United States Patent [19]

Santoleri

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[54] **VAPORIZING APPARATUS**

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[21] Appl. No.: **147,019**

[52] **U.S. Cl.** ..... **126/360 A,** 48/102, 165/39, 261/77, 261/131

[51] **Int. Cl.** **F24h 1/20**

[58] **Field of Search** ..... 261/77, 130, 131, 261/153; 48/89, 102, 211; 165/39, 60; 126/360 A

[56] **References Cited**

UNITED STATES PATENTS

3,138,150	6/1964	Hyer et al.	126/360 A
3,405,759	10/1968	Burrus et al.	165/39

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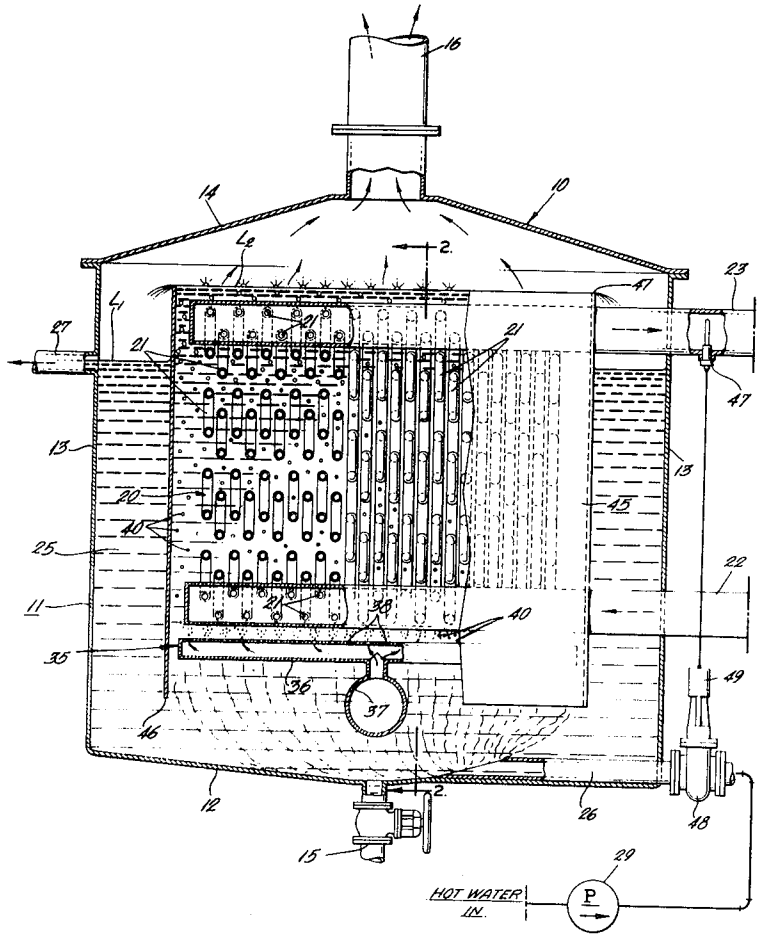
"Performance of a Novel Sub-X Heat Exchanger" by Huckaba et al., July 1967 Issue of Chemical Engineering Progress, pgs. 74-80.

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[57] **ABSTRACT**

Apparatus is disclosed for utilizing relatively low temperature heat sources such as the waste heat of thermally-polluted water for vaporizing liquid mediums such as liquefied natural gas. The apparatus comprises a tank in which is mounted a heat exchanger surrounded by a baffle plate and through which the aforementioned water is flowed. A series of sparger pipes are mounted in the tank below the heat exchanger and within the confines of the baffle plate for discharging air bubbles in an upward direction to increase the transfer of heat from the water and to the liquefied gas flowing through the heat exchanger. Means is provided to sense the temperature of the vapor leaving the heat exchanger for actuating control means associated with a valve which is connected to an inlet pipe of the tank and which is operated to increase the flow of water through the tank in response to a decrease in the temperature of the exiting vapor and to decrease the flow of water through the tank in response to an increase in the temperature of the exiting vapor.

