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(54) **Apparatus for processing industrial gases.**

(57) An apparatus is provided for processing, e.g. incinerating, industrial gases. The apparatus is of the type having a centrally disposed chamber (30). At least three separate heat exchange beds (12, 13, 14) are disposed around the periphery of the chamber (30). Each of the heat exchange beds (12, 13, 14) contains heat exchange packing elements (11). An inlet means (19) is coupled to each bed (12, 13, 14) for conducting gases to the bed (12, 13, 14) for passage therethrough into the chamber (30). An outlet means (46) is coupled to each bed (12, 13, 14) for conducting gases away from the bed (12, 13, 14) after the gases have passed outwardly from the chamber (30) through the bed (12, 13, 14). A heating means (39), preferably disposed within the chamber (30), provides heat to the chamber (30). The improvement in this apparatus comprises providing at least one heat transfer conduit (50), preferably substantially vertically within each bed (12, 13, 14). A means is provided for withdrawing heat transfer fluid from the conduit (50). Alternatively, and preferably, the heat transfer conduits (50) are disposed within the central chamber (30) or adjacent to the central chamber (30).

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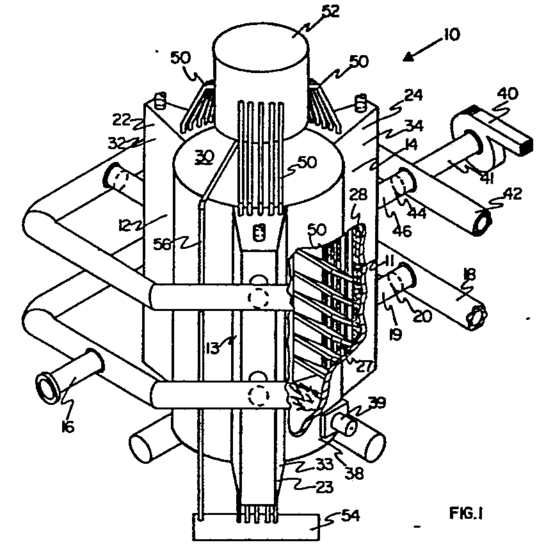
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FIG.1

APPARATUS FOR PROCESSING INDUSTRIAL GASES

This invention relates to an improvement in an apparatus for the combustion of industrial waste gases and is more particularly related to the combustion of waste gases with the extraction of usable energy in an economical and highly effective apparatus.

Steam generators designed to extract heat from waste gases are known in the art. See, for example, U.S. Patent Nos. 2,336,833 to Badenhausen, and 2,048,466 to Hays. Hays describes a heat exchanger design in a steam generator wherein an elongated bed of particulate mass is located about vertical heat transfer conduits and a mixture of combustible gases is passed vertically through the mass of particles. A surface combustion effect is obtained, resulting in a substantial rise in the temperature of the gases, to effect heat transfer to the heat transfer fluid.

U.S. Patent No. 2,967,094 to Mitchell provides for a waste heat boiler which mixes the waste gases with additional air and fuel in a central gas mixing zone to provide for sufficient combustion to elevate the temperature of the gases above a threshhold temperature level. Alternatively, Mitchell proposes to reach the threshhold temperature level by catalytic action of combustion promoters. The gas mixing zone is an elongated vertical cylindrical zone which is surrounded by an annular bed of particles, the gases passing laterally from the central mixing chamber to burn in the annular bed at a high surface combustion rate. Elongated heat transfer conduits are passed vertically through the annular bed in closely spaced, staggered arrangement to provide for a baffled flow of gases over the tubes to continually remix the gases thereby providing high heat transfer rates. Mitchell, eliminates high pressure drops and uneven temperature patterns said to exist in Hays, but requires the baffled flow of gases over the heat transfer conduits, necessitating a complicated tube arrangement, to affect high heat transfer rates.

U.S. Patent No, 3,895,918 to Mueller, the entire disclosure of which is incorporated herein by reference, describes a thermally regenerative processing apparatus having a plurality of spaced, non-parallel heat exchange beds disposed around the periphery of a central chamber. Each bed has an inlet and an outlet conduit coupled to it for conducting the gas through it in the desired direction. This apparatus, as well as other thermal regenerative type apparatus, tend to be inefficient when the gas entering the apparatus has a heating value greater than that needed for combustion of the gas. The apparatus of Mueller cannot utilize and recover this excess heat. The gas leaving the apparatus exits at a very high temperature and an auxiliary heat recovery unit must be added to the unit to recover this excess heat value. The unit described in Mueller is presently manufactured by The Regenerative Environmental Equipment Company, Inc. ("Reeco") of Morris Plains, New Jersey as the RETHERM® SYSTEM.

It is an object of this invention to overcome some of the deficiencies of the prior art waste heat boilers and thermal regenerative processing apparatus, and provide an improved and more efficient apparatus for processing industrial waste gases.

