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Buffiere

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[54] **EXCHANGE PROCESS**

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[52] **U.S. Cl.** **165/1,** 130/38, 165/177
[51] **Int. Cl.** **F28f 1/40**
[58] **Field of Search** .... 110/97 D; 138/38; 165/147, 146, 177, 179, 1; 122/501, 502

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[57] **ABSTRACT**

An exchange process between a fluid which is to be heated and/or vaporized and circulating in a chamber, and an externally circulating liquid heating agent, in which the said chamber comprises means so that the speed of the fluid in the hot exchange zone is higher than that of the fluid in the cold zone. These means consist of a mandrel, of which the diameter becomes greater as the hot end is approached and is possibly formed of several sections of increasing diameters.

1 Claim, 4 Drawing Figures

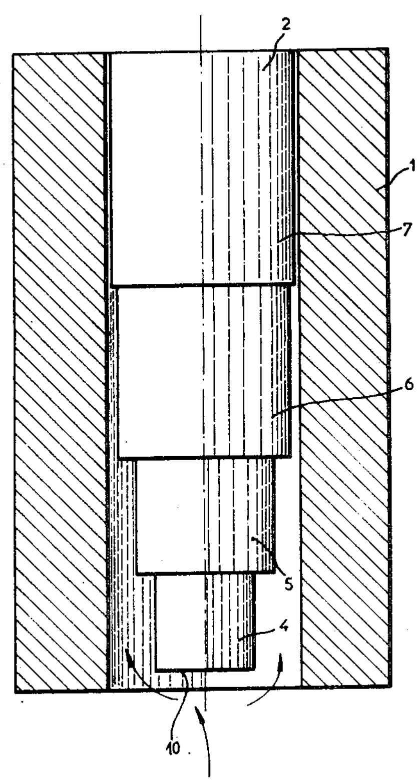

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Fig: 1.

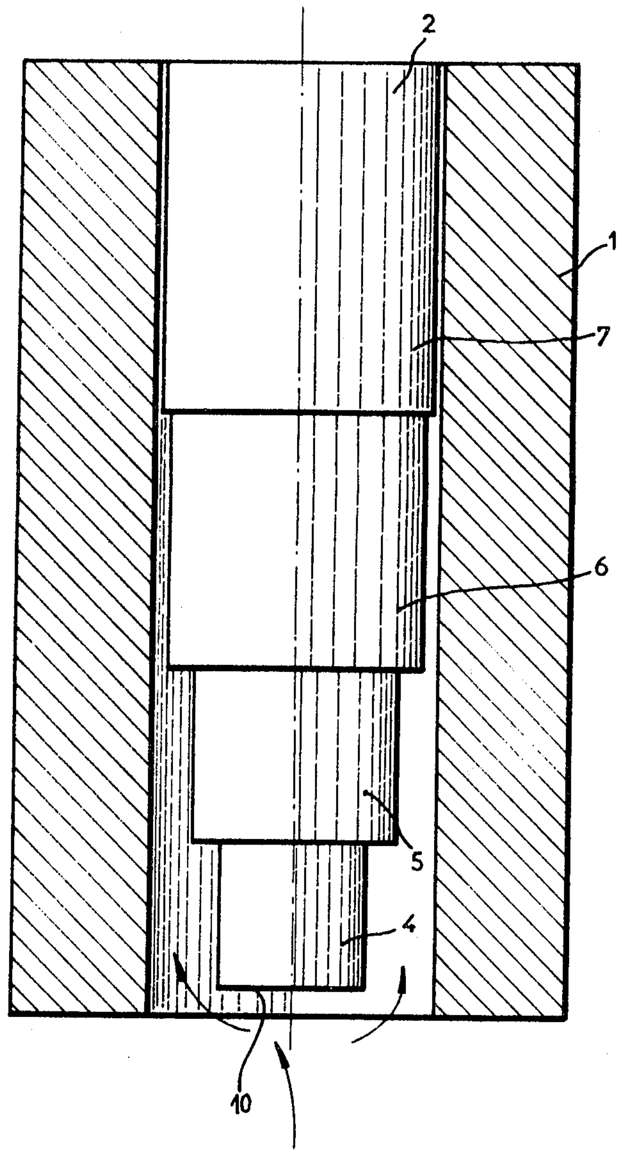

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Fig. 2.

