(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 534 780 A2**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number : **92308760.5**

(22) Date of filing : **25.09.92**

(51) Int. Cl.^{5} : **F23G 7/06,** F23G 5/46, F23M 9/06

(30) Priority : **27.09.91 US 776714**

(43) Date of publication of application : **31.03.93 Bulletin 93/13**

(84) Designated Contracting States : **AT BE CH DE DK ES FR GB GR IE IT LI LU NL PT SE**

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(54) **Flame fired heat exchanger.**

(57) Odor/pollutants from cooking food products are collected and delivered to a plenum (26) proximate the burner (34) of a heat exchanger (10) which serves the food cooker (12). The burner (34) issues a flame (27) in a combustion chamber (31) having a baffle (36) arranged normal to the flame and a central opening in the baffle (36) is partially occluded by a frusto-conically shaped turbulence increasing body (41) spaced from the baffle (36) to define an annular flow slot along the body which has a central flow passageway therethrough.

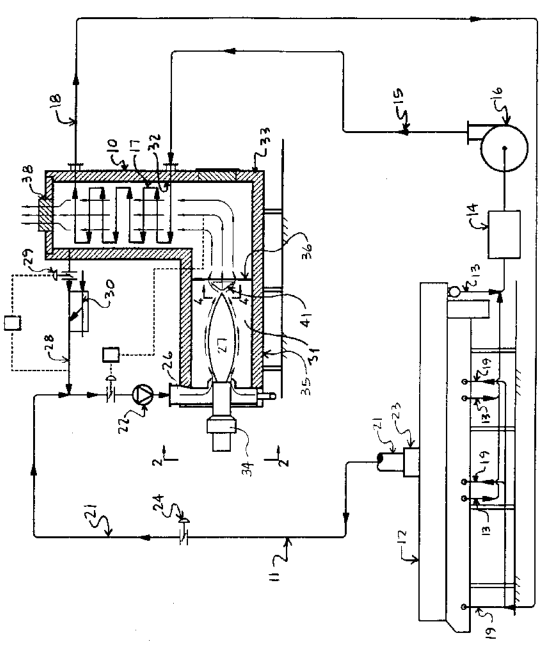

FIG 1

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This invention pertains to flame fired heat exchangers for cooking systems where atmospheric pollutants are generated from the cooking process and are circulated to the heat exchanger for treatment.

The cooking of potato chips, corn chips, chicken, meat balls and the like in a hot oil bath causes a mist to be generated over the bath. This mist includes hydrocarbons, particulates, oil droplets, smoke, water released from the food product as well as fats and other carbonaceous and odor creating elements released during the cooking process. These will be called "pollutants" below. While at one time it was common to release such pollutants to the atmosphere, today's clean air requirements prescribe that a plant operator minimize to a high extent the amount of pollutants released into the environment.

To achieve a minimal release of pollutants it has been observed that improvements are required to heat exchangers used in food cooking systems for remote heating of either a cooking fluid such as oil or water or the heating of a heat transfer fluid such as a thermal oil. Such improvements should produce a result that the odors emitted from the system are greatly reduced, if not undetectable, which is the most desirable condition indicating that pollutants are at a very low acceptable level. It is believed that the delivery of a large amount of the pollutants from the cooker to the heat exchanger combustion chamber often times passes through the combustion chamber and out the exhaust stack leaving a telltale smell in the vicinity of the plant and this is objectionable. The flow of gases in the combustion chamber, it is believed, is in a laminar pattern which tends to minimize mixing of the pollutants with the combustion gases. Thus, improvements in the combustion chamber design should ideally give a higher measure of mixing such as generating a greater amount of turbulent flow of the pollutant vapors and the combustion products so that a very minimum of odor is detectable issuing from the heat exchanger stack. A known parameter for dwell time or residence time of gases in a combustion chamber is three-tenths of a second at 760°C (1400°F) and, when products are held for this time in the combustion chamber, thorough treatment and odor reduction is achieved provided there is sufficient turbulence to ensure mixing of the pollutants and combustion gases.