5 Claims, 2 Drawing Figures

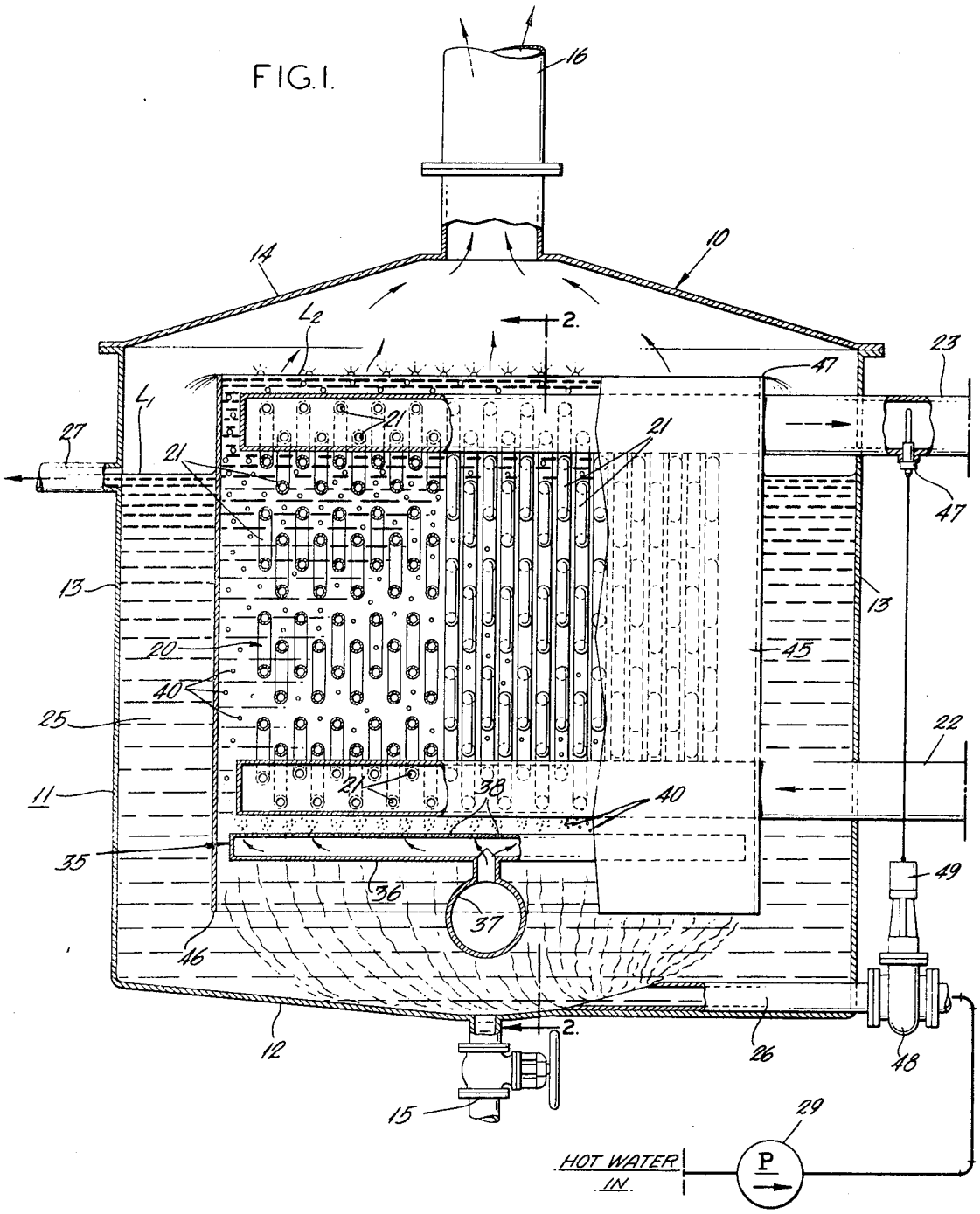


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SHEET 1 OF 2

FIG. 1.

