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Vestre

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[54] **TUBE BANK HEAT EXCHANGER AND UNIT OF SUCH HEAT EXCHANGERS**

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[51] **Int. Cl.** **F28f 9/22**

[58] **Field of Search** 165/140, 143, 160, 165/161, 163; 122/32, 34, 483

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[57] **ABSTRACT**

An improved elongated tube bank heat exchanger and a unit of such heat exchangers coupled in series for heat treatment of gas. The tube bank in the heat exchanger mantle is encompassed by a jacket extending coaxially through the mantle spaced from the inside of the mantle. The heat exchanger mantle is provided with two gas access openings positioned at the same cross-sectional plane on the mantle and substantially at the mid-point thereof. One of the accesses communicates directly with the inside of the jacket, the other access opening communicates with the spacing between the inside of the mantle and the outside of the jacket. The jacket is open at both ends, whereby the gas stream when introduced into one of the access openings is divided into two gas streams each of which flows in opposite directions through the heat exchanger, the streams turning at each respective end of the heat exchanger and being unified anew before leaving the heat exchanger.

3 Claims, 2 Drawing Figures

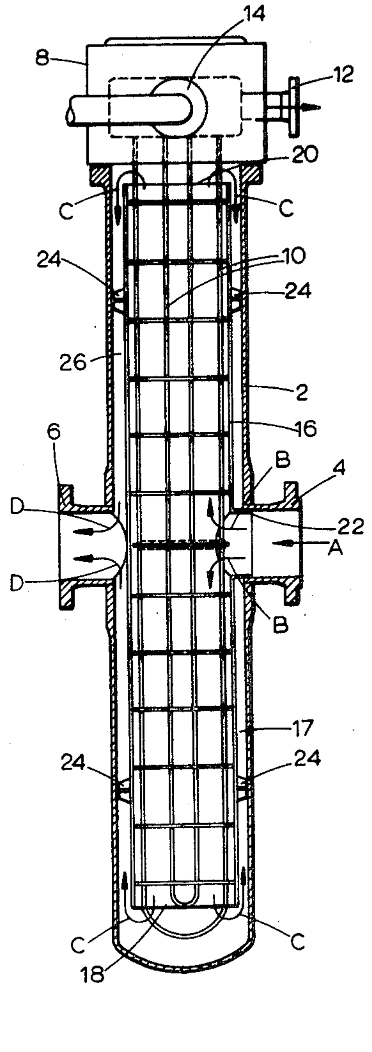

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FIG. 1.