The invention in summary is directed to a flame fired heat exchanger for a system for cooking a food product in a cooking fluid thereby generating cooking vapors and odor pollutants, such vapors and pollutants being released to the combustion chamber of the heat exchanger for incineration. The heat exchanger comprises a housing enclosing a tube array for carrying the cooking fluid or heat transfer fluid (thermal oil) to be heated for cooking the food product and a combustion chamber having burner means arranged therein for projecting a flame into the combustion chamber. Plenum means are disposed on the housing for receiving the cooking vapors from the cooking system and having a discharge opening for releasing vapors and odor pollutants into the combustion chamber. Baffle means are mounted in the combustion chamber extending thereacross and spaced from the burner to just beyond the coolest portion of the burner flame and having a central opening in the baffle serving to pass combustion gases therethrough along a path toward the tube array and to an exhaust discharge. A frusto-conically shaped body is mounted in the combustion chamber in a spaced-apart relationship from the baffle so as to increase the turbulence in the flow and to define an annular slot along the sidewalls of the body through the opening in the baffle. The body projects towards the burner flame and has a central flow passageway therethrough.

In the accompanying drawings:

FIG. 1 is a schematic view of a food cooking system wherein the cooking fluid is heated in a pollution-controlled heat exchanger;

FIG. 2 is a view taken in the direction of the arrows 2-2 of FIG. 1;

FIG. 3 is a view taken in the direction of the arrows 3-3 of FIG. 2;

FIG. 4 is a sectional view taken in the direction of the arrows 4-4 of FIG. 1; and

FIG. 5 is a view taken in the direction of the arrows 5-5 of FIG. 4.

As shown in FIG. 1 of the drawings, a flame fired heat exchanger 10 is arranged in a system 11 for cooking a food product in a cooker 12. The cooker 12 may be equipped for cooking potato chips, corn chips, chicken parts, meat balls and the like and, to this end, is provided-with a cooking fluid or heat transfer fluid maintained by the heat exchanger 10 in the desired cooking range typically from about 82°C (180°F) to about 204°C (400°F) and in the case of a heat transfer fluid in a range of from 204°C (400°F) to about 315°C (600°F). One or more oil outlets 13 from the cooker 12 deliver oil to a fines removal unit 14 where solids are removed from the cooking oil before delivery to a main system pump 16 which delivers oil in the direction of the arrows 15 to a heating tube bundle 17 of the heat exchanger 10 for reheating. The oil emerges from the tube bundle 17 and is delivered by a conduit 18 through one or more oil inlets 19 into the cooker 12.

To prevent vapor emissions from the cooker 12 from polluting the atmosphere surrounding the plant where the system 11 is installed, the pollutants generated in the cooking process within the cooker 12 are collected from a cooker exhaust 21. A fann 22 creates a draft or a negative pressure over the cooking fluid in the cooker 12 so that the vapors from the cooking products are drawn through the exhaust 21, first encountering an oil mist eliminator 23 which serves to remove oil droplets from the cooker exhaust for reuse of the oil in the process. A control 24 is interposed in the cooker exhaust line 21 ahead of the fan 22 so that the cooker exhaust may be delivered to a plenum 26 downstream of the fan 22, the plenum being equipped to exhaust vapors from the cooker 12 to a location within the heat exchanger 10 adjacent to a burner 34 for entrainment into the turbulent flow of the products of combustion. An air dilution stream including fresh air and exhaust from the heat exchanger is delivered through a conduit 28 into the cooker exhaust 21 flow and is controlled by regulators 29 and a barometric damper 30 to ensure that the necessary volume mixture and temperature of the mixtures reaches the plenum 26 and discharges into a combustion chamber 31 of the heat exchanger 10.

The heat exchanger 10, shown schematically in FIG. 1, is generally L-shaped having a generally horizontally disposed combustion chamber 31 arranged at a right angle to a tube bundle compartment 32 which houses the tube bundle 17. The walls of the heat exchanger 10 are formed from steel and are well-insulated as indicated by the cross-hatching in FIG. 1 with use of refractories 33 well-known in the industry. The burner 34 is mounted at one end of the combustion chamber 31 and may burn either liquid or gaseous fuel as dictated by fuel availability and cost. The burner is arranged to project a flame 27 axially along the center portion of the combustion chamber 31 towards a baffle 36 having a central orifice 37 through which the combustion gases must flow from the combustion chamber 31 to a exhaust 38 of heat exchanger 10.

