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[54] **FOR HEATING FLUIDS BY MEANS OF GAS PERMEABLE HEAT GENERATING MEMBERS**

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[51] **Int. Cl.** **H05b 3/12,** F24h 3/04

[58] **Field of Search** 219/301, 307, 374, 375, 219/381, 382, 300, 319; 252/504, 513, 516

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[57] **ABSTRACT**

Apparatus for heating a fluid has first and second heating chambers each having an inlet and an outlet. At least one passage connects the first heating chamber to its inlet and a fluid-permeable electrically energized heat generating member is interposed between each said passages and the first heating chamber. The outlet from the first chamber leads to the inlet of the second chamber. At least one passage connects the second heating chamber to its inlet. A fluid-permeable electrically energized heat generating member is interposed between each of said passages and the second heating chamber.

4 Claims, 2 Drawing Figures

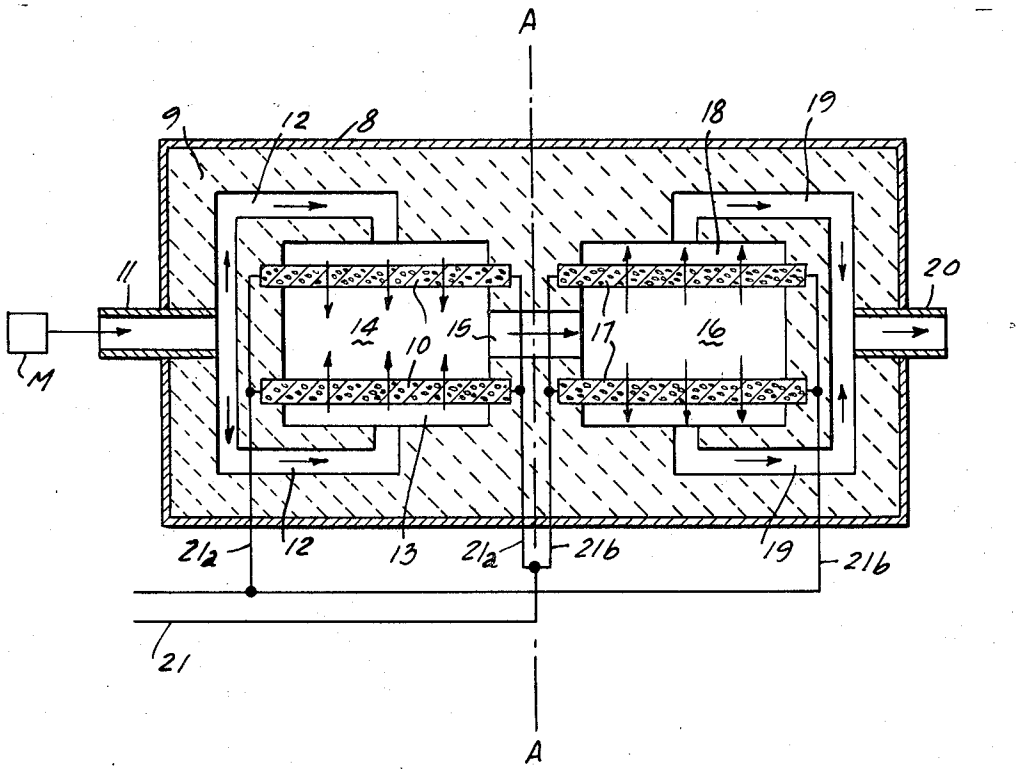


Fig. 1.