According to the invention there is provided an apparatus for processing industrial gases of the type having a centrally disposed chamber, at least three separate heat-exchange beds disposed around the periphery of the chamber, each bed containing heat exchange packing elements, an inlet means coupled to each bed for conducting gases to the bed for passage therethrough into the chamber, an outlet means coupled to each bed for conducting gases away from the bed after the gases have passed outwardly from the chamber through the bed, and a heating means for providing heat to the chamber, the improvement comprising at least one heat transfer conduit within each bed, a means for introducing heat transfer fluid to the conduit and means for withdrawing heat transfer fluid from the conduit.

The invention further provides an apparatus for processing industrial gases of the type having a centrally disposed chamber, at least three separate heat exchange beds disposed around the periphery of the chamber, each bed containing heat exchange packing elements, an inlet means coupled to each bed for conducting gases to the bed for passage therethrough into the chamber, an outlet means coupled to each bed for conducting gases away from the bed after the gases have passed outwardly from the chamber through the bed and a heating means for providing heat to the chamber, the improvement comprising at least one heat transfer conduit within the chamber, a means for introducing heat transfer fluid to the conduit and means for withdrawing heat transfer fluid from the conduit.

In the accompanying drawings:

FIG. 1 is a perspective view, partially in section of an embodiment of an apparatus of this invention;

FIG. 2 is a diagrammatic view showing the possible placement of the heat transfer conduits in relation to the central chamber and heat exchange beds;

FIG. 2A is a diagrammatic view of a preferred embodiment of heat transfer conduits;

FIG. 3 is a plan view of the embodiment of the apparatus of this invention depicted in FIG. 1;

FIG. 4 is an enlarged view in perspective and partially in section of a portion of the apparatus shown in FIGS. 1 and 3;

FIG. 5 is a sectional view of the portion of the apparatus shown in FIG. 4 taken along line 5-5 of FIG. 4; and

FIG. 6 is a diagrammatic plan view of an embodiment of heat transfer conduits and headers.

The apparatus of this invention is an improvement over the apparatus described in U.S. Patent No. 3,895,918 to Mueller. As indicated previously, the entire disclosure of this patent is incorporated herein by reference. For a more detailed description of the apparatus, the reader is referred to that patent.

Referring now to FIGS. 1-6, there is shown an apparatus for processing industrial gases, generally designated (10). The gases are usually combustible waste gases and may include entrained liquids, solids and/or a fuel which may be ignited. Referring to the embodiments depicted in FIG. 1 and FIG. 5, the apparatus (10) comprises three heat exchange beds (12, 13 and 14) containing heat exchange elements (11), e.g. ceramic packing elements. As shown in FIG. 3, the beds (12, 13 and 14) are, preferably, disposed substantially equiangularly around the periphery of a central purification chamber (30). Waste gases from industrial or other processes are conveyed to the beds (12, 13 and 14) by gas inlet (16). Inlet (16) is connected to a distributor conduit (18) that can feed the gases to any of the heat exchange beds (12, 13 and 14).

Referring to FIGS. 1, 4 and 5, the distributor conduit (18) is coupled by connecting pipes (19) to the bottoms of the flues (22, 23 and 24) associated with the beds (12, 13 and 14, respectively). Damper valves (20) are used to control the flow of gas to any selected flue or flues and their associated heat exchange beds. The damper valves (20) may be manually controlled, but alternatively may be arranged for electro-mechanical, pneumatic or other type operation and programming to follow a predetermined cycling. The flue beds (22, 23 and 24) are contained within a vertical support structure (32, 33 and 34) having walls (25) made, for example, of metal, internally lined with refractory or other insulation material.

The beds (12, 13 and 14) are filled with heat exchange elements (11) made of, for example, ceramic or metallic elements such as those sold under the trademark "Interlox" or "Super Interlox" or "Super Interlox" by the Norton Chemical Company. Referring to FIGS. 1, 2, 4 and 5, these elements (11) are held at the innermost portion of the bed by a plurality of canted refractory or metallic louvers (27) substantially adjacent to chamber (30), and at the outermost portion of the bed by a screen, mesh or plurality of louvers (28). Alternatively, as shown in FIG. 2A, the elements (11) may be held at the innermost portion of the bed by a screen or mesh (27a) which is water cooled by the heat transfer conduits (50).

Each bed (12, 13 and 14) and flue (22, 23 and 24) is topped by a refractory lined metallic cover (26). The central chamber (30) is generally cylindrical in cross-section, with a refractory lined dome (31).

The incoming gas after passing through damper valve (20) and connecting pipe (19) enters one of the flues (22, 23 and 24) and then passes through the screen (28) into and through the beds (12, 13 and 14) and over heat transfer conduits (50) (discussed below). The particular bed which the gas enters depends upon the setting of damper valves (20) and (44). The gas is then directed outward and upward through louvers (27) into the central chamber (30). Referring to FIG. 4, just outside of each set of louvers (27) there is an angled gas-deflecting baffle (35, 36 and 37).

