-conically tapered and centrally apertured terminal wall constituting restricted throats at the outlets of the respective chambers, the aperture of the wall of the first of said chambers opening centrally into the next of said chambers and the respective chambers being provided solely at their respective ends remote from their respective walls aforesaid with tangential air inlet ports, a fuel nozzle in the first of said chambers, a sleeve within the first chamber and spaced from its terminal wall and encircling the fuel nozzle between the nozzle and the inlet port of said first chamber, said sleeve being larger in diameter than the opening in the throat at the end of its chamber, said nozzle being materially spaced from the throat end of the sleeve, means for supplying air under pressure to the respective ports to establish correspondingly rotating vortex currents of air in said chambers, and a closure for the first chamber behind said nozzle and in spaced relation to said sleeve, said closure being provided with deflector means having radial extent for guiding toward said nozzle primary air from the air admitted externally of said sleeve by the tangential port opening into said first chamber.

5. A method of burning fuel and controlling the temperature of the products of combustion of said burning, comprising the steps of injecting the fuel into a stream of primary air sufficient only to support stable combustion igniting the mixture of primary air and fuel, surrounding the stream of ignited primary air and fuel with a stratified envelope of helically rotating secondary air at least approximately sufficient to complete combustion when added to said stream, combining said stream and envelope for the first time by abruptly passing said stream and envelope simultaneously through a restricted throat of smaller cross section than the stream of primary air, adding a stratified envelope of cooling air about the ignited mixture, and passing the ignited mixture and the envelope of cooling air through a second restricted throat.

6. The method of claim 5 in which said stream is circular and the secondary air and cooling air are admitted tangentially to be mixed with said burning fuel on a whirling path.

7. The method of claim 5 in which the supply of secondary air and cooling air are relatively adjustable.

8. A burner comprising the combination with a fuel nozzle, of a tubular chamber wall substantially concentric therewith and having a tangential air inlet, a sleeve spaced within said wall and encircling the nozzle, a portion of said sleeve being opposite said inlet to deflect incoming air on a helical path of secondary air between said sleeve and said wall, an igniter adjacent said nozzle, means for supplying said nozzle with primary air within said sleeve, said sleeve having axial extent beyond said nozzle sufficient to maintain said primary air within said sleeve separate and in stratified relation to the helical path of secondary air outside said sleeve at least until said sleeve is substantially filled with an ignited mixture of fuel and primary air in stable combustion, a restricted throat comprising a conically tapered and centrally apertured terminal wall for said chamber spaced from the sleeve at the end of the chamber toward which said nozzle is directed, the aperture being smaller in cross sectional area than the sleeve, said sleeve and restricted throat comprising means for first contacting the helically rotating secondary air with the ignited mixture of fuel and primary air just prior to violent intermixture thereof while abruptly withdrawing both secondary and primary air from the chamber through said restricted throat, said tubular chamber comprising a mixing chamber, and a combustion chamber with which said mixing chamber communicates, said restricted throat comprising a partition between said chambers, the combustion chamber having an air inlet

adjacent the partition to supply additional air to the combustion chamber and the inlet to said combustion chamber being tangential in the same direction as the tangential inlet to the mixing chamber to induce vortex movement in the same direction in both chambers, said inlet comprising a branch of the inlet to the mixing chamber, in further combination with damper means for regulating the relative flow through said inlets.

9. The device of claim 8 in which the port opening tangentially into the combustion chamber is disposed outside of the frusto-conically tapered wall of the mixing chamber outlet to direct cooling air about the external surface of said wall.

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