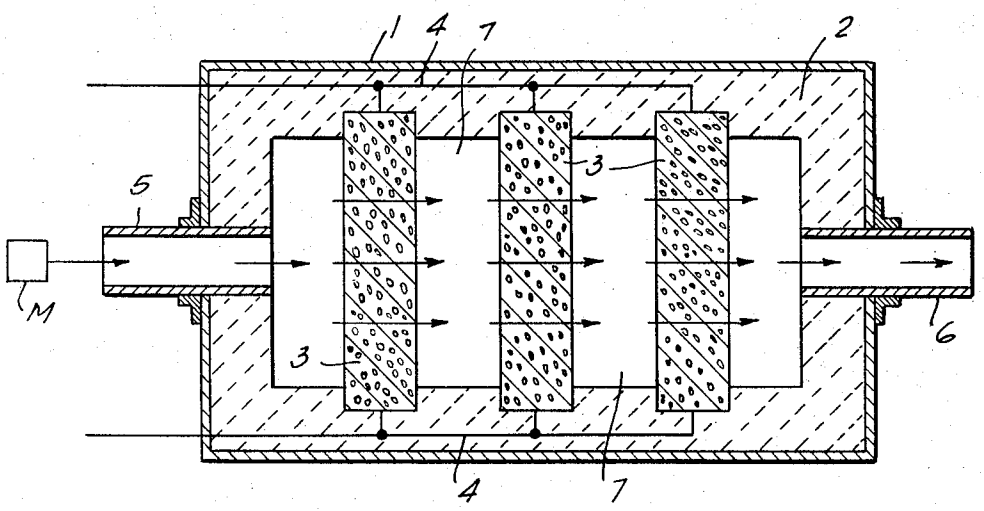
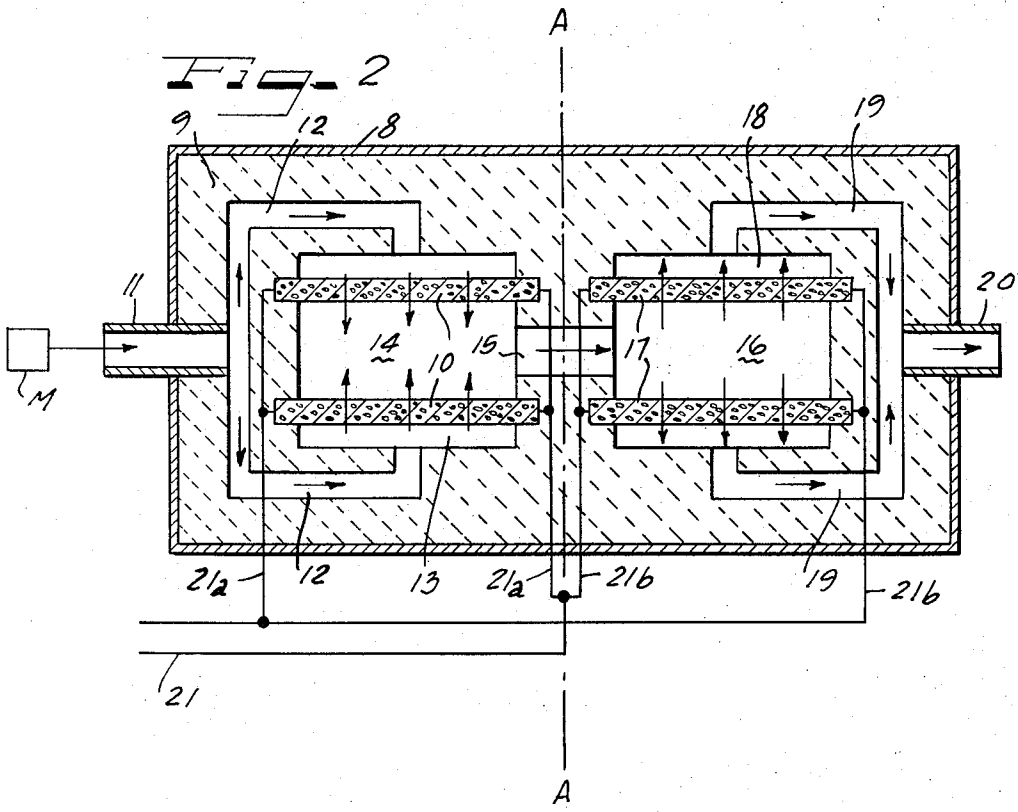

1
4
7
2
3
5
M
3
6
4
7

Fig. 2


A
9
12
8
18
19
11
20
14
10
15
17
16
M
21/2
12
13
21/2
21b
19
21b
21
A

FOR HEATING FLUIDS BY MEANS OF GAS PERMEABLE HEAT GENERATING MEMBERS

The present invention relates to new and improved apparatus for heating fluids, whether gaseous or liquid.

Although there have heretofore been proposed, and are being practiced, various methods and apparatuses for heating fluids such as air, water, and the like, uniform and constant heating of such fluids, particularly where large volume of the fluid in the heated condition is desired at the elevated temperature, has been very difficult.