The chamber (30) is furnished with a heating means, preferably at least one gas, electric or oil burner (39) projecting towards the center of the chamber (30) through an aperture formed in the curved wall (38). Burner (39) in combination with the burning gas, may generate within chamber (30) an intense heat of the order of about 750°C. to about 1100°C., burning all of the gas and any impurities contained therein. The heating means may be used just for igniting a gas which is sufficient to sustain combustion, may be used continuously to maintain an appropriate temperature for gases incapable of sustaining combustion or intermittently as the gas composition varies. The oxidized and purified gas is then withdrawn from chamber (30), passing through a selected one of the other beds and over the conduits (50).

Referring to FIGS. 1, 3, 4 and 5, the gas may be moved through the apparatus by, for example, a negative pressure produced by the action of exhaust blower (40). Blower (40) is connected by conduit section (41) and circular conduit (42) via valve (44) and conduit segments (46) to flues (22, 23 and 24). The conduit segments (46) are connected to the flues (22, 23 and 24) at points higher on the vertical support structures (32, 33 and 34) than the corresponding points at which connecting pipes (19) are connected.

Referring to FIGS. 4 and 5, at least one, and preferably a plurality of substantially vertical heat transfer conduits (50) are passed through each heat exchange bed (12, 13 and 14) and through the heat exchange elements (11). As indicated in FIG. 5, the conduits (50) are adjacent the central chamber (30). Alternatively, the heat transfer conduits (50) may pass through the central chamber. Preferably, the conduits (50) are vertical, but the invention is not to be so limited.

FIG. 2 is a diagrammatic view showing the placement of the heat transfer conduits (50a, 50b, and 50c), in relation to the central chamber (30), heat exchange bed (12, 13 and 14) and innermost louvers (27). Configuration A shows vertical conduits 50a within the heat exchange bed; Configuration B shows vertical conduits 50b within the central chamber and adjacent the bed (12, 13 and 14); and Configuration C shows vertical conduits 50c within the bed (12, 13 and 14) and adjacent the central chamber (30), i.e., just outside louvers (27).

Configuration B and C are highly preferred. Configuration C allows for high efficiency of the conduits in transferring the heat to the heat exchange fluid.

FIG. 2A shows another embodiment of the conduits (50) wherein screen 27 (a) holds elements (11) in the bed and the conduits (50) cool the screen while absorbing heat therefrom.

Conduits (50) may be placed in a closely nested and staggered arrangement to cause a continuous baffling of the flow of gas which is passed laterally over the conduits (50). This provides a continuous mixing of the gas. In the embodiment depicted in FIGS. 4 and 5, however, the conduits (50) are within each bed adjacent to the central chamber (30) just outside louvers (27) and not nested and staggered. Such nesting and staggering of the conduits (50) is not required in the apparatus of this invention to obtain optimum heat recovery, although such configurations may be utilized.

In FIGS. 4 and 5, conduits (50) are substantially surrounded by heat exchange elements (11). High heat transfer rates to the conduits (50) and heat transfer fluid (e.g. water) within the conduits (50) are provided by radiation from the hot elements (11) surrounding the conduits (50) and by convection from the turbulent gas passing over the conduits (50).

The temperature during combustion can reach a level of about 950°C. to about 1100°C. during the transfer of the gas through the beds. The gas is then rapidly cooled during its transfer through the bed through which it exits. The bed through which it exits also has vertical heat transfer conduits (50) contained therein. This provides for the efficient extraction of a large portion of the heat from the gases.

The heat transfer fluid is preferably water. Referring to FIG. 1, preferably a steam drum (52) is located above the chamber (30) on its centerline. The steam drum (52) is connected by conduits (50) (or via headers-not shown) to, for example, mud drums (54) at the lower end of the apparatus. One or more downcomer pipes (56), external to beds (11, 12 and 13) connect the steam drum (52) to the mud drum (54). Such a boiler configuration permits natural convection circulation and may be utilized with any of the conduit configurations depicted in FIG. 2 or 2A. Steam which is formed as a result of heat exchange to the conduits (50) is returned through the conduits (50) to the steam drum (52) for transfer to a desired location.

FIG. 6 depicts inward facing expansion loops (60) in the headers to conduits (50). This permits the expansion of the header during heating.

In operation the apparatus operates in a similar manner to that depicted in U.S. Patent 3,895,918 to Mueller, with the exception that excess heat above that required to raise the gases to combustion temperatures is utilized to produce steam, hot water, etc. The apparatus of this invention may have any number of beds and associated baffles, inlet and outlet valves, etc.

Optionally, in order to enhance the efficiency, reduce fuel costs, and obtain more efficient conversion of noxious gases to useful heat, the various heat exchange beds (11, 12 and 13) may have associated therewith or incorporated therein a catalytic material. The catalysts may be any one of the known catalysts suitable for the chemical reaction involved, such as the conversion, for example, of nitrous oxide into nitrogen and carbon dioxide. Of course, the particular catalyst used will depend on many things such as the inlet gas temperature, the type of noxious fumes being treated, the type and size of the heat exchange elements, etc.