So as to increase turbulence for mixing and reduce laminar gas flow within the combustion chamber, there is mounted in a substantially occluding relationshop with respect to the aperture or orifice 37 a frusto-conically shaped body 41 mounted with the larger base disposed away from the flame and the narrower base disposed closer to the flame 27, FIGS. 4 and 5. The conical-like member 41 is supported from the baffle plate 36 by one or more gusset plates 42 and is arranged concentric with the orifice 37 so as to provide, as viewed in FIG. 4, an annular slot 44 through which the combustion gases flow. In other words, the conical body 41 serves somewhat as a plug or target within the combustion chamber for increasing the turbulence, uniformity of gas temperature and uniformity of gaseous mixing between the pollution gases introduced into the combustion chamber from the plenum 26 and the products of combustion released by the burner 34. The plug or target 41 has a centrally arranged opening 46 which serves as a gas passageway into the tube chamber 32. Thus, the flow of heating gases from the combustion chamber to the tube chamber takes place through the annular slot 44 and through the cylindrical opening 46. The presence of the opening serves to reduce laminar flow along the conical surface of the body 41 and to reduce the stagnation zone of gas flow behind or downstream of the body 41.

A typical effective relationship between the inside radius "A" of the combustion chamber 31, the radius "B" of the orifice 37 and the radius "C" of the base of the plug 41 is as follows: A = 0.91 m (36 in); B = 0.57 m (22.5 in); and C = 0.53 m (21 in). The distance from the baffle plate 36 to the base of the plug 41 can be about 0.41 m (16 in).

These dimensions were selected so as to create a condition within the combustion chamber of reduced laminar gaseous flow and increased turbulent flow. At typical firing rates to maintain a combustion chamber temperature of about 760°C (1400°F), the gas flow across the target or plug 41 as indicated generally by the arrows in FIG. 5 generates a *vena contracta* which is larger in area than the orifice 37 and which dwells a distance upstram from the baffle plate 36. Gas flow through the orifice 37 generates a *vena contracta* which is smaller in area than the orifice 37 and which dwells a distance downstream from the baffle plate 36. This serves to create a more turbulent condition and to hold the gases in the combustion chamber a somewhat longer time than if the foregoing structures were absent. One important result is a decrease in laminar flow through the combustion chamber with increased temperature and mixing uniformity of the pollutants with the combustion gases to achieve a more complete incineration of the pollutants, reaching the desired low level of pollutant emissions into the atmosphere from the heat exchanger exhaust 38.

So that the position of the plug or target body 41 may be optimized with respect to the most desirable position as to the selected temperature zone of the flame and its location on the orifice plate 36, one or more of the gusset members 42 and supports 43 are provided with a series of openings and fasteners whereby different positions may be selected for adjustment of the body 41.

The baffle 36 is supported from the steel sidewall 35 of the heat exchanger by arcuately-spaced gussets 48 as shown in FIG. 4. Slots 49 are cut in the baffle plate 36 opening into the orifice 37 so as to accomodate for expansion and contraction of the baffle plate in accordance with the heat load imposed upon it.

Referring more particularly to FIGS. 2 and 3, the plenum 26 is equipped with a drain 51 and discharge valve 52 so that any liquid collected therein may be removed. It will be seen that the neck 53 of the plenum enshrouds the burner flame 27, thus ensuring that pollution products delivered by the pollution fan to the plenum will be introduced into the combustion chamber in pattern concentric with the burner flame 27.

Claims

1. A flame fired heat exchanger (10) for coupling to a system (11) for cooking a food product in a cooking fluid thereby generating cooking vapors and odor pollutants released during cooking which are retrieved and circulated to the flame burner of the heat exchanger for incineration serving to reduce the pollutants released to the atmosphere, and comprising:

   housing means (32) enclosing a tube array (17) for a heat transfer or a cooking fluid to be heated for cooking the food product, and a combustion chamber (31),

   burner means (34) arranged on the housing to project a flame (27) into the combustion chamber (31),

   plenum means (26) proximate the burner means (34) and equipped to receive cooking vapors from the cooking system and having a discharge opening (53) serving to release such vapors and odor pollutants into the combustion chamber (31),

   baffle means (36) mounted in the combustion chamber (31) and extending thereacross in a plane generally normal to the principal axis of the burner flame (27), the baffle means (36) having a central opening (37) therein serving to pass combustion gases therethrough along the path towards the tube array (17) to an exhaust discharge (38) from the heat exchanger (10), and

   a frusto-conically shaped, turbulence increasing body (41) mounted in the combustion chamber (31) spaced apart from the baffle means (36) so as to define an annular flow slot (44) along the sidewalls of the body (41) through the opening (37) in the baffle means (36), the body (41) being arranged to project towards the burner flame (27) and having a central flow passageway (46) extending therethrough.

