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RECUPERATIVE FORM OF DIRECT THERMAL INCINERATOR

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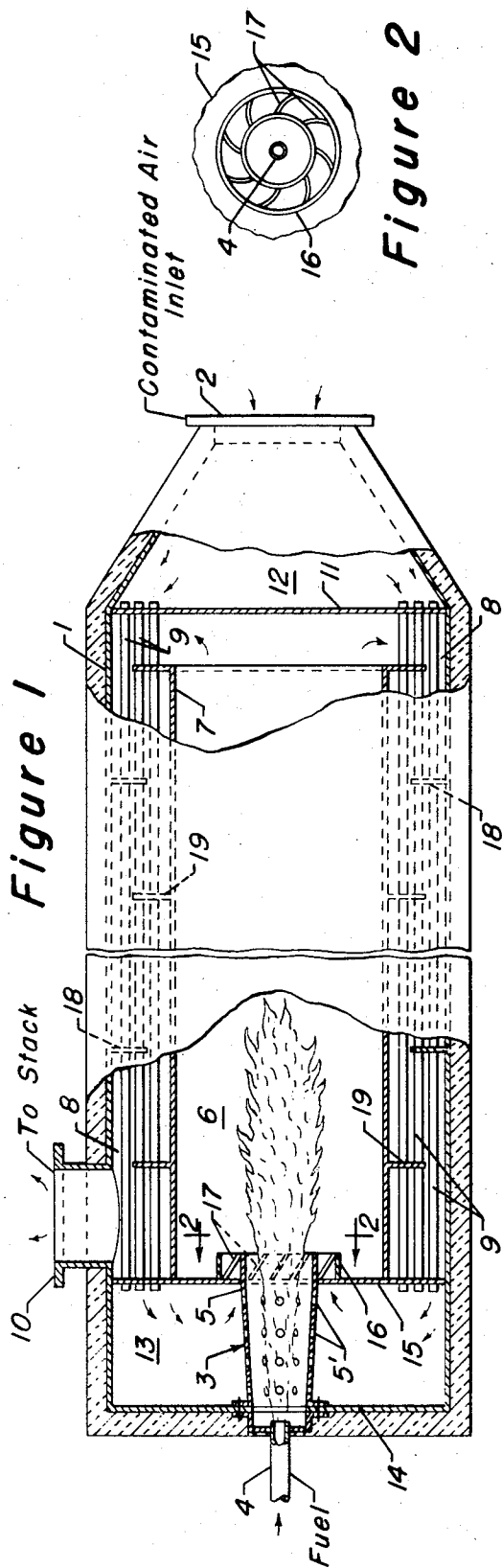
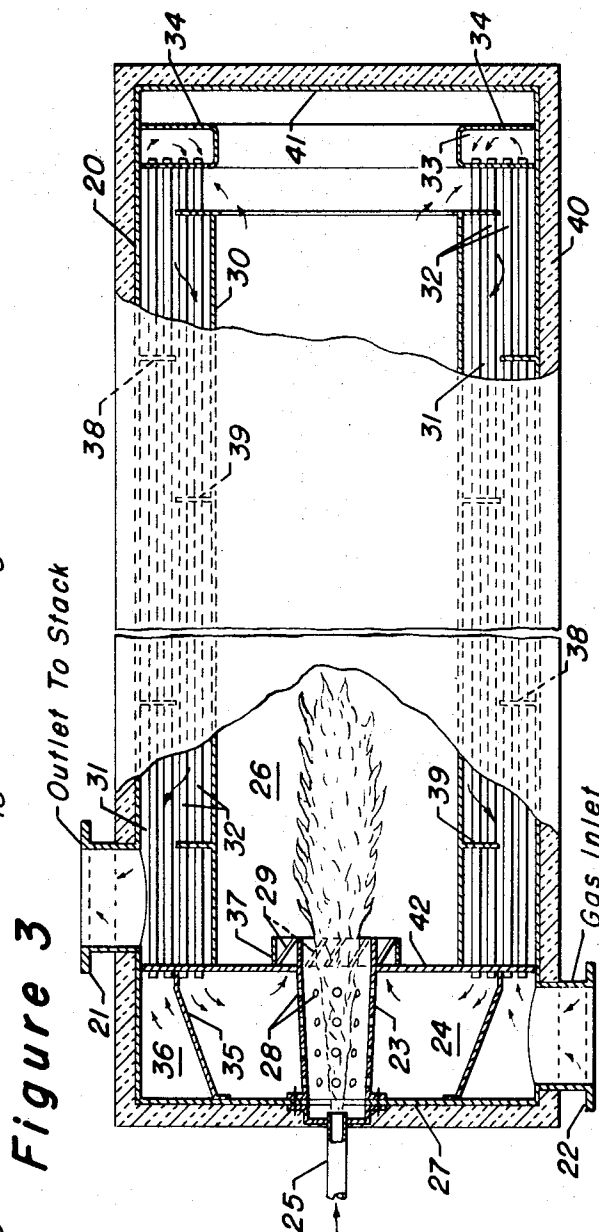
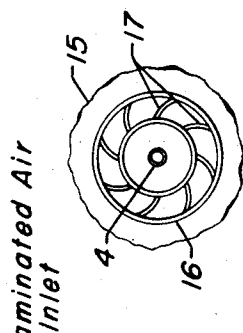