Uniform and constant heating of fluids such as air or water is now required for many purposes, i.e., not only for chemical and metallurgical industries, but also for domestic heating. Such uniform and constant heating, however, normally requires heavy equipment and complicated controlling and regulating means and devices and, therefore, presents many problems both from the technological and economic viewpoints.

Heating of other fluids such as chemicals, fuels and the like besides air and water presents even greater difficulties.

An important object of the present invention is to overcome the foregoing and other disadvantages, deficiencies, inefficiencies, shortcomings and problems in prior methods and structures and to attain important advantages and improvements as will hereinafter become apparent.

Another object of the invention is to provide new and improved apparatus enabling and providing simplified structure and operation as compared with prior art methods and apparatus.

A further object of the invention is to provide a new and improved heating apparatus especially useful for industrial purposes but also having advantageous utility for space heating purposes.

It is also an object of the invention to provide a new and improved simplified, efficient, economical, large capacity means for continuous heating of fluids, both gaseous and liquid.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts embodied in the disclosure.

The heat generating member or members employed according to the present invention are required to be able to generate heat by virtue of the electrical resistance thereof to electric current passed therethrough as well as to have good gas or liquid permeability, as the case may be. By way of example, the fluid to be heated, for example, air, may be heated generally to about 1,000° C. In the case of heating to approximately a temperature ranging from 500° to 600° C. and, particularly to a relatively lower range of temperature, a uniform and constant heating can be obtained even if the heating is up to a temperature below 200° C.

According to the present invention, a fluid such as air, or other gas, or a liquid such as water or other liquid, is caused to flow through one or more heat generating members which have good, uniform permeability for the gas or liquid, as the case may be, and which are heated to a desired elevated temperature so that the fluid is heated thereby. The elevated temperature to which the fluid is heated depends upon the temperature to which the heat generating member or members can be or are heated. Uniform and constant heating of a fluid can be obtained when the heating condition for the heat generating member or members and the condition for the flow of the fluid therethrough are maintained constant.

Contrary to prior art heating which, because of the fact that a fluid is heated within a chamber by means of electrodes or combustion of fuel, tends to produce unequally heated fluid, always encountering temperature variation and has difficulties in operation and installation or in the equipment, the method according to the present invention enables a fluid to be heated while being passed through minute and uniform perforations or passages through the respective heat generating members. Especially advantageous according to the present invention is that the operation of equipment is relatively simple and enabling the heat generating member or members to be maintained at a controlled temperature so as to heat the fluid to a desired elevated temperature.

As shown in the drawing:

FIG. 1 is a schematic longitudinal sectional view of an embodiment of apparatus for performing the method of the present invention; and

FIG. 2 is a schematic longitudinal sectional view through another embodiment of apparatus for performing the method of this invention.

In a typical apparatus as represented in FIG. 1, a housing 1 is provided with a lining 2 of a refractory material or the like. At least one fluid permeable heat generating member 3 is provided, although in this instance three such members are shown equally spaced from one another and electrically connected in parallel by means of conductors 4 so that current from an electrical source, not shown, may be passed through the heat generating members. The housing is provided with a fluid inlet 5 at one end and with a fluid outlet 6 at the other end, and within the lining 2 is defined, between the inlet and outlet, a heating chamber 7 across which the heat generating members 3 are mounted so that all fluid travelling between the inlet and the outlet must pass through the heat generating member or members, as the case may be. In a preferred form, the heat generating members 3 are panels, plates or cakes of uniform porosity and uniform heating characteristics to attain uniform heating of the fluid, whether gas or liquid for which the apparatus is designed.

According to the present invention, a suitable, well known conventional permeable heat generating member or members may be employed, wherein the heat generating characteristic is by virtue of electrical resistance to electric current passed therethrough. Each heat generating member may be made of a metallic or non-metallic material which is prepared in the form of powder or wires and molded into a porous body by techniques familiar to the art, and having the desired gas or liquid permeability characteristics.

In a preferred form, the heat generating members comprise mainly a material such as silicon carbide, carbon, Ni-Cr alloys or the like which will be prepared in the form of wires, pieces, grain size, or the like. Binding material to be added to the main component of the mass may comprise powdered carbon, carbonyl iron, Ni-Cr, Co or the like and alloys thereof, a foaming agent, sawdust, organic binding materials such as

starch and plastic materials and the like which can be removed in the course of curing or baking to provide a cured or baked article with a required uniform porosity.