2. A heat exchanger as claimed in claim 1, wherein means (42,43) are provided for mounting the frusto-conically shaped body (41) in a manner for spacing the body at selected distances from the baffle means (36) for changing the size of and the flow rates through the annular slot (44).

3. A heat exchanger as claimed in claim 1, wherein the turbulence increasing body (41) is positioned a distance with respect to the baffle means (36) with the major base of the body closest to and generally parallel with the baffle means (36), and the diameter of the major base being selected so that the vena contracta created by gas flow with respect to the body (41) is larger in diameter than the diameter of the central opening (37) in the baffle means (36).

4. A heat exchanger as claimed in claim 1, 2 or 3, wherein the minor base of the turbulence increasing body (41) has an opening (46) for gas flow therethrough serving to improve mixing of the pollutants and combustion gases.

5. A heat exchanger as claimed in claim 3, wherein the diameter of the major base of the body (41) is selected so that the said *vena contracta* is larger in diameter than the vena contracta created by gas flow through the central opening (37) of the baffle means (36).

6. A combination of a cooking system and a heat exchanger as claimed in any preceding claim.

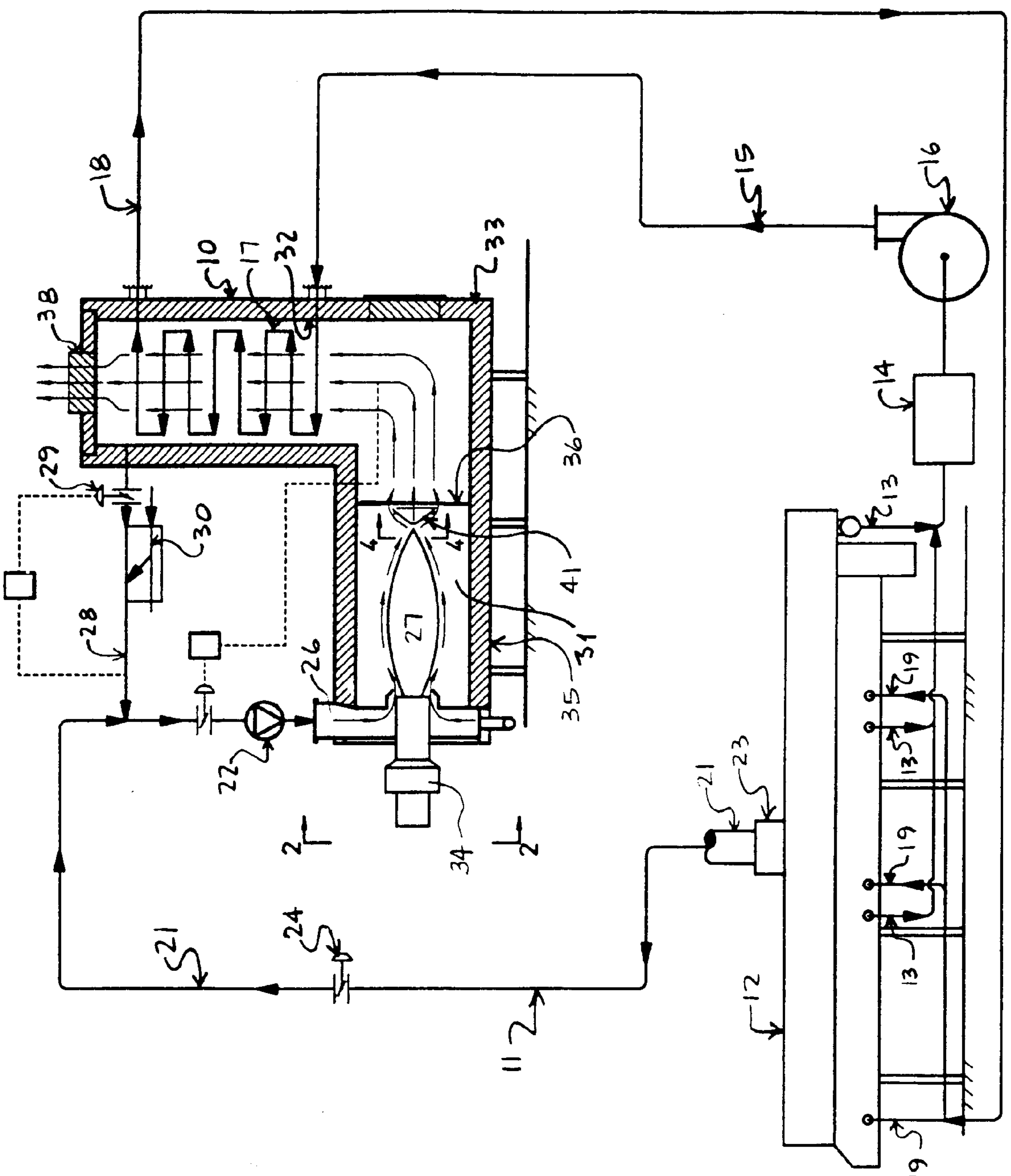
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FIG 1