Figure 2



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RECUPERATIVE FORM OF DIRECT THERMAL INCINERATOR

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4 Claims

ABSTRACT OF THE DISCLOSURE

A recuperative form of direct flame incinerator unit providing a contaminated gas stream inlet plenum section which fully surrounds an axially positioned burner means so as to provide efficient mixing with the fuel within and downstream from the burner. The internally located combustion section of the unit is encompassed with an elongated annular form heat exchange section which in turn is provided with multiple tubes so as to have an elongated confined passageway for hot combustion gases and a separated adjacent passageway for the incoming gas stream. The passageways are in heat exchange relationship with one another to give a highly efficient recuperative heat transfer to the incoming gas stream and a uniform full 360° annular flow to the plenum section.

The present invention relates to an improved form of incinerating apparatus and more specifically to a direct flame incinerator unit which provides an annular heat exchange section, as well as an improved burner arrangement, to give a highly efficient self-recuperative operation.

The early conventional incinerator installations merely involved the connection of burner means with the waste gas stack so that direct flame and heat could be added to the stack and effect an oxidation of noxious components in the waste gas stream. Such early operations were inefficient and had high fuel requirements. The more modern incinerator units have made use of improved burner means, such as utilizing the "scroll" type burner in order to obtain better mixing with the gas stream and, generally, these later units have provided some measure of heat exchange between the combustion section and the incoming gas stream. However, even these present types of incinerator units still fail to make use of recuperative designs and to obtain economical, high efficiency operations.

It is thus a principal object of the present invention to provide a thermal incinerator with an efficient recuperative design.

It is also an object of the present invention to provide a special burner and gas inlet plenum section so that there is efficient mixing of the gas stream into the burner gases. Preferably the burner means eliminates primary air and provides for 100% secondary air for burner operation being obtained from the waste gas stream itself.

In a broad aspect, the present invention may be considered to provide a recuperative form of direct flame incinerator, and comprises in combination, an elongated confined housing with a spaced internal shell defining an internal combustion section and an annular form heat exchange section, burner means with fuel inlet means thereto projecting through one end of said housing and discharging into one end of said combustion section, a plenum section encompassing said burner means and opening to said combustion section, multiple-tubular partitioning in said heat exchange section providing a first elongated gas passageway for combustion gases and a second gas passageway for an inlet gas stream, said passageways being coextensive and an indirect heat exchange relationship with one another, a passageway means from

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the end of said combustion section into first said gas passageway of said heat exchange section at the end opposite said burner means, a combustion gas outlet from the downstream end of such elongated gas passageway and from said housing, a contaminated gas stream inlet into said housing and means connecting it to the second of said elongated gas passageways, and a gas stream outlet from the latter connecting to and discharging into said plenum section, whereby a resulting preheated incoming gas stream passes into said combustion section with burner gases.