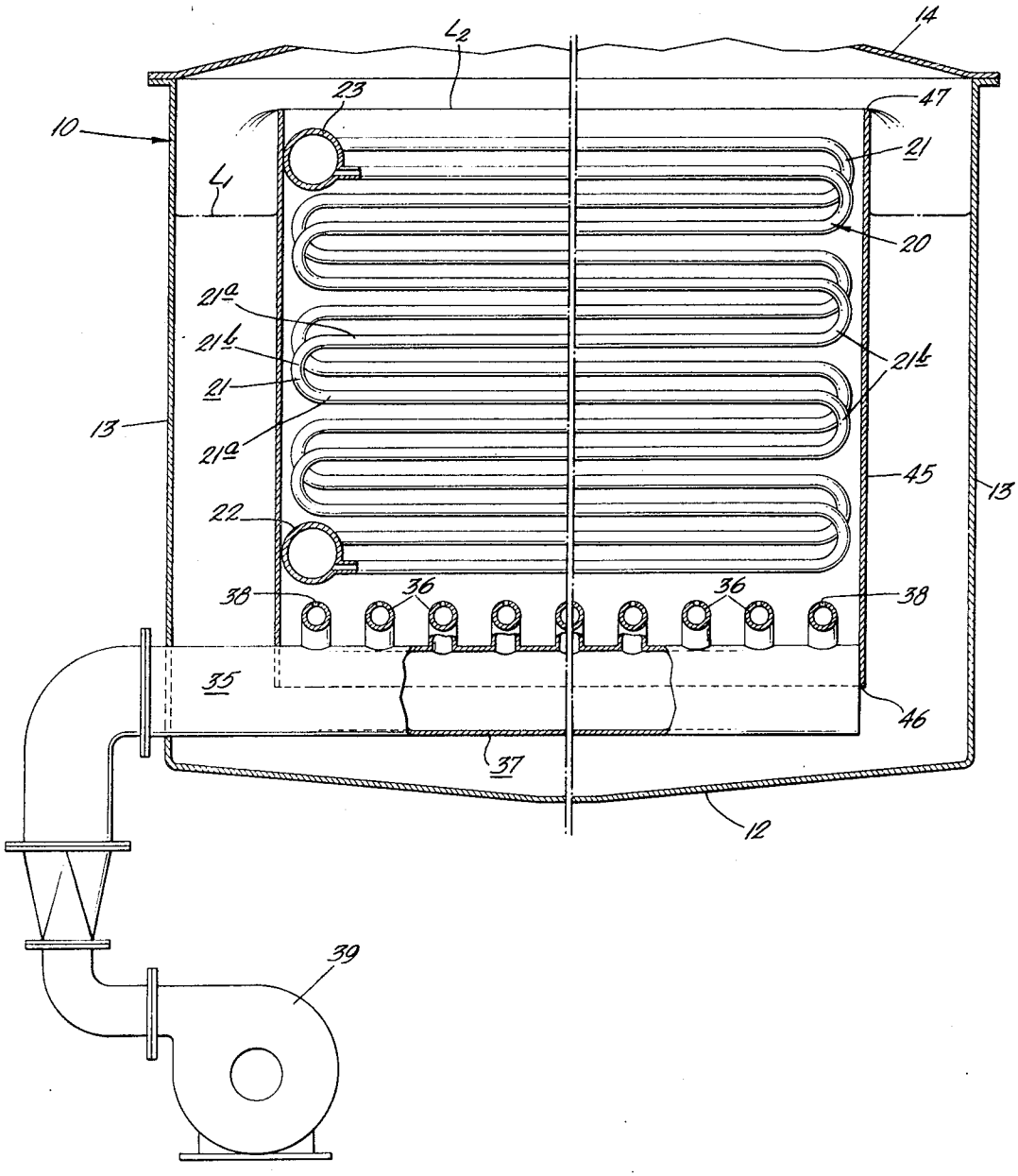


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FIG. 2.



