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Tabak

[11] **3,838,975**

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[54] **THERMAL INCINERATOR WITH HEAT RECUPERATION**

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[52] **U.S. Cl.** ..... **23/277 C,** 23/284, 110/8 A, 431/5, 423/210

[51] **Int. Cl.** **F01n 3/14**

[58] **Field of Search** ..... 23/277 C, 288 F; 423/210; 110/8 A

[56] **References Cited**

UNITED STATES PATENTS

3,090,675	5/1963	Ruff et al.	23/277 C
3,353,919	11/1967	Stockman	23/277 C
3,484,189	12/1969	Hardison et al.	23/277 C X
3,549,333	12/1970	Tabak	23/277 C

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[57] **ABSTRACT**

The present form of direct flame incinerator unit makes use of heat exchange tubing in two different, end-to-end heat exchange sections. Large diameter, self-supporting tubes are used to surround the flame-combustion zone and eliminates the conventional use of an expensive, interior cylinder positioned within and around the flame zone so as to separate the incoming gas stream from the combustion product stream. A multiplicity of small diameter tubes are used in the downstream part of the unit, with respect to combustion gas flow, and these tubes connect through a redistribution section to the larger diameter tubes around the flame-combustion section, whereby the incoming gas stream passes entirely countercurrently to the combustion gases and feeds directly into a plenum section around the burner means.