Generally, most of the prior art Mueller type regenerative incinerators are installed with fixed specifications. The unit is designed to incinerate gas at a specified temperature for a specified length of time or longer. A typical temperature is 1600°F. (871°C.) for 2 seconds. Such a unit will also be designed for a maximum gas flow rate. Given the design flow rate, temperature and time, the size of the central chamber is determined. The design firing rate is fixed at a maximum to accommodate start-ups and variations in the energy (BTU) content of the gases, if any. The energy recovery chambers are then designed to achieve a desired efficiency.

For example, a unit may be designed for a 25,000 SCFM, 1600°F. (871°C.) for 2 seconds with a varying BTU content in the gases to be incinerated. A frequent source of gases requiring incineration are from processes where hydrocarbons or solvents are being evolved, such as in plastics manufacture. The solvents from this process are usually mixed with large quantities of air. These gases must be collected and incinerated to meet OSHA or other standards for worker protection.

In the prior art Mueller type regenerative incinerators, during start-up the central chamber is fired sufficiently to bring the gases to ignition temperature (assuming the gases contain sufficient energy), and then continued to be fired if the gases contain an insufficient amount of energy to maintain the gases at design temperature (e.g. 1600°F., 871°C.). The auxiliary firing into the central chamber is varied to maintain this design temperature. If there is insufficient energy in the gas to maintain design temperature then there will always be auxiliary firing to maintain that temperature. If there is more energy in the gas than required to maintain design temperature, means must be supplied to remove part of the heat otherwise the incinerator will continue to increase in temperature with very undesirable effects. Several means have been employed in the past. One is to bypass the gas from the central chamber to the exhaust. This removes part of the excess heat before it re-enters an outflowing energy conservation chamber. Such a procedure maintains design temperature. Another means used, particularly where there is a large quantity of excess energy in the gas, is to pass the gas from the central chamber through a waste heat system or boiler before exiting to the exhaust. Part of the hot gases required to be bypassed are used to maintain design temperature and the remainder of the excess heat recovered is used, for example, for making hot water or steam.

The above described embodiment of the invention:

1. Provides nearly 100% efficiency of heat transfer from the hot gases to steam or hot water. The apparatus of this invention provides an extremely high efficiency (almost 100%) in heat transfer from the hot gases in the chamber to the steam or water in the heat transfer conduit. The only heat losses possible are the losses through pipes or conduits external to the chamber, e.g. pipes connecting the heat transfer conduits to the mud drum and steam drum and the downcomer, and these losses can be almost eliminated with proper insulation.

2. Is in essence a "base load" or "constant steaming" boiler. Due to the fact that the temperature inside the chamber may be maintained comparatively constant, and the mass flow rate through the chamber constant, a "constant steaming boiler" exists. This type boiler is often very desirable.

3. Provides the option of over firing to obtain a boiler having a high efficiency; and

4. Is an inexpensive boiler.

Having set forth the general nature and embodiments of the present invention, the scope is now particularly set forth in the appended claims.

CLAIMS:

1. In an apparatus for processing industrial gases of the type having a centrally disposed chamber, at least three separate heat-exchange beds disposed around the periphery of the chamber, each bed containing heat exchange packing elements, an inlet means coupled to each bed for conducting gases to the bed for passage therethrough into the chamber, an outlet means coupled to each bed for conducting gases away from the bed after the gases have passed outwardly from the chamber through the bed, and a heating means for providing heat to the chamber, the improvement comprising at least one heat transfer conduit within each bed, a means for introducing heat transfer fluid to the conduit and means for withdrawing heat transfer fluid from the conduit.

2. In an apparatus for processing industrial gases of the type having a centrally disposed chamber, at least three separate heat exchange beds disposed around the periphery of the chamber, each bed containing heat exchange packing elements, an inlet means coupled to each bed for conducting gases to the bed for passage therethrough into the chamber, an outlet means coupled to each bed for conducting gases away from the bed after the gases have passed outwardly from the chamber through the bed and a heating means for providing heat to the chamber, the improvement comprising at least one heat transfer conduit within the chamber, a means for introducing heat transfer fluid to the conduit and means for withdrawing heat transfer fluid from the conduit.

3. The apparatus of Claim 1, wherein the heat transfer conduit is adjacent the chamber.

4. The apparatus of Claim 2, wherein the heat transfer conduit is adjacent the beds.

5. The apparatus of Claims 1, 2, 3 or 4, wherein the heat transfer conduit is substantially vertical.

6. The apparatus of Claim 5, further comprising:

a steam drum located above the chamber and external thereto in fluid, communication with the conduits;

a mud drum near the bottom of the chamber, external thereto, in fluid communication with the conduits; and

at least one downcomer external to the chamber connecting the steam drum and mud drum.