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VAPORIZING APPARATUS

The present invention relates to heat exchange apparatus and more particularly, the present invention relates to apparatus for vaporizing liquids such as liquefied natural gas, liquefied oxygen, hydrogen, helium, ethylene and other liquefied gases.

At present apparatus is available for vaporizing liquids. An example of such apparatus is disclosed in my U.S. Pat. No. 3,138,150. Although this type of apparatus operates satisfactorily to vaporize flammable liquids such as liquefied natural gas, it is desirable to vaporize such liquids without the use and expense of the burning of fuel.

It is known that there is a considerably quantity of heat which is wasted each year, some of which finds its way into waterways to cause thermal pollution. For instance, it is not uncommon for water temperatures downstream of a steam generating plant to range between 45° and 60° F. Also it is known that there are certain areas along oceans and bays which have natural water temperatures within the foregoing range and which could provide a source of thermal energy. Thus, apparatus which is capable of utilizing natural thermal energy or waste heat as described above for performing work such as vaporizing liquefied fuels is highly desirable from an economic standpoint and the standpoint of reducing thermal pollution of waterways.

With the foregoing in mind, it is the primary object of the present invention to provide novel apparatus for safely vaporizing flammable mediums.

It is another object of the present invention to provide improved heat exchange apparatus which is capable of utilizing either waste heat or natural thermal energy for vaporizing liquid mediums.

As another object, the present invention provides unique apparatus which employes sparging means to increase the rate of heat transfer between fluid flowing across the outside of a heat exchanger and a medium flowing inside the heat exchanger.

More specifically, the present invention provides apparatus for vaporizing a liquid medium comprising a tank having an inlet and an outlet through which a fluid is flowed by means of a pump. A heat exchanger is mounted in the fluid in the tank to extract heat from the fluid and means is provided beneath the heat exchanger to expel air in an upward direction for sparging the fluid surrounding the heat exchanger. Baffle means surrounds the heat exchanger and the sparging means and means is provided defining a weir around the upper end of the baffle means to permit sparged fluid to flow outwardly toward the tank outlet after flowing upwardly across the heat exchanger. The tank is covered and vent means is provided in the cover to permit the sparging air to escape. Means is provided to sense the temperature of the medium exiting the heat exchanger and to operate in conjunction with control means to actuate a valve in the tank inlet to increase the flow of fluid into the tank in response to a decrease in the temperature of the exiting medium and to decrease the flow of fluid into the tank in response to an increase in the temperature of the exiting medium.

These and other objects, features and advantages of the present invention should become apparent from the following descriptions when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevational view of vaporizing apparatus embodying the present invention and having portions broken away to illustrate in detail a heat exchanger which is surrounded by a baffle and which is mounted above sparging pipes inside a tank containing a heated fluid; and

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1 and schematically illustrating an air compressor connected to a manifold mounting the sparging pipes.