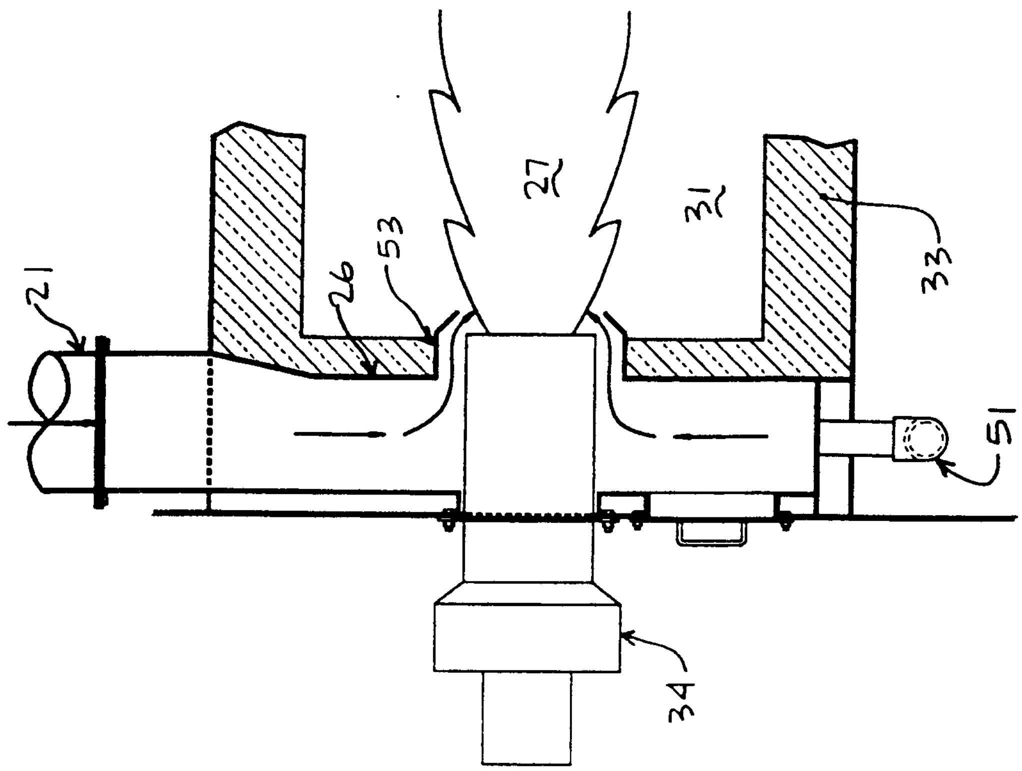

FIG 3