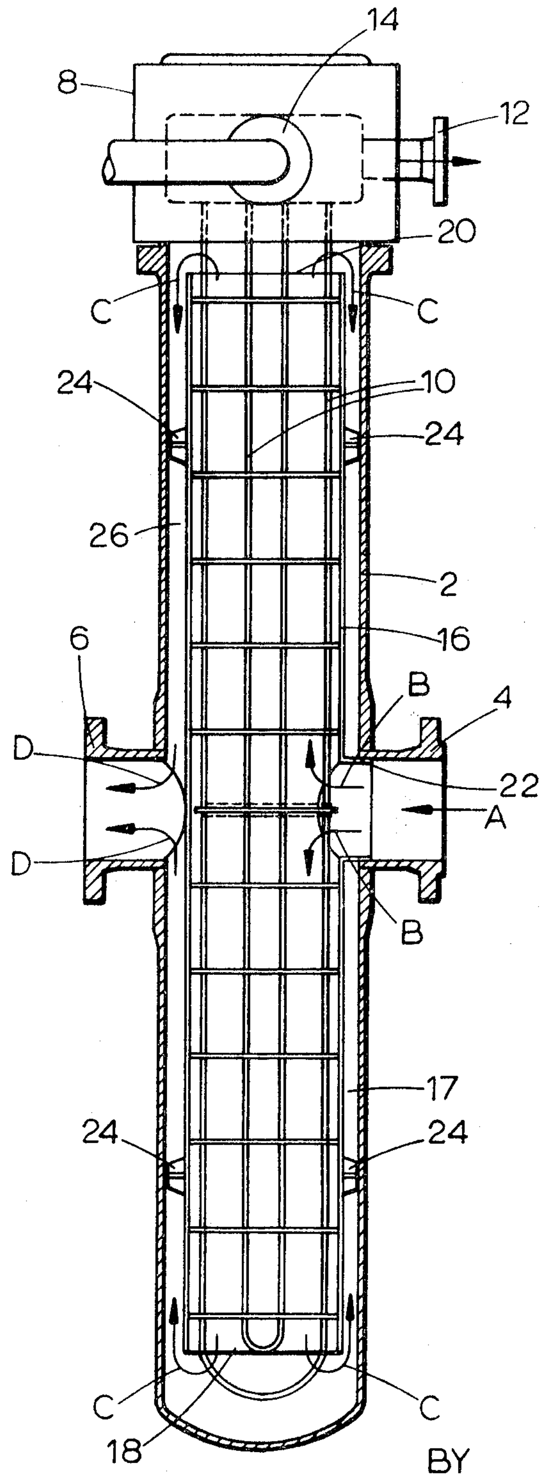

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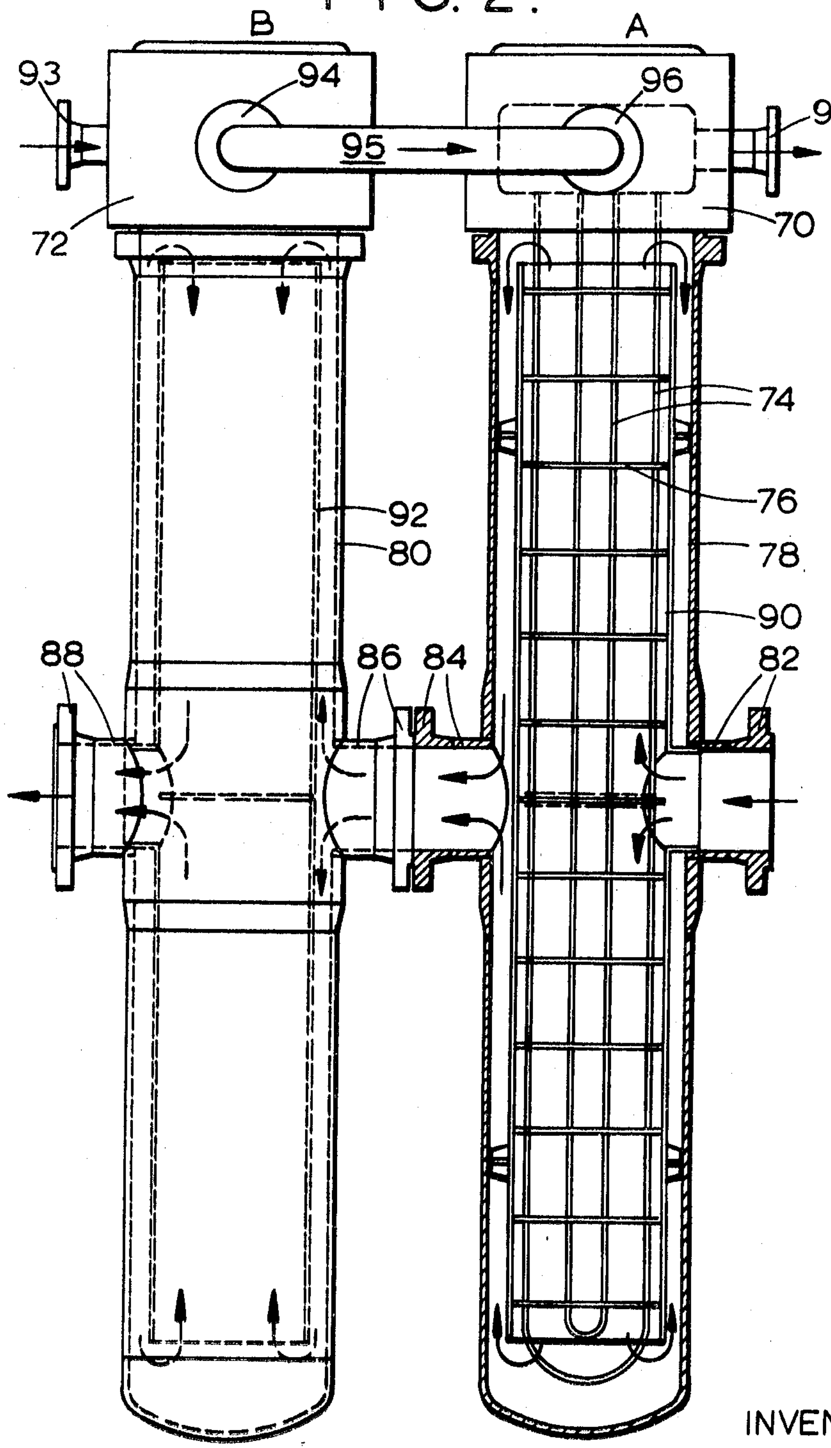
FIG. 2.