As a feature of the improved unitary recuperative form of incinerator, the heat exchange section is maintained entirely around an inner combustion section, i.e. as an annulus, so that there may be heat transfer along the full length of the combustion zone directly into the adjacent heat exchange section. This arrangement, of course, eliminates the need for any type of insulating material around the combustion section itself and which had been required in certain of the early designs. The actual recuperative flow in the heat exchange section of the present improved unitary system may be varied. In one case, the combustion gas flow will undergo a reversal of flow direction to pass in a parallel flow manner with the contaminated gas stream entering the incinerator housing at a downstream end of the unit and becoming preheated by passing in indirect heat exchange relationship with the hot combustion gases for the full length of the unit and in a codirectional manner. Alternatively, the recuperative heat exchange flow may be such that the inlet gas stream, will have a countercurrent flow with respect to the hot combustion gases for at least a part of the heat exchange relationship. However, with either unidirectional flows or countercurrent flow arrangements, there may be variations in the tubular heat exchange means and in variations of the location of the contaminated gas inlet into the unit. For example, in a specific embodiment, the gas inlet stream may be introduced at a zone opposite the burner end of the unit such that in a single pass the inlet gas stream passes toward the burner end of the unit countercurrently to the hot combustion gas flowing away from the burner unit within the combustion section. In still another arrangement, the gas inlet may be at the burner end of the unit and have a two-pass arrangement such that in one pass the inlet gas stream passes in the same direction as the hot combustion gas stream to the downstream end of the heat exchange section and then will reverse in flow direction to pass towards the burner end of the unit in a flow countercurrent to the hot combustion gas stream in the combustion section. However, preferably in all cases, the hot combustion gas stream will undergo a reversal in flow at the downstream end of the housing so that the hot gases are available to pass back over the combustion section and in heat exchange with the incoming contaminated gas stream. Various types of baffles may be used within the heat exchange section to insure a uniform and non-channeling type of heat exchange relationship with the incoming gas stream, without regard to whether the inlet stream is within the tubular members of the recuperative section or in a passageway surrounding the tubular members.

At the burner end of the unit, there is preferably a preheated gas plenum section which is uniformly positioned around a fuel inlet burner nozzle means, such that there is a full 360° introduction of the waste gas stream into contact with the burner and the hot combustion gases being emitted therefrom. A particular advantage in utilizing an annular form heat exchange section, as part of the recuperative design, resides in the uniform, full 360° flow from the end of the heat exchange annulus into the plenum section and thence radially inward toward the axially positioned burner means.

In order to obtain the most efficient form of direct flame incineration, there are, of course, utilized the customary three elements of combustion, which comprise: time, temperature and turbulence. The time element is provided by utilizing an elongated combustion section downstream from the end of the burner means so that there may be a complete oxidation of the contaminating fumes, or other materials, entrained with the waste gas stream. With respect to mixing or turbulence and as a feature of the present improved unit, the waste gas stream is preferably introduced into contact with the burner gases by (1) providing uniformly positioned port holes around the burner nozzle means and (2) by the utilization of vanes or baffles which will, in turn, provide a spiral flow to the injected gas stream to effect a mixing thereof into the hot combustion gases being emitted from a nozzle section. A preferred design actually utilizes an outwardly flared conical section around the end of the fuel inlet line and spaced therefrom so that there may be provision to operate the burner section entirely with 100% secondary air. In this case, the flared conical section will have a multiplicity of holes which will permit air from the waste gas stream to become mixed with the fuel vapors or gases directly at the end of the fuel line and sustain oxidation from that point forward. Thus, a portion of the waste gas stream supplies air for combustion as a secondary air burner means and the remaining portion of the waste gas stream passes through the vane means to the downstream end of the conical section so that there is a thorough spiral mixing of such remaining portion of said waste gas stream with the resulting hot burner gases to be carried on into an elongated combustion section. This type of burner design, of course, makes unnecessary the provision of a combustion air blower and the accompanying air lines and valve means which will in turn provide for the premixing of primary air with the fuel upstream from a burner nozzle system.

Reference to the accompanying drawing and the following description thereof will serve to emphasize the features and advantages of the present invention as well as point out specific aspects of construction to obtain an improved recuperative form of efficient operation.

DESCRIPTION OF THE DRAWING

FIG. 1 of the drawing is a longitudinal sectional elevational view showing one embodiment of the present improved recuperative form direct flame incinerator where there is a parallel flow between the hot combustion gas stream and the incoming waste gas stream.