7. The apparatus of Claims 1 or 2, wherein the heating means is within the chamber.

8. The apparatus of Claim 3 or 4, wherein the conduits are connected by an expansion header.

9. The apparatus of Claim 3 or 4, wherein the heat transfer conduits maintain the heat exchange packing elements in the bed.

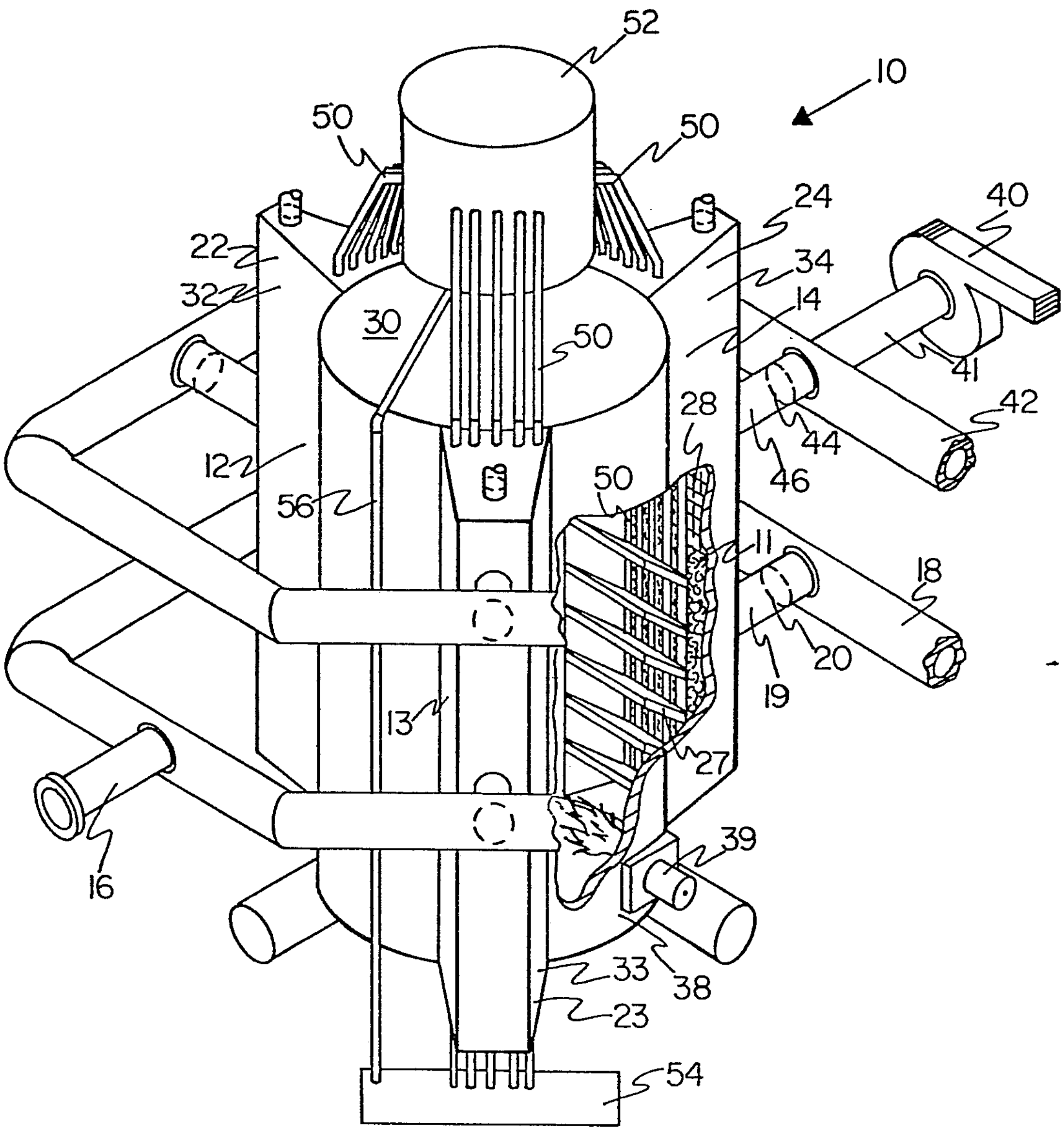
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FIG.1