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TUBE BANK HEAT EXCHANGER AND UNIT OF SUCH HEAT EXCHANGERS

The present invention relates to improvements in tube bank heat exchangers of the kind provided with an internal jacket encompassing the tube bank in the mantle resulting in a two-way gas flow through the heat exchanger, namely through the jacket and through the spacing between the jacket and the inside of the heat exchanger mantle, respectively. The gas may after introduction into the heat exchanger first flow through said spacing or alternatively first flow through the jacket, depending upon whether the heat exchanger shall be used as a cooler or as a heater.

The present invention relates furthermore to a unit of such heat exchangers coupled together in series. A particular object of the invention is to solve the problems prevailing when large gas quantities having high temperature, possibly also high pressure, shall be cooled, for instance by means of feed water or steam which is pre-heated in pre-heaters, and the invention shall in the following be described with these objects in mind, but it shall be understood that the heat exchanger in accordance with the invention and units of such, also can be used for other purposes with similar advantages.

When cooling large quantities of gas having high temperature and also having large pressure the tube bank heat exchangers preferably used will most often attain a somewhat slender, elongated shape and in order to avoid too large sizes one must utilize several heat exchangers which are coupled in series and/or parallelly coupled units. With these types of heat exchangers the gas flow speed or gas rate will be high, which again results in a relatively high pressure loss through the system. This problem can be solved by employing a greater number of heat exchangers, and for instance introducing the gas at the mid-point of the heat exchanger and arranging outlets at both ends. When for instance two heat exchangers are coupled in series in a known manner, this results in the draw-back that different expansions will occur in the various heat exchangers with the result that expansion bellows or the like must be arranged in the tubing. When dealing with both high temperature and high pressure, this is not only undesirable, but causes severe structural design problems.

A further problem in connection with known methods and heat exchangers is that when the gas temperature exceeds 500° – 550° C, one cannot utilize ferritic steel material in the pressure mantle, but must instead utilize austenitic 18/8 steel, or for instance high-percentage nickel alloy, which as known is very expensive.

The main object of the invention is to provide a new type of heat exchanger whereby there can be reduced or eliminated the problem arising in consequence of the expansions and contractions in the heat exchanger and tubing materials.

A further object of the invention is to provide a new type of heat exchanger making it possible to reduce or avoid the corrosion problems due to high temperatures, tensions and stresses in the material, etc.

A particular object of the invention is to provide an improved type of heat exchanger and heat exchanger units for heating or cooling hot gases subjected to high pressure which simultaneously renders it possible to

utilize relatively reasonable material in the heat exchanger systems.

A further aim of the invention is to provide a new type of heat exchanger making it possible to increase the gas flow rate through the heat exchanger.

A further object of the invention is to provide a new type of heat exchangers which in a particularly desirable manner can be coupled together in series providing a unit which presents a special advantageous flow pattern.