FIG. 2 of the drawing is a partial cross-sectional view, as indicated by line 2—2 in FIG. 1, showing an arrangement of vanes around the end of a burner cone so as to provide a spiral gas flow into the combustion section.

FIG. 3 is a longitudinal sectional elevational view of another modified form of recuperative type incinerator where there is countercurrent parallel flow with respect to the hot combustion gas stream and the incoming contaminated gas stream.

Referring now particularly to FIGS. 1 and 2 of the drawing, there is indicated an outer shell or housing 1 adapted to have a contaminated air inlet opening 2 at one end of the housing and a burner unit 3 at the opposing end of the housing. In this embodiment, the burner unit 3 has a fuel line 4 introducing gas or oil vapors into one end of the conical-form tube or member 5 which has an open end for discharging flame and gases internally into a combustion section 6. Cone member 5 is shown to have a multiplicity of holes 5' whereby at least a portion of the waste gas stream may enter the interior thereof and effect mixing with the fuel from line 4 and provide for 100% secondary air type burning within the unit.

The combustion section 6 is defined by an inner shell 7 which, in turn, is spaced away from the inside of the housing 1 so as to provide an annular space 8 which accommodates the hot combustion gases that are reversing

in direction of flow from the downstream end of section 6. The hot gases pass over a plurality of heat exchange tubes 9 and then are discharged by way of outlet means 10. A tube plate 11 extends across the inside of the housing at the downstream end of the combustion section 6 so that an inlet section 12 is defined within the one end portion of the housing 1. The waste gas stream, entering through inlet port 2, will thus be diverted to pass through the plurality of tubes 9 in annular heat exchange section 8 while hot combustion gases will pass in indirect heat exchange relationship, and in a parallel flow with the incoming gases, toward the burner end of the unit and for the full length of section 6.

The preheated waste gas stream which issues from the outlet ends of the plurality of tubes 9 will enter an annular form plenum section 13 which entirely surrounds the perforate cone member 5. The plenum section is also defined between the end plate 14 of housing 1 and an internal partition plate 15. The latter has a flanged portion 16 spaced away from the internal end of the conical member 5 such that there is an annular space with a plurality of diverter plates or vanes 17. These vanes 17 are positioned at an angle and 360° around the cone 5 so as to give a spiral flow to the waste gas stream entering the end of the combustion section 6.

As noted hereinbefore, a portion of the waste gas stream will enter the multiplicity of holes 5' so as to provide air for a mixing with the fuel in the burner zone, while the remainder passes through the vane means 17 and will enter as a high velocity spiralling flow into the upstream end of the combustion section 6. The latter is, of course, of sufficient length to provide adequate burning time and contact time with the hot combustion gas from the burner section whereby there will be both sufficient temperature and sufficient time to effect the temperature reaction of all combustible materials in the waste gas stream. Where there is incomplete reaction time with entrained volatile organic materials in the waste gas stream, then there may be the undesirable production of aldehydes, organic acids, carbon and carbon monoxide and a generally undesirable incineration. However, with the proper mixing as shown and with an elongated combustion section and adequate fuel and air mixing within the burner means to insure good burning of fuel to in turn provide a high temperature operation, there will be a resulting efficient incineration operation. In addition, with the utilization of the recuperative heat exchange arrangement as provided by the present unitary system, there will be a recovery of a major portion of the heat into the incoming waste gas stream to reduce the temperature of the combustion gas stream carrying to the stack as well as minimization of heat requirements at the burner section. This aspect will be reflected in the fuel requirements and with 100% secondary burning to eliminate primary air, there is the ideal highly efficient overall operation.

Various types of directional vanes, such as 17, may be used to surround the burner means or the axially positioned cone member 5 and it is to be understood that the arrangement shown in FIGS. 1 and 2 is merely diagrammatic. However, the placement of vanes should be symmetrical, such as shown, and provide a uniform distribution of the waste gas stream into the combustion section 6. It may be further noted that the arrangement of the present embodiment is of a simple design and will eliminate the use of expensive forms of scroll burners or, alternatively, would eliminate the need of expensive fabrication for spiral-form plenums or scroll-shaped plenum chambers which would otherwise be required to provide a spiral flow to an entire waste gas stream being fed into the flame and combustion gases of a conventional form of burner.