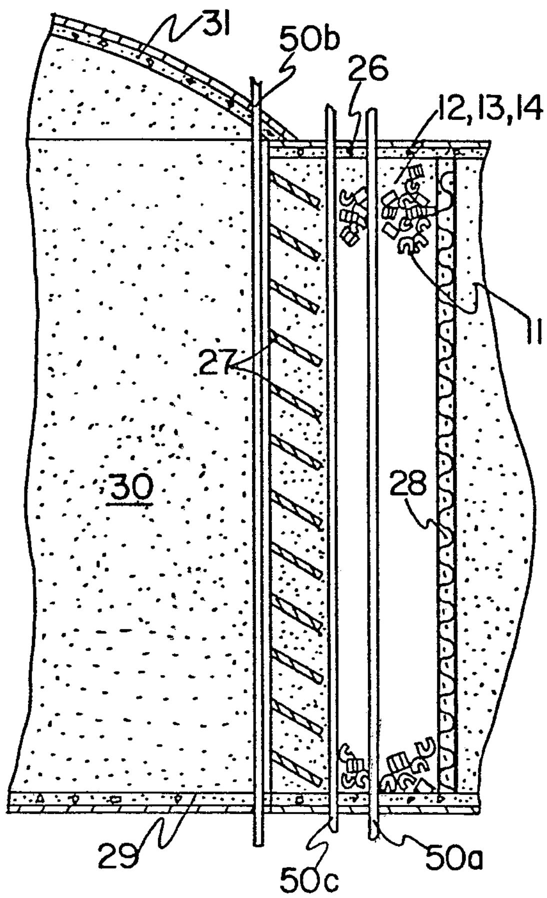
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FIG. 2

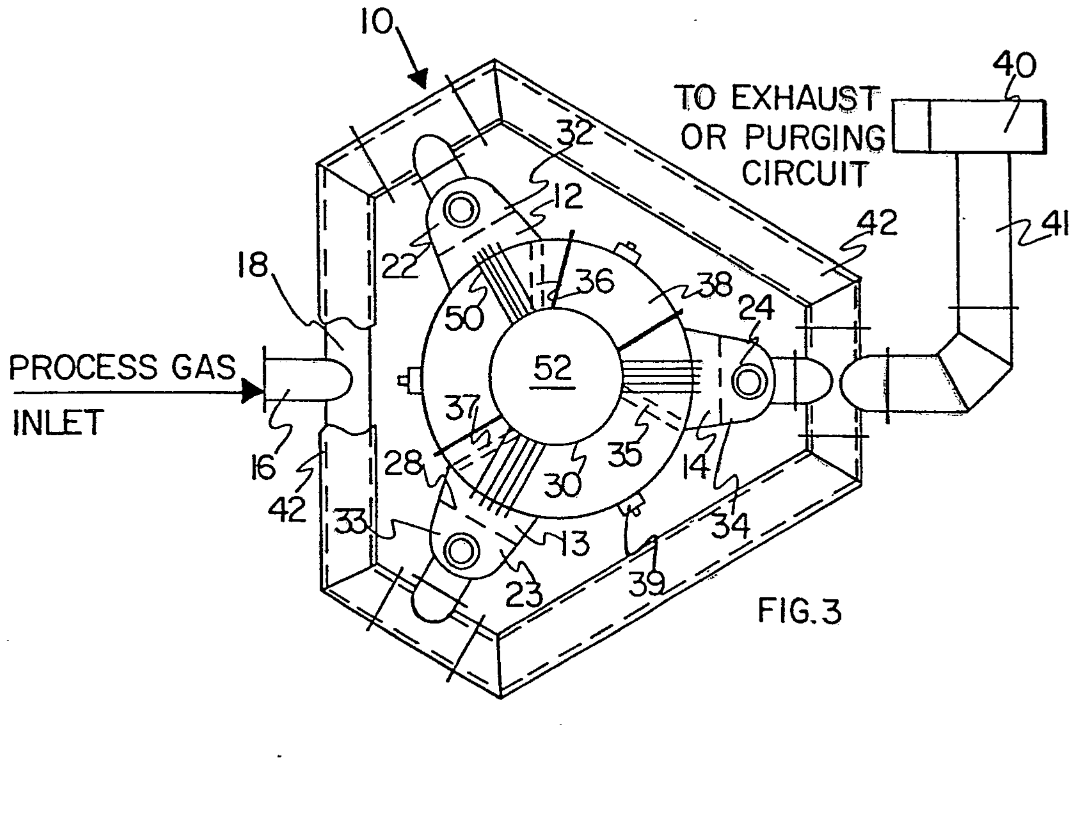
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FIG. 3