4 Claims, 4 Drawing Figures

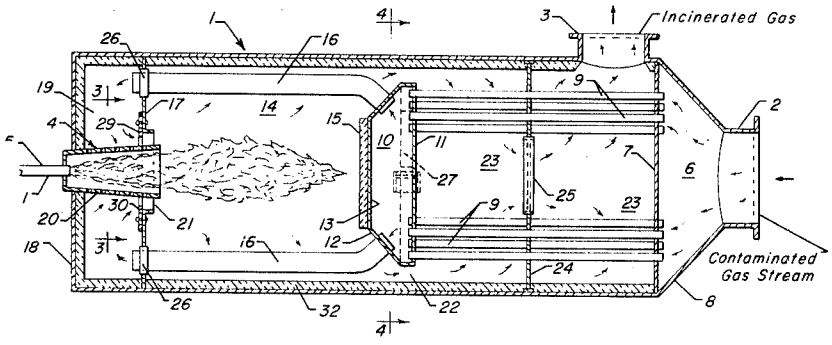


Figure 1

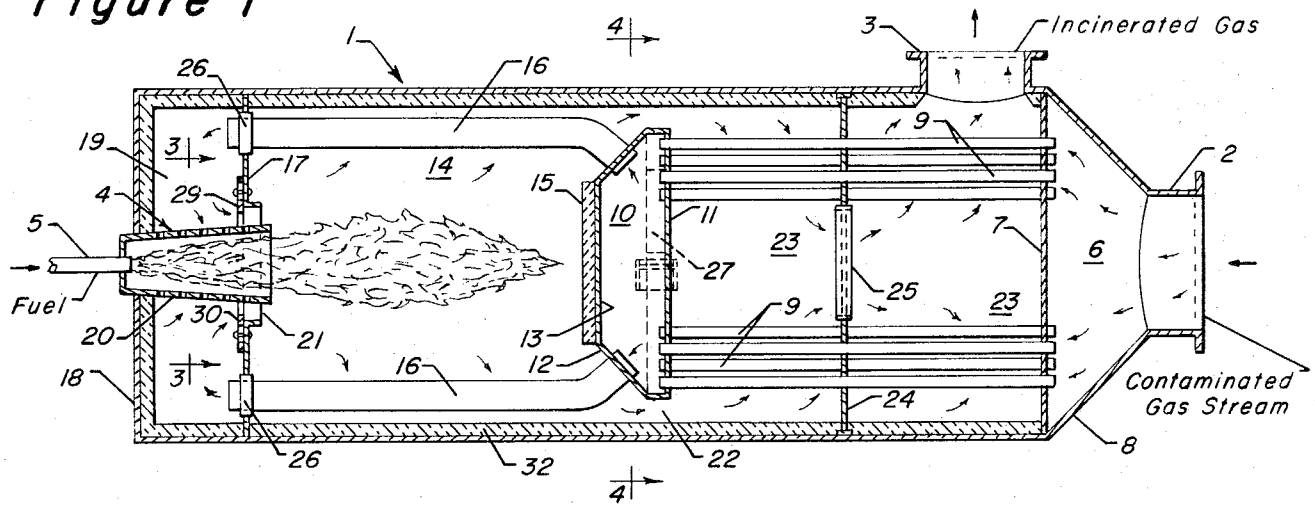


Figure 3

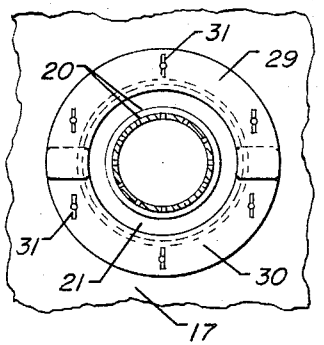


Figure 2

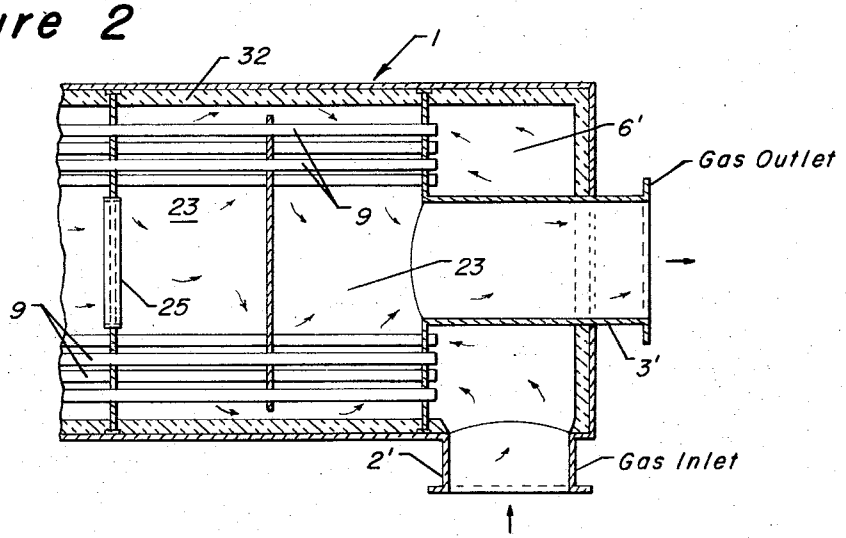
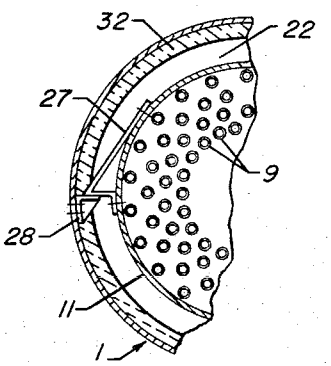


Figure 4



THERMAL INCINERATOR WITH HEAT RECUPERATION

The present invention relates to a simplified and improved form of thermal incinerator unit for treating a contaminated gaseous stream. More particularly, the improved design utilizes heat exchange tubing of two sizes, with relatively large diameter, self-supporting tubes encompassing the combustion zone to accommodate the incoming gas stream prior to its discharge to the burner zone and to the flame-combustion section.

It is recognized that most known forms of thermal incinerators provide for heat recuperation in that the incoming contaminated gas stream is passed through one or more passageways to have a heat exchange relationship with the flame and/or hot gases from the combustion zone; however, most designs and constructions have incorporated an internal cylindrical wall or partition, that is spaced inwardly from the outer housing wall. Such partitions are necessarily large and since they are in high temperature zones they must be of a heat resistant alloy material so as to be expensive from both the metal and fabrication aspects.

The present simplified and improved form of incinerator is similar to my earlier design, such as described in U.S. Pat. No. 3,549,333, as well as related to the Hardison et al construction in U.S. Pat. No. 3,484,189, to the extent that the preheated incoming waste gas stream is channeled circumferentially around the burner cone and becomes mixed with the fuel stream to provide for 100 percent secondary air burning and, preferably, no utilization of primary air to the burner means and to the combustion zone of the apparatus. It will, however, be noted that both the aforesaid patented designs incorporate internal partitioning cylinders to help define the combustion and heat exchange sections of the units. Thus, there is the expense of providing these large alloy pieces and the accompanying problems of taking care of the support and expansion of such large sized cylinders in high temperature zones.

It may also be pointed out that from a practical aspect it is desirable to have observation means into the combustion section of an incinerator and that with units having a large internal cylinder around the combustion zone it is difficult to have satisfactory observation ports to fully observe the flame conditions. On the other hand, with spaced large diameter tubes around the central combustion section, it is readily possible to have one or more observation ports through the housing wall at positions providing a sight line between tubes.