The tube bank heat exchanger in accordance with the invention is of the kind wherein the tube bank in the heat exchanger mantle is encompassed by a jacket extending coaxially through the mantle with a spacing from the inside of the mantle, the heat exchanger mantle provided with two accesses serving as gas inlet and outlet respectively, one of the accesses communicating directly with the inside of the jacket, for providing a flow of gas through the jacket between the heat exchanger tubes, the other access opening communicating with the spacing between the inside of the mantle and the outside of the jacket. The heat exchanger in accordance with the invention is characterized therein that both access openings are positioned at the same cross-sectional plane and substantially at the mid-point of the tube bank, the jacket being open at both ends, whereby the gas flow when introduced into one of the access openings is divided into two gas streams flowing in opposite directions through the heat exchanger, the two streams being unified anew before leaving the heat exchanger.

A unit comprising at least two heat exchangers in accordance with the invention coupled in series is characterized therein that the said heat exchangers are coupled in opposite directions with respect to the gas flow pattern therein so that the gas in the first heat exchanger firstly flows through the inner jacket and thereafter leaves the jacket at both ends of the mantle and flows back between the jacket and the inside of the mantle in a two-way, oppositely directed flow, being unified at the access opening serving as outlet, said outlet being coupled to the access opening on the second heat exchanger. The access opening on the second heat exchanger leads into the spacing between the jacket and the mantle inside whereby the gas flow here firstly will streams the spacing and then return to the mid-point of the second heat exchanger and leaves the second heat exchanger to the access opening leading from the jacket and to the access on the mantle.

The present invention comprises also other features and advantages which will appear from the following description in connection with the accompanying drawings wherein is described and shown respectively a preferred embodiment of a heat exchanger in accordance with the invention and furthermore a unit of such heat exchangers, and wherein:

FIGS. 1 shows a longitudinal cross-sectional view through a preferred embodiment of a heat exchanger in accordance with the invention, and

FIG. 2 shows a similar longitudinal cross-sectional view through two such heat exchangers coupled in series.

In FIG. 1 reference 2 designates the pressure mantle on an elongated heat exchanger which at the mid-point is provided with two tube connections 4 and 6 which serve as the inlet and the outlet of the heat exchanger, respectively, for the gas which shall be cooled or heated. At the one end of the heat exchanger is mounted a head 8 with a U-shaped tube bank 10 which extends through the inside of the mantle and which in known fashion is provided with inlet and outlet designated and 12, respectively, such that said tube bank can be supplied with a heat treatment media, for instance cooling water or steam.

Coaxially through the mantle is furthermore arranged a tube-shaped jacket 16 which as shown encompasses the tube bank 10. The jacket 16 is open at both ends 18 and 20 and is at the mid-point provided with a pipe connection 22 which extends outwards and into the pipe connection 4 on the mantle. The jacket 16 is provided with a substantially smaller diameter than the diameter of the mantle so that between the jacket and the inside of the mantle there is provided a relatively large spacing 17, the jacket being kept in place by means of circumferentially arranged spacers 24 which rest displaceably against the inside space of the mantle, or vice versa. The jacket 16 is thus fixed in the mantle only by means of the pipe connection 22, which as mentioned is journalled into the pipe connection 4 on the mantle.

As will be understood from the FIGS, wherein by means of arrows there has has illustrated the flow pattern of the gas, a heat exchanger in accordance with the invention will operate as follows:

In the illustrated embodiment — wherein gas volumes par example shall be cooled down from a high temperature — the gas is introduced in the direction of the arrow A into the pipe connection 4 and the gas will flow from same via the pipe connection 22 into the jacket 16 directly into the tube bank 10 wherein the gas flow will divide into two equal streams which will flow in opposite directions and are designated with the arrows B-B. (The tube bank an in a known manner be provided with baffles such that the gas will flow partly longitudinally and partly transversely through the tube bank). At both ends of the mantle the gas streams will flow out of the jacket through the opening 18 and 20 and will turn 180° as shown with the arrows C-C and thereafter flow back through the spacing 26 to the mid-point of the heat exchanger where the gas streams anew will be unified at the arrows D—D and flow together out of the pipe connection 6.

As will be understood the pressure mantle 2 of the heat exchanger will not be exposed to the inflowing gas before the gas has passed through the tube bank and thus either has been cooled or has been heated depending upon for which object the heat exchanger is used. Thus, both expansion and contraction problems as well as corrosion problems will be reduced substantially. Furthermore the problems in connection with thermal expansion and contractions also will be reduced at both pipe connections on the heat exchanger since these are arranged in the same cross-sectional plane and at the mid-point of the mantle.