With the described apparatus, electrical current is passed through the heat generating members to heat these members to an elevated temperature by virtue of the heat generated by the electrical resistance of the members to the current. Fluid, such as air or liquid, is introduced through the inlet **5** into the heating chamber **7.** The fluid is passed through the respective heat generating members **3,** as indicated by the arrows, and is heated by the heat of the heat generating members. The heated fluid then leaves through the outlet **6.**

While in the embodiment of FIG. **1,** three of the heat generating members **3** have been disclosed in spaced relation with respect to each other along the elongated passage **7,** the number of heat generating members may be appropriately determined to meet the particular conditions for which the apparatus is to be used. Fluid permeability of the heat generating members, allocation of installation thereof, dimensions, etc., may be appropriately determined in accordance with the intended use purposes. The most important consideration is that the heat generating members be designed and arranged such that they are enabled to heat a required volume of fluid to a desired elevated temperature at a required speed. At least that part of each of the heat generating members **3** which is exposed to the space within the heating chamber **7** is preferably designed to assure uniform temperature generation throughout such exposed portion, so as to avoid any difference which might otherwise be caused in temperature of the mass of fluid passed through any part of the heat generating member or any of such members. In other words, uniformity of heating is a prime consideration as the fluid passes through the heat generating members or any portions thereof.

In the embodiment of the invention shown in FIG. **2,** multiple stage heating is provided for in a somewhat different manner than in the form of FIG. **1.** To this end the apparatus in FIG. **2** comprises a plurality of heating devices arranged serially and this may be as separate connected units or a plurality arranged within a common housing **8** provided with a heat-resistant lining **9** which may be a refractory material or the like. The dot-dash line AA represents a line of demarcation separating the two stage sections represented in FIG. **2.** This embodiment is able not only to heat a fluid by a first heating device and further heat the initially heated fluid by a second heating device so that much more uniform and equal heating of the fluid can be effected than may be possible by the embodiment of FIG. **1,** but also enables the first and second heating devices to be individually heated by different electric currents so that the first heating device in the series performs a preheating of a fluid to an elevated temperature and then the second or additional heating devices perform final heating of the fluid to further elevated temperature, namely, a progressive heating of the fluid where that is desirable. It will be appreciated, of course, that the apparatus can be provided with several heating stages, i.e., more than the two stages illustrated.

In the first heating stage portion of the apparatus in FIG. **2,** fluid enters to heat generating means **10** through an inlet **11** located at one end of the section. The inlet communicates with one or more, in this instance two, fluid passages **12** leading into a chamber **13** wherein the heating means **10** are located. In this instance the heating means comprise one or more heat generating members of the same general construction as the heat generating members **3** of FIG. **1,** and a number of optional arrangements are feasible. For example, a plurality of plate-like heat generating members **10** may be provided dividing the chamber **13** into a plurality of areas, one of which is adjacent to the delivery end of each of the passages **12** and with the heat generating elements or members **10** spaced in generally confronting relation to one another to define a heating chamber **14** therebetween into which the fluid heated in passing through the heat generating members is comingled and further heated by radiant heat from the generating members. Instead of separate plate-like elements, the heat generating members **10** may be in the form of a hollow tube of cylindrical or annular or square or other desirable geometric cross sectional shape, defining therein the heating chamber **14.** In any event, all of the fluid delivered by the passages **12** to the chamber **13** must pass through the heat generating member or members **10** and be heated thereby while passing to the heating chamber **14,** as indicated by the directional arrows.

From the chamber **14,** the heated fluid leaves by way of an outlet passage **15** from the chamber **14,** as indicated by directional arrow, and also serving as an inlet into a heating chamber **16,** within the second stage section or heating device of the apparatus on the other side of the dividing line AA from the first stage heating device. While the second stage heating device may be structurally the same as the first stage section or device, flow of the fluid to be further heated upon entry into the chamber **16** is in reverse direction to the flow in the first stage section. Thus, the fluid leaves the chamber **16,** as indicated by directional arrows, through heat generating means **17** in the form of a plurality of heat generating members or a tubular heat generating member structure, as preferred, and is further heated in passing therethrough into a fluid chamber **18** outside of the generating member or members **17.** It will be understood, of course, that the heat generating member or members **17** will be the same as the heat generating members **10** and **3.** From the chamber **18,** the now sequentially heated fluid leaves by way of one or more, and in this instance shown as two, passages **19** and exhausts from the apparatus through an outlet **20,** whence it is conducted to the point or place of use of the heated fluid.