In addition to being able to use observation ports, various further advantages and design features will be set forth hereinafter; however, it may be considered a principal object of the present invention to provide at least a two-stage heat exchange arrangement and to utilize tubular members in a way to eliminate the need of any cylindrical form of inner partitioning around the main combustion zone of the unit.

It is also an object of the present invention to provide an incinerator design which can utilize commercially available tubing in both the combustion and heat exchange sections and that effects the connection of the tubing, through a redistribution section, in an end-to-end relationship such that the tubing can expand as one piece within the interior of the housing.

In a broad aspect, the present invention provides a recuperative form of thermal incinerator unit for a waste gas stream, which comprises in combination, (*a*) an elongated confined housing with an internal axially positioned combustion section at one end thereof, and a heat exchange section at the other end thereof, (*b*) burner means with fuel inlet means thereto projecting through an end of said housing and into said combustion section, (*c*) a plenum section for preheated waste gases encompassing said burner means and opening into the burner end of said combustion section, (*d*) a plurality of spaced apart large diameter heat exchange tubes positioned longitudinally adjacent the interior wall of said housing and around said internal combustion section, with an open end to each tube discharging into said plenum section at said burner means while the opposite inlet ends of the tubes connect with a gas redistribution section hereinafter defined, (*e*) a multiplicity of small heat exchange tubes positioned within said housing and extending longitudinally therewith in said heat exchange section, (*f*) combustion gas passageway means from said combustion section provided around said large diameter tubes and around said multiplicity of small tubes to be in heat exchange relationship therewith, (*g*) waste gas stream inlet means to said housing and into one end portion of each of said multiplicity of small heat exchange tubes, whereby said waste gas stream flows countercurrently to the combustion gases, (*h*) intermediately positioned gas redistribution means connective with the other end portions of each of said small heat exchange tubes and also connective with said large diameter heat exchange tubes as heretofore described whereby the resulting preheated waste gas stream can flow to said plenum section around the burner means and into said combustion section, (*i*) and an incinerated gas stream outlet from said housing downstream from said combustion section and from said combustion gas passageway means.

The tube sizes and spacings within the combustion and the heat exchange sections of the unit may vary in accordance with the quantity of waste gas stream, its temperature, velocity, etc., and it is, of course, not intended to limit the invention to the use of any predetermined number of tubes within any one section. However, the larger diameter tubes positioned around the periphery of the combustion section are preferably unsupported in an intermediate portion thereof and thereby necessarily have a relatively large diameter to be self-supporting for the length of a conventional combustion zone. In connection with the smaller diameter tubes in the heat exchange section, there may be intermediate tube support means to accommodate the spanning of tubes throughout the length thereof, as well as various types of baffling for the hot gas flow.

Various gas redistribution means may also be utilized for effecting the connection of the smaller diameter tubes with the larger diameter tubes in order to transfer the partially preheated waste gas stream from the initial heat exchange zone(s) into the larger diameter tubes around the combustion zone and thence on into the plenum section surrounding the burner means; however, in a simplified form of construction, there will be an intermediate plenum type section or chamber. In other words, this intermediate gas redistribution section may comprise a small chamber with one wall section which serves as a tube sheet for the plurality of small diameter tubes transferring the incoming gas

stream through the heat exchange section and an opposing wall section which serves to connect with the spaced larger diameter tube members passing around the combustion section of the unit. As will be pointed out more specifically hereinafter, this intermediate redistribution section may also serve as an intermediate support for the tube members, with such section being either fixedly or slideably supported from the inside wall of the housing whereby the tubular members can, in effect expand from one end of the housing to the other as one entire section.

Reference to the accompanying drawing and the following descriptions thereof will serve to point out specific aspects of design which can obtain both simplification and improvement with respect to a recuperative form of thermal incinerator.

FIG. 1 of the drawing is a longitudinal sectional elevational view showing one embodiment of the present recuperative form of direct flame incinerator where there is the use of two sizes of tubular members in an end-to-end relationship to accommodate the incoming gas stream.

FIG. 2 of the drawing illustrates in a partial sectional elevational view a modified arrangement with respect to the gas inlet and the gas outlet means from one end of the housing.

FIG. 3 of the drawing shows, in a partial sectional view, a means for adjusting the size of an air passageway means around the burner cone at the burner end of the unit, as indicated by the line 3—3 in FIG. 1.

FIG. 4 is a partial sectional view illustrating a means for slideably supporting an intermediate gas redistribution section within the interior of the housing, as indicated by the line 4—4 in FIG. 1.