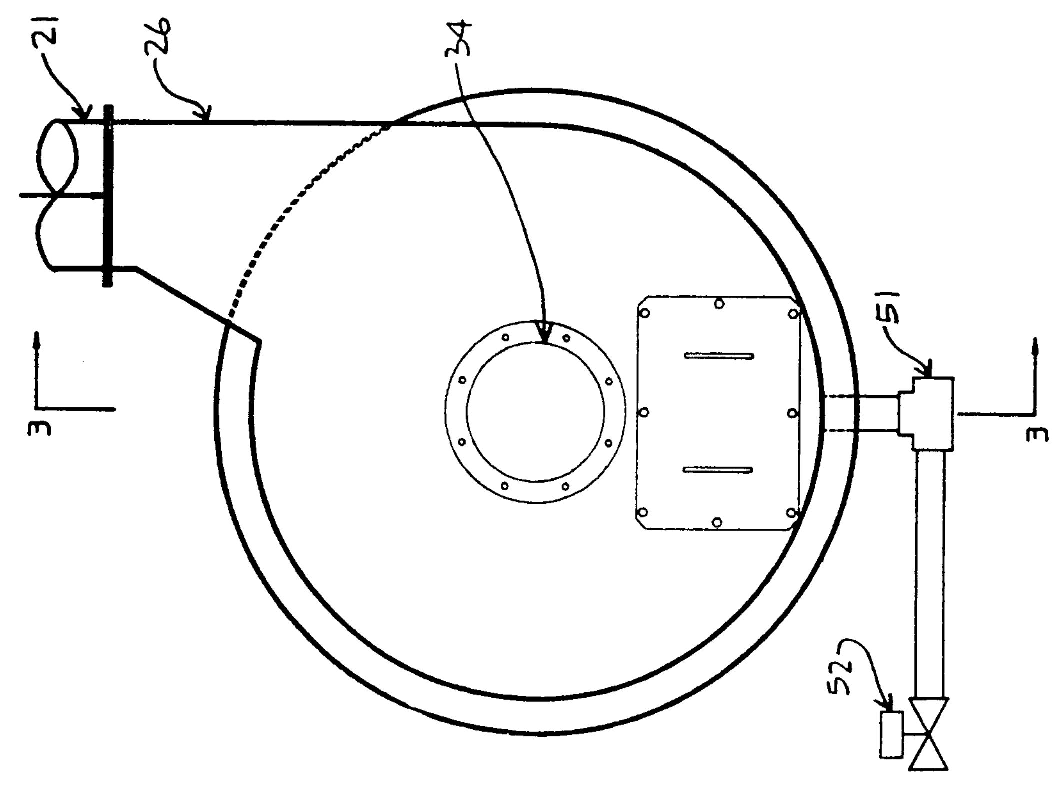

FIG 2

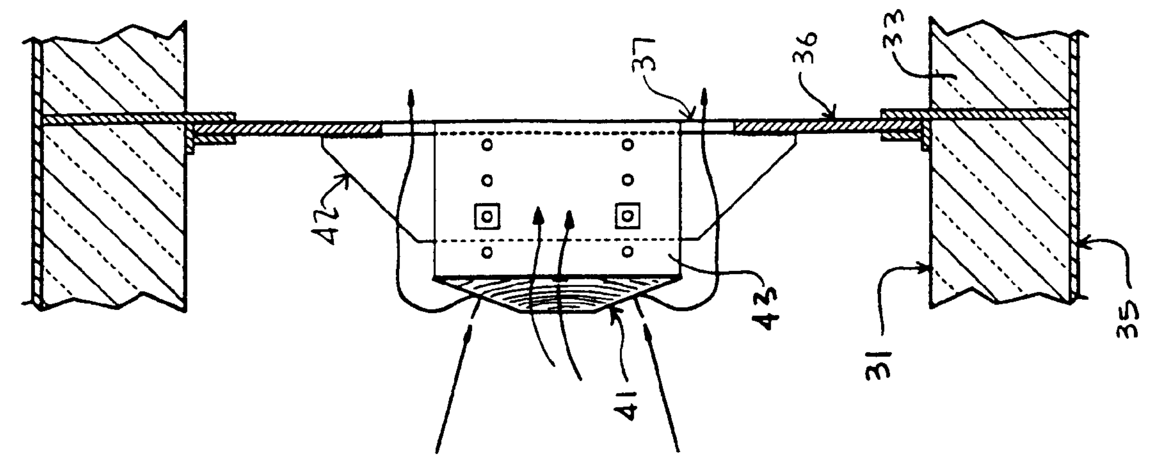