Referring now to the drawings, there is illustrated in FIG. 1 vaporizing apparatus **10** embodying the present invention. As illustrated therein, the apparatus **10** comprises a tank **11** having a concave bottom wall **12**, sidewalls **13, 13** and a removable top closure **14.** A valved drain **15** is provided centrally in the bottom wall **12** and means, in the present instance a stack **16,** is provided in the top closure **14** for venting the interior of the tank **11.** A heat exchanger **20** is mounted centrally in the tank **11** and comprises a series of tubes **21, 21** each having substantially horizontally-disposed runs **21*a***, **21*a*** with U-shaped end portions **21*b***, **21*b*** forming a continuous tube which is sinuous in a vertical plane (see FIG. 2). In the illustrated embodiment, the runs **21*a***, **21*a*** of adjacent tubes are vertically offset with respect to one another so that fluid **25** is forced to flow in a tortuous upward path across the tubes. In order to supply the medium to be heated to the sinuous tubes **21, 21,** an inlet header **22** and an outlet header **23** are provided. As may be seen in FIG. **1,** the inlet header **22** opens into the ends of the tubes **21, 21** in the lowermost tube run and the outlet header **23** opens into the ends of the tubes **21, 21** in the uppermost tube run. The headers **22** and **23** are connected to a source of a fluid medium such as liquefied natural gas, and the liquefied gas is flowed through the heat exchanger **20** in the direction indicated by the arrows in FIG. **1.**

In accordance with the present invention, heat is supplied to the liquefied gas in the at exchanger **20** by the fluid **25** in the tank **11.** To this end, an inlet conduit **26** extends inwardly along the bottom wall **12** and terminates substantially centrally of the tank **10** below the heat exchanger **20** and an outlet conduit **27** is provided in the sidewall **13** of the tank at an elevation which is below the top of the heat exchanger **20.** In the present instance the fluid **25** is caused to flow through the tank **11** by means of a pump **29** to establish in the tank **11** a fluid level L_1 which, for reasons to be described, is lower than the level L_2 of the fluid immediately surrounding the heat exchanger **20** (see FIG. **1**). Thus, with this structure, fluid passes upwardly across the heat exchanger tubes **21** to vaporize the liquefied gas flowing therethrough.

In order to increase the rate of heat transfer between the fluid **25** and the liquefied gas in the heat exchanger **20,** means **35** is provided for sparging the fluid **25.** In the illustrated embodiment, the sparging means **35** comprises an array of pipes **36, 36** mounted in horizontally spaced relation on a manifold **37** which underlies the heat exchanger **20** and which extends substantially horizontally along the bottom wall **12** of the tank **11.** The ends of each pipe are closed, and each pipe has a plurality of upwardly open orifices **38, 38** for discharging air in an upward direction into the fluid surrounding the heat exchanger **20.** The sparging air is supplied to the pipes **36, 36** through the manifold **37** which is connected to a source of compressed air, in the present instance an air compressor **39** (FIG. **2**). Thus, when the air compressor is operated, air bubbles **40, 40** are injected into the fluid **25** surrounding the heat exchanger

20 to increase the rate of heat transfer between the fluid 25 and the medium flowing through the heat exchanger 20. For a more detailed explanation of the theory behind the use of sparging air to improve the efficiency of heat exchangers, reference is made to my article entitled "Performance of the Novel Sub-X Heat Exchanger" which appeared in the July 1967 issue of the "Chemical Engineering Progress" magazine.

In order to ensure that the air bubbles 40, 40 are flowed across the heat exchanger 20, baffle means 45 is provided around the heat exchanger 20 in the tank 11. As may be seen in FIG. 1, the baffle means 45 depends below the level of the pipes 36, 36 in the sparging means 35 and its lower edge 46 is spaced from the bottom wall 12 of the tank 11 to permit the circulation of fluid 25 in the tank. The baffle means 45 also projects above the heat exchanger 20 and has means defining a weir 47 around its upper edge. Thus, with this structure, the air bubbles 40, 40 issuing from the orifices 38, 38 in the sparging means 35 causes the fluid 25 immediately surrounding the heat exchanger 20 to rise to the level L_2 and to flow outwardly across the weir 47 toward the outlet 27 after transferring its heat to the liquefied gas medium in the heat exchanger. The sparging air is permitted escape from the tank through the stack 16.

Preferably the size of the bubbles of air issuing from the sparger are maintained as small as possible and in order to cause good contact of the bubbles with the tubes, the tubes are spaced closely adjacent one another. For best results, the spacing between adjacent tubes should be in the range of approximately 1.5 to 3.0 times the outside diameter of the tube.