The flow pattern as shown for the gas will (as mentioned) be utilized when gas is to be cooled. When the same heat exchanger is utilized for heating of gases, the flow pattern through the heat exchanger is reversed so that the gas initially is introduced through the outlet 6, and flows through the spacing 17. The gas will then primarily be heated in the jacket and will reach the highest temperature towards the outlet of the jacket, that is at the inlet 4 whereby the heated gas will not come into direct contact with the pressure mantle 2.

A thermo-dynamical imperfection of the operation of the heat exchanger illustrated in FIG. 1, as will be understood, is that only one half of the U-shaped tube bank will be utilized in accordance with the counter flow heat exchanger principle, but thermodynamical and economical calculations show that these circumstances are of minor importance compared with the advantages which are obtained. In addition to the advantages as previously mentioned the fact that the gas is flowing in two directions through the heat exchanger so that the gas speed or rate can be increased substantially, in many cases is a large advantage.

A heat exchanger in accordance with the invention can with rather special thermodynamical and structural advantages be utilized in connection with two or more such heat exchangers coupled in series. Such in series coupling or heat exchangers are utilized, as known, particularly in connection with the cooling of very hot gases subjected to high pressures. For several reasons, among them problems in connection with the size and the weight of the heat exchanger, it is not possible to obtain the desired temperature fall across one single heat exchanger, and one utilizes therefore a number of parallelly and/or in series coupled heat exchangers. Series coupled heat exchangers cause however particular problems, for instance because the temperatures in adjacent that exchangers then necessarily will be different due to the stepwise heat exchanging which will take place.

The problems in this connection are subsantially reduced by means of the invention which is characterized in that two or more such heat exchangers are coupled into series in opposite or reversed manner, more specifically so that the pipe connections on two adjacent heat exchangers both lead into the spacing between the jacket and the inside of the mantle. Hereby is obtained the substantial advantage that adjacent gas quantities or flows in adjacent heat exchangers will possess substantially the same temperature. Thus, if the heat exchangers coupled in series are utilized for the cooling of gases the gas will in one first heat exchanger initially flow directly into the internal jacket and from this return in the opposite direction through the spacing between the jacket and the mantle, flow out through the outlet and from said outlet of the first heat exchanger flow into the inlet on the second heat exchanger and in this initially flow through the spacing between the inside of the mantle and the jacket and thereafter flow through the jacket and from the same directly out through the outlet of the jacket and out through the pipe connection on the mantle.

Two heat exchangers, coupled into series as above described, are illustrated in FIG. 2, the flow pattern being illustrated by means of arrows and heat exchanger process which here takes place shall in the following be illustrated in connection with a practical example.

A gas quantity of 250,000 m^3/h and a maximum temperature of 570° C and pressure of 30 kp/cm^2 shall be cooled by means of high pressure steam (110 kp/cm^2), which shall be superheated. The high steam pressure uses a heat exchanger with a tube bank consisting of U-tubes where the steam pass through the tubing and the gas on the outside of the tubing. The large gas quantity makes it preferable to divide the gas flow into two parallel flows and the large cooling rate makes it necessary to lead each flow through two in series coupled heat exchangers, such that the unit comprises all together four heat exchangers which all are of the same size. FIG. 2 shows only two in series coupled heat exchangers designated A and B. The reference numbers **70** and **72** designate the outlet and inlet headers for the high pressure steam and also the header plates, **74** is the U-shaped tube bank, **76** the baffles, **78** and **80** the pressure mantles, **82, 84, 86,** and **88** are the gas pipe connections including flanges, **90, 92** are jackets for guiding the gas in accordance with the invention, while the reference numbers **93, 94, 95, 96** and **97** are pipes and flanges for high pressure steam.