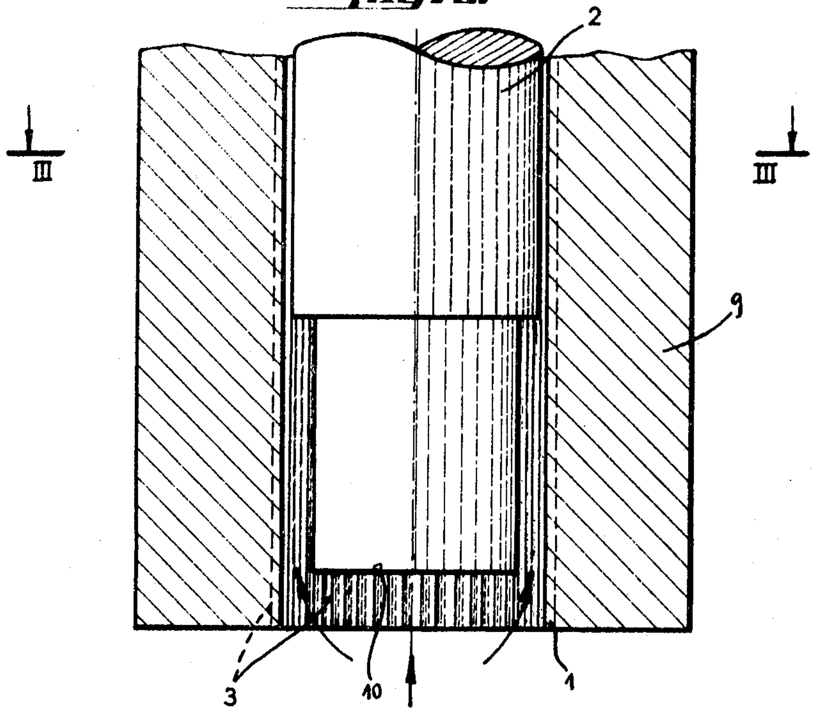
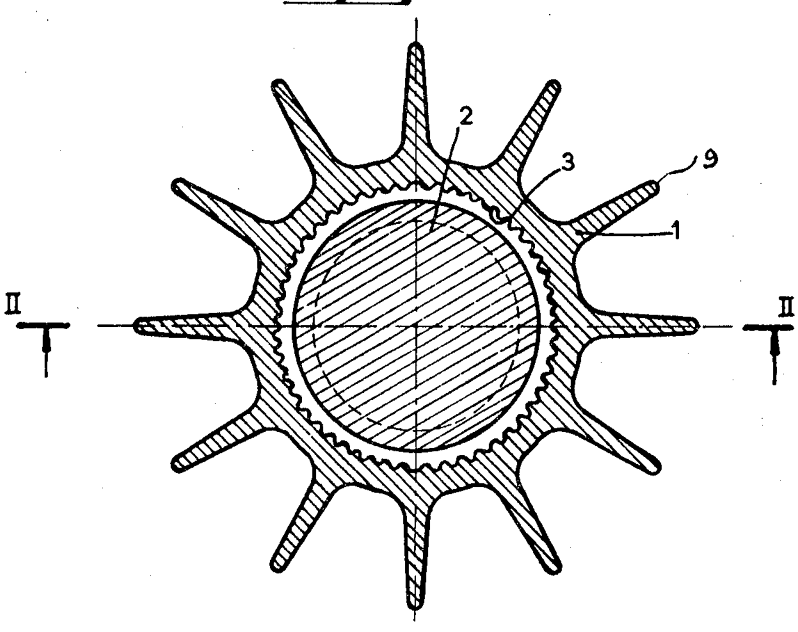


Fig. 3.