FIG. 1 of the drawing also shows the utilization of baffle means 18 and 19 such that there are, respectively, two sizes of doughnut type baffles at spaced points along the length of the heat exchange section 8. This type baf-

fling, provides for a staggered or tortuous flow path for the hot combustion gas stream around all of the plurality of heat exchange tubes 9 whereby there will be an efficient heat exchange relationship between such combustion gas stream and the waste gas stream in the tubes 9. Again, it is not intended to limit the present invention to the exact construction shown since other types of baffle arrangements may be used within the heat exchange section, as for example, spaced perforate plates which will redistribute one of the flow streams and preclude channeling or by-passing.

Referring now particularly to FIG. 3 of the drawing, there is shown still another modified form of recuperative direct flame incinerator. In this embodiment there is an outer housing 20 which in turn is provided with a gas stream inlet 22 and an outlet 21 suitable to discharge combustion gases to stack means not shown. One end of the housing is provided with burner means which, like FIG. 1 of the drawing, has a perforated cone means 23 extending through a gas inlet plenum section 24 and discharging into a combustion section 26. A fuel line 25 extends through an end portion 27 of the housing 20 and is provided to discharge a suitable fuel stream into the interior of cone section 23. Within the latter, air from the waste gas stream passes through a plurality of holes 28 to become mixed with the fuel from line 25 and provide a resulting high temperature flame and combustion gas stream directed axially into and through the mid portion of combustion section 26. Also, as in the manner of the first described embodiment, the waste gas stream is preferably spirally mixed with the hot combustion gases from the burner means by means of directional vanes 29 which are in an annular zone circumscribing the entire end of cone section 23. The mixture of the waste gas stream and the hot burner gases will be directed longitudinally down through the elongated combustion section 26. The latter shall, of course, be of sufficient length to provide adequate time to obtain good mixing and substantially complete oxidation of the combustible components being entrained with the waste gas stream.

The combustion zone 26, in this embodiment, is defined by end plate 41, partition plate 42 and an inner cylindrical shell 30. The latter, in turn, defines the inner wall of an elongated annular form heat exchange section 31 within the interior of housing 20. The heat exchange section, in this compact unitary arrangement, receives hot combustion gases from a downstream end of zone 26 such that the gases reverse their flow to pass in indirect heat exchange relationship with a plurality of tubular members 32 which in turn accommodate the waste gas stream entering through inlet 22. Actually, in this instance, the waste gas stream initially passes through the outermost rows of the plurality of tubes countercurrent to the combustion gases and then discharges into a header section 33 provided at the downstream end of the unit. In section 33, the gases reverse direction of flow and in a second pass in the inner rows of tubes will move such that flow is concurrent with the hot combustion gases to eventually discharge into the plenum section 24. The result of the two-pass or two-directional flow arrangement for the waste gas stream results in a highly efficient heating system and the recuperation of a major portion of available temperature in the hot combustion gas stream being discharged by way of outlet stack 21. Suitable partitioning 34 at the downstream end of the incinerator unit provides for defining the header section 33 and for maintaining separate the hot combustion gases at the downstream end of section 26. In lieu of a header section 33, there may be used conventional U-bends at the ends of tubes 32 in order to give the desired reversal in flow.

At the waste gas inlet end of the unit and in the zone surrounding the burner cone 23, there is a circumferential partitioning plate 35 which provides an outer annular gas distributing space 36 that will uniformly introduce the waste gas stream into the upstream ends of tube means

32. At the same time, plate 35 defines the outer periphery of the inner annular-shaped plenum section 24 which receives the preheated waste gas stream and distributes it radially inwardly into and along the cone means 23. A part of the stream provides secondary air for the burning of fuel from line 25 and the maintenance of a high temperature flame for emission downstream axially into combustion section 26. As indicated hereinbefore, the remaining portion of the waste gas stream passes through the spaced angular vanes 29 in the annular passageway defined by flange section 37 on partition 42 and the periphery of cone section 23.

Again, it should be noted that various forms of baffle means may be utilized within the recuperative heat exchange section 31, such as conventional perforate plate means or disc and doughnuts arrangements, etc. In this instance, doughnut type baffle means 38 are shown extending from the inner wall of housing 20 while smaller diameter baffle means 39 are shown extending around the inner combustion chamber wall 30 so that there is a resulting tortuous path for the hot combustion gases to provide an efficient contact of such gases against the multiplicity of tubular members 32.