Electrical energy is supplied from a suitable electrical current source (not shown) through suitable conductors **21** to respective branches **21***a* connected to the opposite ends of the heat generating member or members **10** which are of the resistance heater type. Similarly, electrical lead branches **21***b* are connected to the heat generating member or members **17** which are of the resistance heater type. If preferred or desirable, or necessary, the potential may be varied in respect to the generating members **10** and **17** to provide for successive stage heating of varied intensity, for example, wherein the heat generating member or members **17** generate a higher temperature than the heat generating member or members **10.**

Heating of the fluid with unusually efficient uniformity, as well as successive stage differential heating, can be accomplished in the FIG. **2** arrangement.

In all forms of the invention, heating is effected not only by direct contact of the fluid as it passes through the porous, permeable heat generating members, but is also heated by radiant heat serving to preheat the fluid upstream and additionally heat the same downstream from the members.

Although the heat generating members may be permanently installed in the devices, they may also be mounted in replaceable relation within the apparatus. For this purpose any preferred access doors, panels, closures, separable connections, etc., may be provided in the construction of the apparatus, as preferred. In any event, the heat generating members are positioned across the flow path of the fluid as permeable heated barriers through which all of the fluid must pass in travelling through the respective devices.

It will be appreciated, of course, that suitable fluid impelling, propelling, forcing, guiding means M, such as compressor, blower, fan, pump, impeller will be employed in motivating the fluid through the respective heating devices.

Mounting of the permeable electrical resistance heat generating members **3, 10** and **17** is in suitably electrically insulated relation to the respective housings. For this the dielectric refractory linings **2** and **9** are well suited for supporting the members directly, but other insulating means; thermal or electrical, may be employed.

It will be understood that variations and modifications may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. In apparatus for heating a fluid;

means defining a first heating chamber;

an inlet to said first chamber and an outlet from said chamber;

a passage leading to said first chamber from said inlet;

an electrical resistance fluid-permeable heat generating member;

said heat generating member being interposed between said passage and said first chamber such that the fluid to be heated must pass through the heat generating member before entering said first chamber;

a second heating chamber;

said outlet leading from the first chamber into the second chamber;

a passage leading from said second heating chamber to an outlet from said second chamber;

a second heat generating member located between said second heating chamber and the passage leading from said second heating chamber;

said inlet and outlet and passages providing for effecting movement of fluid to be heated therethrough and through said members; and

means for supplying said members with electrical current to effect electrical resistance heating thereby by passing of the current therethrough.

2. Apparatus according to claim **1,** including another passage leading from said inlet to said first mentioned heating chamber, a second heat generating member located between said second passage leading to said first mentioned chamber and such chamber, another passage leading from said second chamber, and another heat generating member located between said second chamber and said another passage.

3. Apparatus for heating a fluid, comprising:

means defining a first heating chamber and a second heating chamber with an inlet for fluid to be heated communicating through a first branch passage with the first heating chamber, a second branch passage leading from said second heating chamber to an outelt, with a passageway effecting communication between said first and second heating chambers;

a first electrical resistance, fluid-permeable heat generating member located between said first passageway and said first chamber;

a second electrical resistnace fluid-permeable heat generating member located between said second chamber and said second passage leading therefrom;

means for supplying said heat generating members with electrical current to effect electrical resistance heating thereof by passing of the current therethrough; and

means for effecting movement of fluid to be heated through said inlet and successively through said first passage and said first heat generating member to said first heating chamber, then through said passageway into said second heating chamber and therefrom through said second heat generating member and said second passage to said outlet.

4. Apparatus according to claim **3,** wherein said first passage has a plurality of branches communicating with said first chamber, each of said branches having one of the heat generating members located between it and said first heat chamber, said second passage having a plurality of branches leading from said second chamber, and each of said second passage branches having one of the heat generating members located between it and said second heat chamber.

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