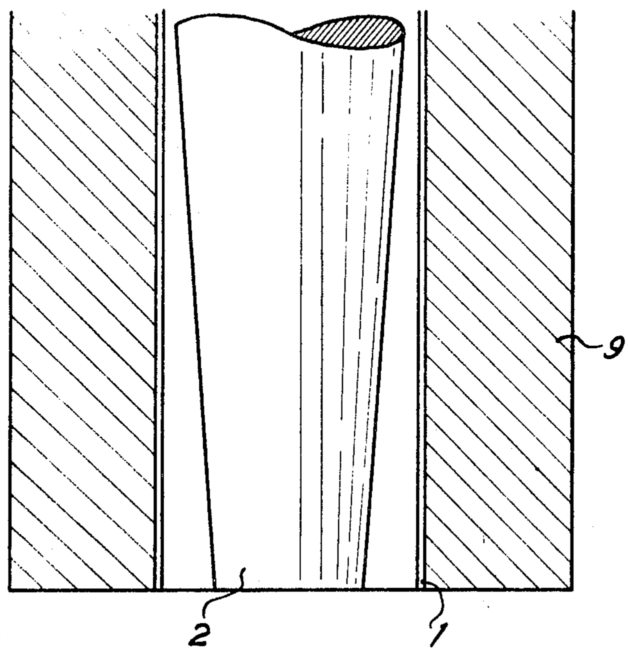


Fig 4

EXCHANGE PROCESS

The present invention is concerned with an improvement in exchange processes between a fluid to be heated and/or vaporized and is also applicable to an arrangement for carrying this process into effect.

For eliminating the dangers of formation of lumps of ice, which is found in the arrangements with forced water circulation in tubes, annular spaces and the like, fluid/cooling installations have been constructed, in which the cold necessary for the cooling is supplied by water circulating in a manner completely externally of the arrangement. In general, in these exchangers of known type, the fluid to be treated, i.e., to be heated and/or vaporized, circulates from bottom to top in vertical tubes which are cooled externally by water which is flowing by gravity.

It was found that, by providing the vertical tubes with longitudinal external fins, it was possible to obtain a continuous flow of the water along the tube without any detachment of the water film, and thus to obtain a better exchange between the fluid to be treated, i.e., to be heated and/or vaporized and the stream of heating water.

In fact, in the construction of these heat exchangers, it is necessary to yield to the two following needs : firstly, of not withdrawing from inside the tube more cold units than the wall is capable of evacuating therefrom on the water side without excessive formation of ice, and secondly to supply the cold units as uniformly as possible at all points of the internal wall of the tube, so as to utilize to the best possible the exchange surface, and to control the dangers of ice formation.

The finned heat exchangers of known type make possible a uniform supply of the cold units and, in order to permit the evacuation of the cold units in accordance with the first of the two needs previously referred to, must have the largest possible exchange surface on the water side. Actually, the known arrangements either require excessive tube lengths or too large a number of parallel tubes, which has particularly the disadvantage of making the cost of the conventional exchangers relatively high.

The present invention has for its object an improvement in the exchange processes between a fluid to be heated and/or vaporized, which permits the disadvantages of the known processes to be overcome.

Within the scope of the present specification and the claims defining the extent of the protection applied for, there is understood by "fluid to be treated" both the heating and vaporization and possibly the superheating of a fluid.

The present invention has for its object an exchange process between a fluid to be treated, i.e., to be heated and/or vaporized, circulating in a chamber, on the one hand, and an externally circulating liquid heating agent, on the other hand, in which means are provided in the said chamber so that the speed of the fluid in the hot exchange zone is higher than that of the fluid in the cold zone.

It is thus possible firstly to control the ice formation in the cold exchange zone and secondly to reduce to a reasonable height the height necessary for the vaporization in the hot exchange zone.

According to one embodiment of the invention, the said means consist at least of one mandrel, of which the diameter is larger as the hot zone is approached, which mandrel has a regularly increasing section or may be formed of several sections of increasing diameters.

According to another embodiment of the invention, the said mandrel is in addition associated with a variable pitch helix, of which the pitch is larger in the cold zone than in the hot exchange zone.

According to yet another embodiment of the invention, the said means consist in the cold zone of an insulating internal lining and in the hot zone of fins fixed to the said chamber.

Other objects and advantages of the present invention will be apparent from reading the following specification and the non-limitative embodiments which are described and illustrated.

FIG. 1 is a diagrammatic longitudinal section showing one embodiment of an exchanger for carrying out the process according to the present invention.

FIG. 2 is a diagrammatic longitudinal section of another embodiment of an exchanger according to the invention.

FIG. 3 is a section along the line III—III of FIG. 2.

FIG. 4 is another embodiment of an exchanger permitting the process according to the invention to be carried out.

The exchanger **1** according to FIG. **1** comprises a central mandrel **2** which has a diameter which is larger as the hot zone or the hot end of the exchanger is approached ; this central mandrel comprises in fact four sections **4, 5, 6** and **7**, respectively, of increasing diameters.

FIG. 2 shows an exchanger **1** which, according to a modification of the invention, is provided with internal fins **3** which in particular permit the exchange surface at the hot end to be increased.