Each of the units of FIGS. 1 and 3 are provided with a suitable form of external insulation 40; however, it is not intended to restrict the present improved incinerator construction and operation to the use of one form of insulation or to any one a method of applying insulation to the housing. It should, of course, be particularly noted that the use of an annular form heat exchange section in the recuperative manner provides an elongated annulus around a central combustion section so that there is eliminated the need of any insulating material around a hot combustion section itself. Actually, it is a desired effect to have an indirect heat exchange relationship between the hot wall of the combustion section and the heat exchanger section as well as hot combustion gas flow through the annular zone.

In alternative structural arrangements of the multiple-tubular heat exchanger means of the present improved recuperative unit, it is to be noted that still other combinations of tubes and cylindrical baffles may be utilized within the scope of this invention. For example, in a two-pass counterflow arrangement, the waste gas stream may enter at the burner end of the unit, such as in FIG. 3, but instead of passing through tubular means the stream will first pass around tubes carrying hot combustion gases from the downstream end of the combustion section. Then, in a second stage countercurrent flow, the incoming gas stream will reverse flow and pass through an annular section around the combustion section to reach the burner end of the unit and feed into the combustion section. Thus, in essence, the use of an extra cylindrical partition, there is provided a double-pass, countercurrent recuperative system.

Also, other forms of burner means may be used within the scope of the present invention, however, as has been pointed out hereinbefore, it is of advantage to preclude the necessity of using primary air and having a 100% secondary air operation, with such air being from the waste gas stream itself to sustain combustion and, in turn, provide an efficient high temperature operation where all of the desired elements of combustion; i.e. time, temperature and turbulence, are available in a simplified form of unitary incinerator design.

I claim as my invention:

1. A recuperative form incinerator unit, which comprises in combination, an elongated confined housing with a spaced internal shell defining an internal combustion section and an annular form heat exchange section, a contaminated gas stream inlet means at one end of said housing, burner means with fuel inlet means thereto projecting through one end of said housing and discharging into one end of said combustion section, a plenum section comprising an annular chamber, encompassing said burner

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means and opening to said combustion section, partitioning means in said heat exchange section providing a first elongated gas passageway for combustion gases and a second annular gas passageway exterior to said first passageway for an inlet gas stream, said first and second passageways being coextensive and in indirect heat exchange relationship with one another, said second annular passageway having multiple tubular means therein, a passageway means from the end of said combustion section opposite said plenum section into first said gas passageway of said heat exchange section, a combustion gas outlet from the downstream end of said first elongated gas passageway and from said housing, said contaminated gas stream inlet having means connecting it to said tubular means, and a gas stream outlet from the latter connecting to and discharging into said plenum section annular chamber, whereby a resulting preheated incoming contaminated gas stream passes into said combustion section with burner gases.

2. The incinerator unit of claim 1 further characterized in that said contaminated gas inlet is provided at the end thereof opposite the burner means and feeds into said tubular means extending through said heat exchange section, with said tubular means opening into and communicating with said plenum section encompassing said burner means whereby said incoming gas stream passes parallel and unidirectionally with the hot combustion gas stream in the annular form heat exchange section.

3. The incinerator unit of claim 1 further characterized in that the contaminated gas inlet to said housing and the means connecting it to the second of said elongated gas passageway is at the end of the housing adjacent the burner means, circumferential partitioning around the burner means defines said annular chamber encompassing the burner means and, in addition, said annular chamber is connective with said gas inlet for distributing the con-

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taminated gas stream into said tubular means, and the latter has means for reversing flow direction whereby such incoming gas stream passes in at least two directions to provide both co-current and countercurrent flow with hot combustion gas stream prior to flow into said annular chamber encompassing the burner means.

4. The incinerator unit of claim 1 further characterized in that said annular chamber of said plenum section encompassing said burner means is provided with a plurality of vanes extending around the internal end portion of the burner means whereby a spiralling discharge flow of preheated contaminated gas will enter into the elongated combustion section and mix with high temperature burner gases, while another portion of the contaminated gas stream passes through port means directly into admixture with fuel being discharged axially into and through the burner means to be directed axially toward the elongated combustion section.

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