Referring now particularly to FIG. 1 of the drawing, there is indicated an outer shell or housing 1 which has a contaminated gas stream inlet at 2 and a treated gas stream outlet at 3, both being at one end of the housing while a burner means 4 with fuel inlet means 5 is indicated as being provided at the opposing end of the housing. In accordance with the present simplified design, the contaminated gas stream enters inlet 2 and distribution zone 6, which is defined by tube sheet 7 and conical end portion 8, such that there is gas flow into the multiplicity of small diameter tubes 9 to carry on into a redistribution section 10 within a central portion of housing 1. The redistribution section 10 is defined by a vertical tube sheet 11, a conical portion 12 and a vertical plate 13. The latter defines the downstream end of a combustion zone 14 and will generally be insulated by suitable high temperature insulation means 15 such that flame and hot combustion gases which may impinge thereon will be diverted around the redistribution section 10.

Also in accordance with the present invention, a plurality of larger diameter tube members 16 will be spaced around the periphery of the combustion section 14, spanning between the sloping tube sheet 12 and a vertical tube sheet 17 which is spaced from end portion 18 of housing 1 to define a gas plenum section 19. Thus, the contaminated incoming gas stream will pass longitudinally through housing 1 from one end to the other by way of tubes 9, redistribution section 10 and tubes 16 into the gas plenum section 19 to then flow into and around the perforated cone member 20 and thence into combustion section 14. It should also be noted that tube support plate 17 is provided with a central opening 21 entirely around the conical member 20 such that there is space for the flow of a major portion of the contaminated gas stream entirely around the latter to be able to mix with the hot combustion gases and flame being emitted from the end of said member 20. Although not shown in the drawing, suitable ignition means may be provided to effect the initiation of flame from the fuel gas stream entering by way of line 5. After ignition the fuel will be adjusted in accordance with the amount of combustible materials in the waste gas stream entering the unit such that there is sustained flame and combustion during all periods of operation. The combustion gases from section 14, as shown by the arrows in the drawing, will be diverted over and around the plurality of tube 16 so as to flow through passageway means 22 extending around redistribution section 10 and then reach heat exchange zone 23 accommodating the multiplicity of smaller tubes 9. Various types of baffled flow may be provided for the hot combustion gas stream entering the heat exchange zone 23 and it is not intended to limit the present invention to any one type of tortuous flow path for the combustion gas stream passing through the heat exchange section to the outlet means 3.

In the specific arrangement shown, there is an intermediate tube support plate 24 with a central passageway means 25 which will channel the combustion gas stream from passageway 22 into the central portion of the heat exchange section 23 and thence into a downstream section which will then channel the gases into outlet 3.

Inasmuch as the small diameter tubes 9 are, in effect, connected to the interior ends of tubular members 16 through the redistribution section 10, it is to be noted that the resulting combination of tubes will thus tend to expand as one long unit. Also, as a result, expansion may be accommodated from one end portion of the interconnected tube arrangement or it may be from a central portion at the redistribution section 10, with expansion going each direction therefrom. By way of example, in one arrangement, the tube bundles may expand from a fixed point at the tube support sheet 7, through the support means for redistribution section 10, and on through support means 26 in the tube sheet 17 at the burner end of the unit. Although not shown in detail, the tube support means 26 for each of the tubes 16 passing through sheet 17 can have adequate sizing to permit slideability for each of the tubes 16 and permit accommodation of expansion movements for the entire combination of tubes. Also, as specifically shown in FIG. 4 of the drawing, there may be a bracket member 27 connective with each side portion of redistribution section 10 which will in turn rest on suitable shelf-support means 28 attached to an inside wall portion of housing 1, with slideability being permitted between brackets 27 and brackets 28.

Referring now to FIG. 2 of the drawing, there is indicated a modified flow arrangement through the heat exchange section 23 for the thermal incinerator unit and an accompanying modification with respect to the gas inlet and gas outlet means. In other words, gas inlet means 2' is shown at the side of the housing 1 to discharge into an inlet distributing zone 6' which in turn feeds the incoming gas stream into the plurality of tubular members 9, while the gas outlet 3' is indicated extending axially through the end of the housing 1 from heat exchange zone 23 rather than from a side portion

thereof. Still other variations may be made in connection with the design and arrangement of gas inlet and gas outlet means for the present form of incinerator unit.