The hot gas comes in through the pipe **82** on the midpoint of the heat exchanger and is passed through the inside of the jacket **90** which is not pressure sustaining. The hot gas flow is divided into two parts which flows towards each respective end of the heat exchanger. The gas will here be cooled down and is now passed back through the spacing between the jacket **90** and the inside of the pressure mantle **78** to the central outlet **84.** The jacket **90** is fixed at the centre and it can therefore expand and contract freely towards both ends. Via the pipe **86** the gas is passed to heat exchanger B between the pressure mantle **80** and the jacket **92.** The gas stream is again divided into two parts which are passed towards each respective end, whereafter the streams will pass back through the jacket **92** through the tube bank and are finally gathered together into one stream at the outlet of the second heat exchanger.

By providing jackets **90** and **92** which guide the gas flow in this fashion, one avoids the necessity of utilizing two external connecting pipes, one in each end, between the respective heat exchangers and one avoids therefore the problems in this connection due to the different expansion in the material. Furthermore is obtained the advantage that the gas temperature is substantially equal between the mantle and the jacket in both heat exchangers and thereby is eliminated also the expansion difference at the steam pipe **95.** Furthermore the gas will be cooled prior to it reaching the pressure mantle **80** such that one can utilize normal ferritic steel material in the mantle. Without the jacket **90** one had to, in the present example, utilize a very expensive high-percentage nickel/chrome alloy (for instance Incoloy **825**) due to the hazard of stress corrosion.

In the foregoing description and in the drawings are only shown embodiments of heat exchangers and a unit of such in accordance with the invention whereby there is utilized U-shaped tube banks, but it shall be understood that in many cases one can also utilize straight tube banks which are connected to one header at each end of the heat exchanger mantle. Thermodynamically, such solution will be substantially equally advantageous, but structurally this solution is not as desirable as the embodiments herein described and shown since one will meet greater expansion and contraction problems, since among other items one must arrange an expansion bellow or the like in the pressure mantle.

What is claimed is:

1. A tube bank heat exchanger for the heat treatment of gas, said exchanger comprising:

a heat exchanger mantle having first and second access openings therein, both of said access openings opening into said mantle at the same cross-sectional plane at the midpoint of said mantle;

a tube bank positioned within said mantle and extending from one end to the other thereof;

means positioned coaxially within said mantle for providing two separate, divided unobstructed gas flow streams through said mantle, of said gas being treated;

said means for providing comprising a single internally open jacket positioned coaxially within said matle, said jacket surrounding said tube bank substantially from one end thereof to the other, the outer surface of said jacekt being spaced from the inner surface of said mantle, thus forming a chamber therebetween, the opposite ends of said jacket being completely open, the inner surface of said jacket being continuous and unobstructed from one of said opposite open ends thereof to the other; and

means to communicate one of said access openings directly to the interior of said jacket at substantially the longitudinal midpoint thereof;

the other of said access openings communicating with said chamber at substantially the longitudingal midpoint thereof;

said jacket being operative to divide gas from one of said access openings into two equal gas streams which flow unobstructedly in opposite directions and which at said opposite open ends of said jacket are turned around to flow unobstructedly and unite at the other of said access openings.

2. A heat exchanger unit comprising a plurality of heat exchangers as recited in claim **1**, wherein said plurality of heat exchangers are coupled in series, the communication between said plurality of heat exchangers taking place via the access opening thereof which communicate with said chambers between said jackets and mantles thereof, such that the gas flows into a first heat exchanger and out of a second heat exchanger via said access openings thereof which communicate directly with the interiors of said jackets.

3. A heat exchanger unit as recited in claim **2**, wherein said heat exchangers are coupled together in opposite directions with respect to the flow of gas therethrough, such that the gas in a first heat exchanger first flows through the interior of the jacket thereof and thereafter leaves said jacket at both ends of the mantle and flows back through the chamber between said jacket and the inside of said mantle in a two-way, oppositely directed flow to be unified at the access opening serving as an outlet, said outlet being coupled to a first access opening on the following heat exchanger, said first access opening on said following heat exchanger leading into the chamber between the jacket and the mantle thereof, whereby the gas first will flow through said chamber and then return to the midpoint of said following heat exchanger and leave said following heat exchanger via the access opening thereof communicating directly with the interior of said jacekt thereof.

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