According to the present invention, vaporization of the liquefied gas medium in the heat exchanger is controlled by regulating the flow of heat supplying fluid through the tank in response to changes in the temperature of the vaporized medium flowing from the heat exchanger. To this end, means, in the present instance a thermocouple 47, is mounted in the outlet header 23 of the heat exchanger 20. Motorized valve means 48 is connected in the inlet pipe 26 of the heat-supplying fluid downstream of the pump 29 and the valve 48 is selectively operable between open and closed positions to vary the rate of flow of the fluid into the tank 11. In addition, control means 49 is associated with the thermocouple 47 and the valve 48 and operates to actuate the valve in response to changes in the temperature sensed by the thermocouple 47. Thus, the control means 49 operates to open the valve 48 for increasing the fluid flow rate in response to a decrease in the temperature sensed by the thermocouple and to close the valve 48 for decreasing the fluid flow rate in response to an increase in the temperature sensed by the thermocouple. In this manner, satisfactory performance of the vaporizer is ensured by the automatic control of the flow of heat-supplying fluid to the tank. If desired, some means may be provided to supply heat to the fluid, for example, by discharging steam directly into the fluid with the control means regulating the quantity of heat supplied to insure that the liquid medium being treated is completely vaporized during passage through the heat exchanger tubes 21.

In view of the foregoing, it should be apparent that there has now been provided apparatus which is capable of efficiently vaporizing liquid mediums and which is particularly suited for safely vaporizing flammable mediums such as liquefied natural gas.

While a preferred embodiment of the present invention has been described in detail, various modifications, alterations and changes may be made without departing from the spirit and scope of the present invention as defined in the appended claims.

I claim:

1. Apparatus for converting a liquid medium to its gaseous state comprising: a tank for containing a heat transfer liquid, said tank having an inlet conduit and an outlet conduit for said heat transfer liquid, a heat exchanger mounted in said tank, said heat exchanger including an inlet header and an outlet header and a series of closely spaced serpentine tubes interconnecting the inlet and outlet headers, means to supply the liquid medium to be treated to the inlet header and carry away the gaseous state of said medium from the outlet header, a baffle member positioned within and spaced from the walls of said tank and closely surrounding the tubes of said heat exchanger, the tubes of said heat exchanger being spaced substantially uniformly within said baffle means, air sparging means mounted in said tank below said heat exchanger to discharge quantities of bubbles of air upwardly under pressure uniformly below the tubes of said heat exchanger and within said baffle and cause said heat exchange liquid to rise within said baffle and swirl around said tubes, valve means connected to said tank inlet to control the flow of said heat exchange liquid into said tank, means mounted in the outlet header of said heat exchanger to sense the temperature of the medium flowing therefrom, and means interconnecting said temperature sensing means and said valve means to control the rate of flow of said heat exchange liquid into said tank in response to the sensed temperature.

2. Apparatus according to claim 1 wherein said sparging means includes an array of pipes each having a plurality of upwardly open orifices for discharging air and a manifold mounting said pipes in spaced relation below said heat exchanger, so that sparging air is flowed upwardly across the tubes in said heat exchanger to increase the transfer of heat from said fluid and to said medium.

3. Apparatus according to claim 1 wherein said baffle means depends below the level of said sparging means in said tank to ensure the flow of sparging air upwardly across the heat exchanger.

4. Apparatus according to claim 1 including means forming a weir on said baffle means above the heat exchanger with the outlet conduit in said tank being located below said weir so that the level of the unsparged fluid in the tank is below the weir and the level of the sparged fluid is above the weir, whereby the sparged fluid flows over the weir after flowing across the heat exchanger.

5. Apparatus according to claim 1 in which the series of tubes are closely spaced adjacent one another with the spacing between adjacent tubes being in the range of approximately 1.5 to 3.0 times the diameter of the tube.

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