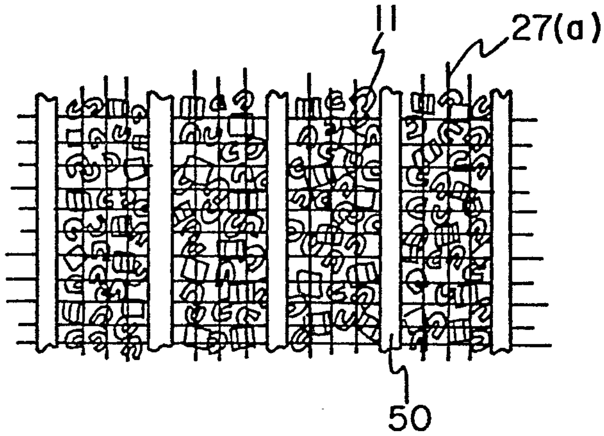
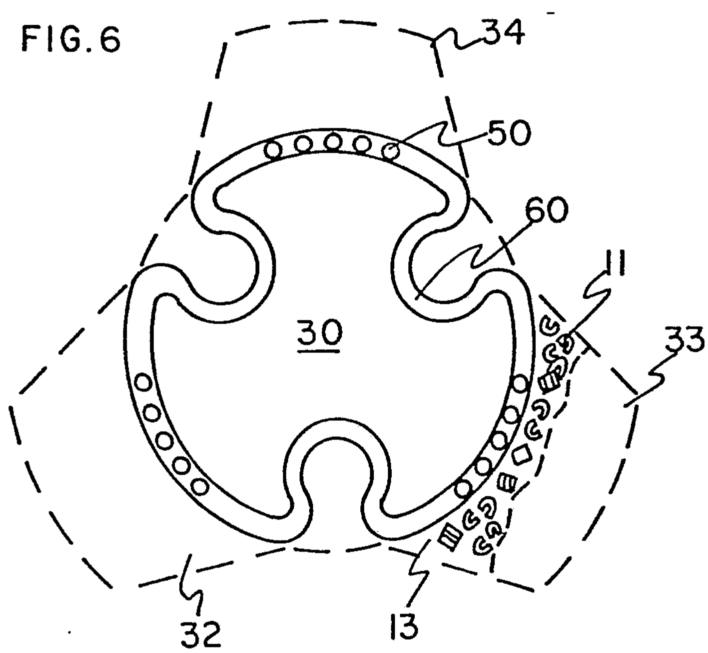