FIG 5

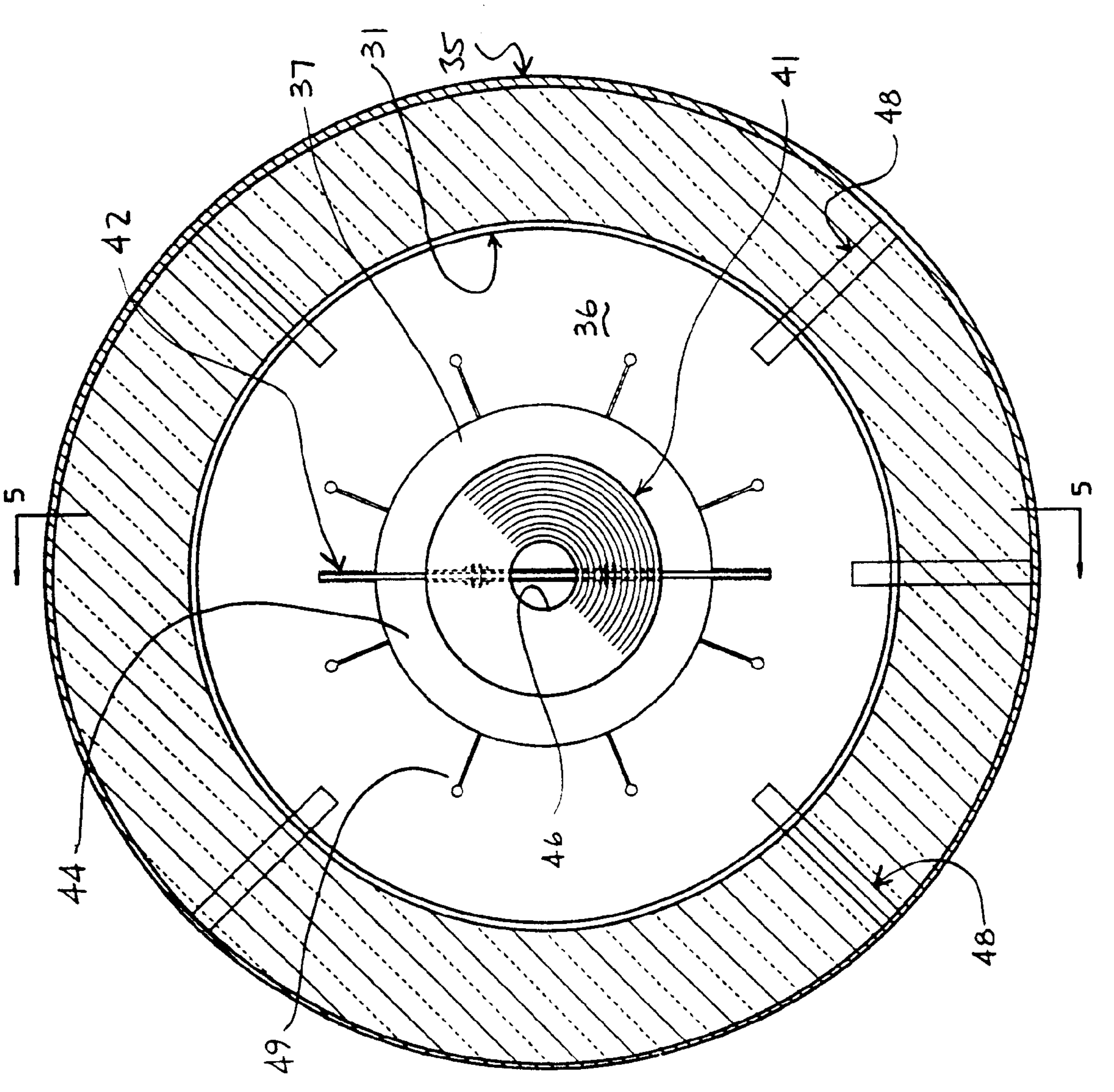

FIG 4