It is thus possible to cause the ratio between the exchange surface on the water side and the exchange surface on the fluid side to vary from **2** to **4.** These internal fins **3** can be seen more particularly in FIG. **3.** According to another modification, the exchanger **1** can comprise external fins **9** designed to assist the heat exchanges. The choice of the number of fins is determined as a function of the problems connected with the surface treatment of the metal being used, and designed to avoid the corrosion caused by the possible use of sea water or corrosive industrial water. The protection of the metal is generally assured by metallization, preferably by zinc-spraying, although the use of a plastic material may be justified.

The central core **2** can be formed by the assembly of tubes of variable diameter and is attached at its lower part **10.**

According to the embodiment shown in FIG. **4,** the mandrel **2** can be formed of a mandrel which has a section increasing regularly from the hot end to the cold end.

The operation of the arrangements as illustrated is as follows :

The fluid to be treated, i.e., to be heated and/or vaporized circulates with an ascending movement inside the exchanger **1,** in the space contained between the internal wall of this exchanger and the mandrel **2.** This fluid is heated and/or vaporized by thermal exchange with a liquid heating agent, in this case water, which is circulating by gravity along the external wall of the exchanger **1.** The longitudinal external fins **9** with which the exchanger is equipped permit of obtaining a continuous flow of water along the exchanger and of avoiding the detachment of the water film. It is thus possible to obtain a better exchange between the fluid to be treated and the stream of heating water. By means of the internal fins **3**, this exchange is further improved.

It is convenient to point out that the speed of circulation of the treated fluid, if it remains in the liquid state and is not subjected to vaporization, would normally be increased in passing to the hot end from the cold end, because of the decrease in the passage section provided between the internal wall of the exchanger and the mandrel in passing from the cold end to the hot end.

In fact, the fluid thus treated experiences a vaporization and its volume is considerably increased, and this causes a considerable acceleration in the speed of travel of the fluid, in passing from the cold end to the hot end. It is thus possible to overcome all the disadvantages of the known processes and particularly to prevent the formation of too large a quantity of ice around the exchanger **1**.

Obviously, the distributors for the externally circulating liquid heating agent and the cold fluid, as well as the headers designed to collect the vaporized or heated fluid at the top of the exchangers, and the trickling water which has served for the vaporization fluid at the bottom of the exchanger, have not been illustrated solely for the purpose of simplification, and it is obvious that it is possible to use any means whatsoever which permit these objects to be achieved.

The following examples are given simply by way of illustration and have no limiting character. They were carried out in an exchanger such as defined above, the heating agent being water at 14° C and the fluid being heated or vaporized being up to 0° C.

Example 1 : Vaporization of liquid methane at 75 bars.

The central core **2** is formed of four successive sections, **4, 5, 6** and **7** (FIG. **1**) with diameters of respectively **25, 36, 45** and 48 mm over lengths which are respectively equal to 1 m, 1m, 1.50 m, and 2 m.

Under these conditions, the quantity of heat exchange per tube is 70,000 Kcal/h.

Example 2 : Vaporization of liquid ethylene at 40 bars.

The core is formed of two successive sections of 45 mm and 48 mm, over respective lengths of 1.50 m and 4 m.

Under these conditions, the quantity of heat exchanged per tube is about 50,000 Kcal/h.

Example 3 : Vaporization of liquid ethylene at 20 bars.

The same installation is used as in the case of Example 2.

Under these conditions, the quantity of heat exchanged per tube is 25,000 Kcal/h.

Example 4 : Vaporization of liquid nitrogen at 40 bars.

The core is formed of three successive sections, with diameters equal to 48, 45 and 35 mm, respectively, over heights of 1.50 m, 0.50 m and 3.50 m.

Under these conditions, the quantity of heat exchanged per tube is 50,000 Kcal/h.

Example 5 : Vaporization of liquid nitrogen at 20 bars.

The same installation is used as in the case of Example 4.

Under these conditions, the quantity of heat exchanged per tube is 30,000 Kcal/h.

It is obvious that the invention is not limited to the embodiments described and illustrated and it is capable of numerous other variants available to the person skilled in the art, depending on the proposed applications and without thereby departing from the scope of the invention.

What I claim is:

1. A method for vaporizing a liquefied gas comprising:

flowing a cold stream of the liquefied gas inside a vertical vaporization tube in an ascending direction;

flowing a warm film of a heating liquid by gravity outside said vaporization tube, on the external surface thereof, in a descending direction, whereby there is heat exchanged between said cold stream and said warm film; and

gradually increasing the speed of said cold stream as it ascends from the cold end to the warm end of said vaporization tube.

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