FIG. 2A

FIG. 6



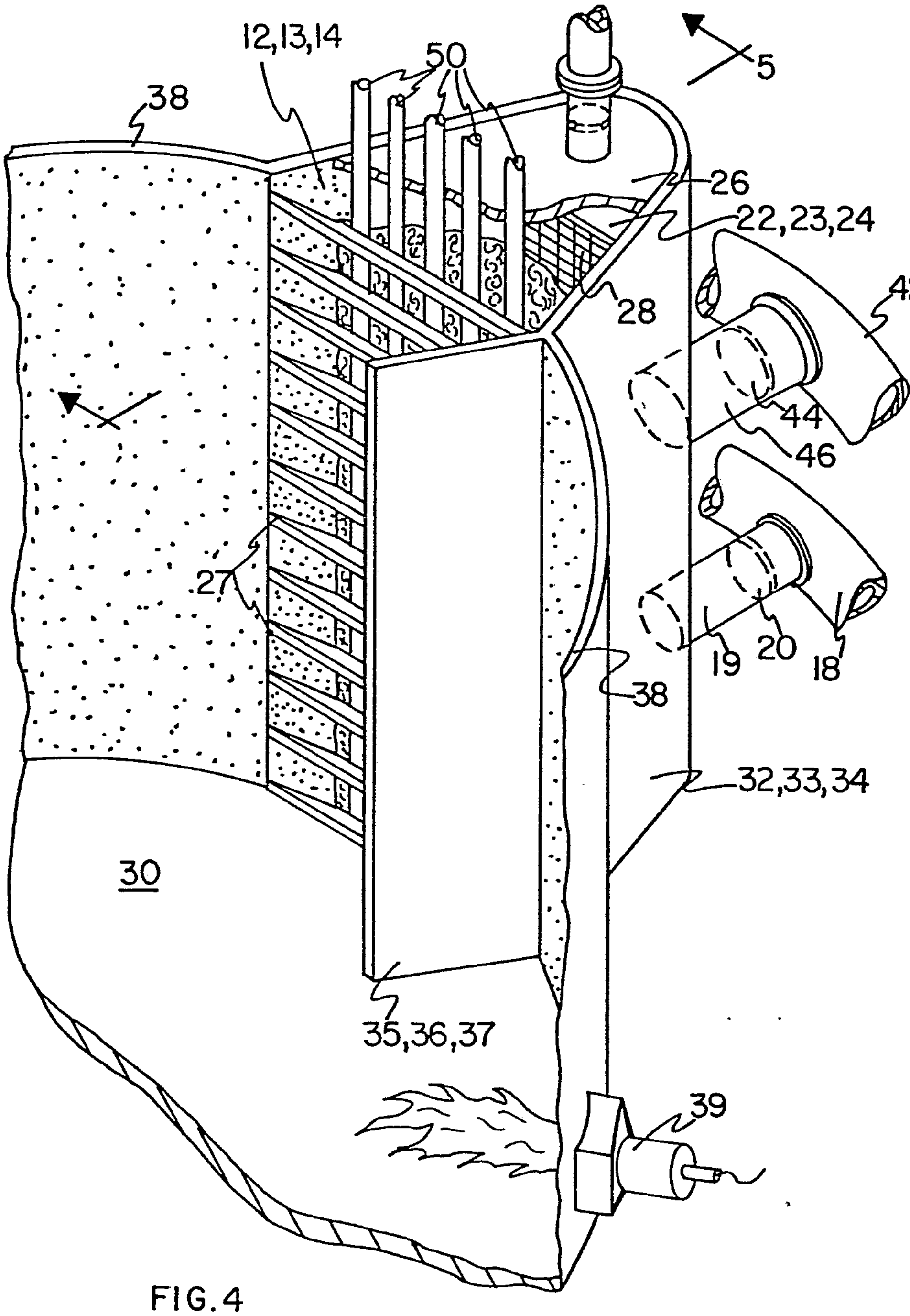

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FIG. 4

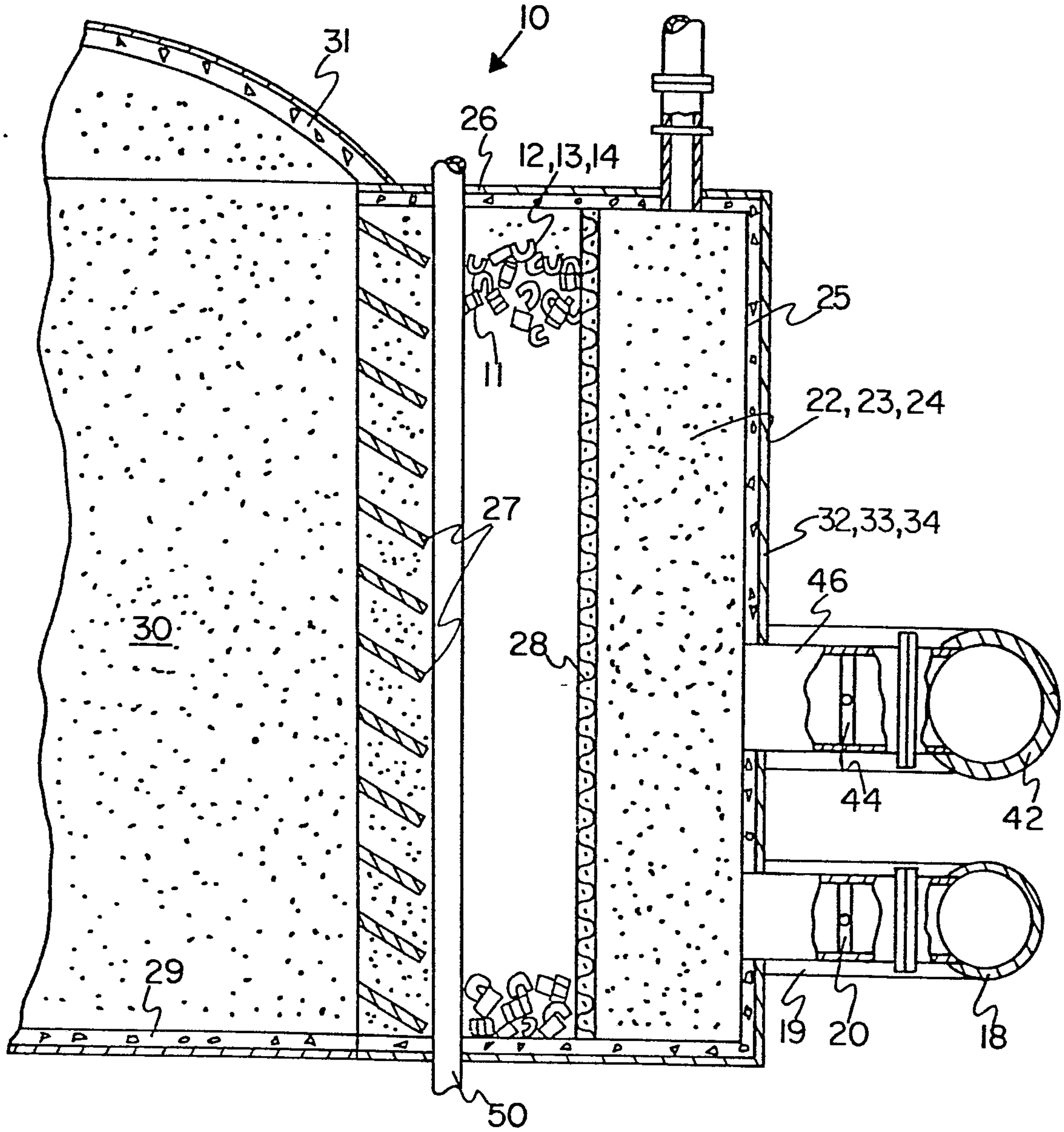
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FIG. 5

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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 81304375.9

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
D	US - A - 3 895 918 (MUELLER) * Totality * --	1,2,7	F 23 G 7/06
A	US - A - 3 543 700 (BAIGAS) * Column 7, lines 1-18; fig. 2,3,6 * --	1	
	DE - A1 - 2 951 525 (NITTETU) * Claims * ----	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.3)

F 23 G 7/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	22-12-1981	TSCHÖLLITSCH