In FIG. 3 of the drawing, there is illustrated an adjustment means for effecting a change in the size of the opening 21 which extends circumferentially around the burner cone member 20 and into the interior of the combustion zone 14. For example, merely by way of illustration, slideable members 29 and 30 may be slideably attached to the tube sheet 17 by bolt means 31 whereby there may be manual adjustment to effect the size of opening 21. When the opening 21 is closed down, there will be a greater amount of gas stream forced through the plurality of openings in perforate member 20 while, conversely, when the opening 21 is enlarged there may be a greater gas flow around cone member 20 and a lesser amount into the interior thereof.

Other types of burner means may, of course, be utilized in combination with thermal incinerator units; however, as noted hereinbefore, it is preferable that the burner means utilize 100% secondary air for sustaining combustion and thereby eliminating the use of any primary air to mix with the fuel at 5, all of which can tend to lower the temperature of the flame and combustion gases being emitted from the burner means into combustion zone 14. It will, of course, be noted that the present arrangement and design provides for the customary three elements of combustion, comprising, time, temperature and turbulence. A sustained time element is provided by incorporating an elongated combustion section 14 along with high temperature and turbulence which continues through the tortuous path for the combustion gas stream as it moves on downstream around the gas redistribution section 10 into the heat exchange section and thence to the gas outlet means, all countercurrent to the incoming gas flow which is carrying through the successive flow paths provided by the small diameter tubes 9 and the larger diameter tubes 16.

An internal insulating layer 32 is indicated as being provided through the entire length of housing 1 as well as over end sheet 18 in order that there is a low wall temperature for the housing and a minimization of expansion. Where desired, there may, of course, be external insulation on the housing 1 to preclude loss of heat from the entire unit. It may again be reiterated that through the elimination of an internal, spaced cylindrical baffle member to define an internal combustion section, as well as the utilization of internal insulation for housing 1, there is a substantial elimination of alloy metal in the overall construction of the incinerator unit and an accompanying lowering of cost therefore.

Although not shown in the drawing, it is to be realized that in accordance with general commercial practice, there may be fresh air inlet means to the fume stream inlet flow path and/or a hot combustion gas bypass means to the stack provided in combination with the present form of incinerator such that there may be temperature control on the system to preclude excessive temperature into the combustion zone or to the heat exchange zone. Typically, there are temperature sensing means connected into the system along with bypass control means such that the heat content of the fumes coming into the incinerator unit will stay below 25 percent of its "lower explosive limit" (LEL) and a regulated high temperature obtained in the combustion zone itself.

I claim as my invention:

1. A recuperative form of thermal incinerator unit for a waste gas stream, which comprises in combination,
   a. an elongated confined housing with an internal axially positioned combustion section at one end thereof, and a heat exchange section at the other end thereof,
   b. burner means with fuel inlet means thereto projecting through an end of said housing and into said combustion section,
   c. a plenum section for preheated waste gases encompassing said burner means and opening into the burner end of said combustion section,
   d. a plurality of spaced apart large diameter heat exchange tubes positioned longitudinally adjacent the interior wall of said housing and around said internal combustion section, with an open end to each tube discharging into said plenum section at said burner means while the opposite inlet ends of the tubes connect with a gas redistribution section hereinafter defined,
   e. a multiplicity of small heat exchange tubes positioned within said housing and extending longitudinally therewith in said heat exchange section,
   f. combustion gas passageway means from said combustion section provided around said large diameter tubes and around said multiplicity of small tubes to be in heat exchange relationship therewith,
   g. waste gas stream inlet means to said housing and into one end portion of each of said multiplicity of small heat exchange tubes, whereby said waste gas stream flows countercurrently to the combustion gases,
   h. intermediately positioned gas redistribution means connective with the other end portions of each of said small heat exchange tubes and also connective with large diameter heat exchange tubes as heretofore described whereby the resulting preheated waste gas stream can flow to said plenum section around the burner means and into said combustion section,
   i. and an incinerated gas stream outlet form said housing downstream from said combustion section and from said combustion gas passageway means.

2. The thermal incinerator unit of claim 1 further characterized in that said intermediately positioned gas redistribution means comprises a confined plenum-type section with one wall portion serving as a tube sheet for said multiplicity of small heat exchange tubes and an opposing spaced spart wall section serving as a tube sheet for the plurality of large diameter tubes extending around said combustion section.

3. The thermal incinerator unit of claim 2 still further characterized in that said gas redistribution section has bracket means extending therefrom to engage support brackets attached to the interior wall of said housing at positions opposing said redistribution section.

4. The thermal incinerator unit of claim 1 further characterized in that movable plate means are positioned to encompass said burner means to vary the size of the opening into the burner end of said combustion section from said plenum section.

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