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HEAT EXCHANGER FOR SEPARATING OUT CONSTITUENTS
FROM A GAS BY COOLING
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2,947,152

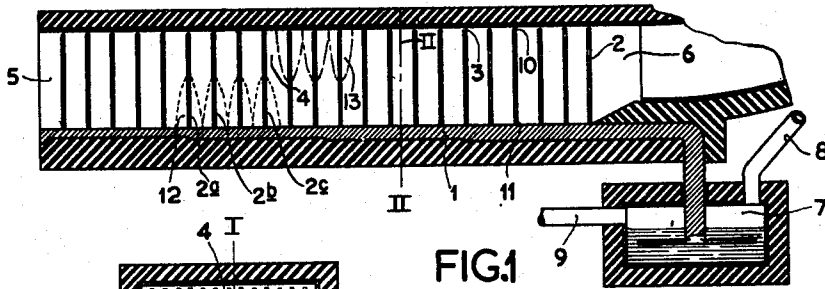


FIG. 1

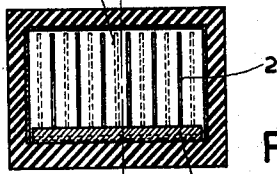


FIG. 2

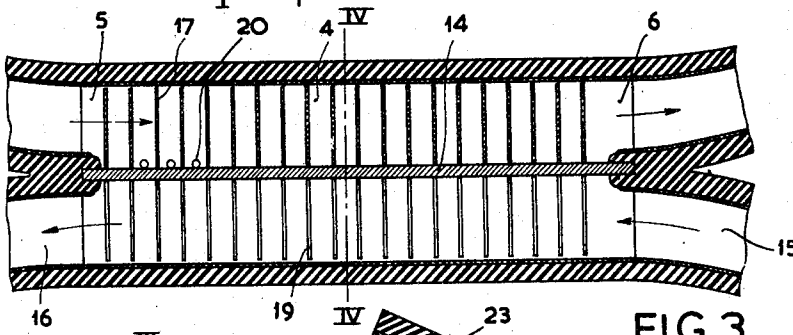


FIG. 3

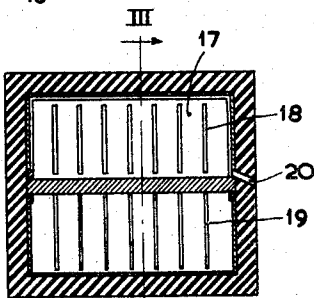


FIG. 4

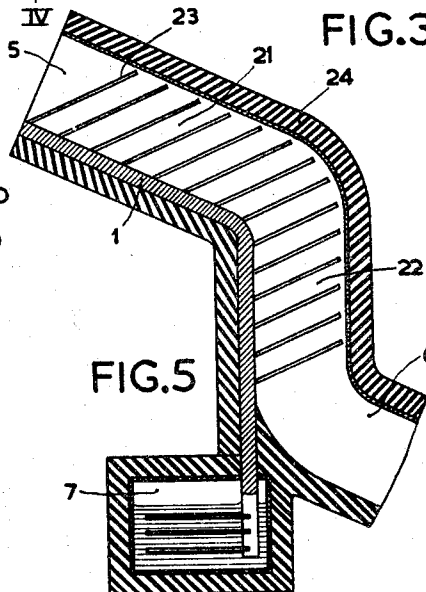


FIG. 5

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HEAT EXCHANGER FOR SEPARATING OUT CONSTITUENTS FROM A GAS BY COOLING

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4 Claims. (Cl. 62—40)

The invention relates to heat exchangers for separating constituents from a gas by means of cooling, which heat exchangers are provided with an aperture for supplying the gas and an aperture for discharging the gas and a number of projections arranged in the path of the gas, which are mounted on a common supporting member, there being during the operation of the heat exchanger in at least a number of these projections or groups of projections a decrease in the mean temperature of at the most 20° C. between adjacent projections or adjacent groups of projections, commencing from the hot side to the cold side. The term "gas" as used herein is to be understood to mean also a vapour or a gas mixture.

Such a heat exchanger may, for example, be used for removing water vapour and carbon dioxide from air. This may be required when air is to be fractionated or condensed. However, other gases also, for example natural gas, have constituents which can be removed by freezing out. In heat exchangers of this kind the separation products accumulate in the heat exchanger, so that this gets clogged sooner or later. After removal of the separation products, for example by heating, the heat exchanger can again be put in operation. The time required to remove the impurities is wasted and it is an object of the present invention to provide a design for a heat exchanger of the above-mentioned kind such that compared with the known heat exchanger a larger amount of impurities can be frozen out.

According to the invention, at least a number of the projections arranged in the path of the gas have a thermal resistance such that during operation the end of a projection more remote from the support has a temperature exceeding by at least 5° C. the temperature at the point of attachment to the common support. The thermal resistance of a projection depends upon the thermal conductivity of its material and upon its size. Thus, in a number of the projections on which the constituents are separated out, there is a comparatively considerable temperature difference along the length of the projection, i.e. at right angles to the supporting member, in contradistinction to the known heat exchangers in which there is no such temperature difference along the projections. As will be explained more fully hereinafter, this appreciable temperature difference enables a greater amount of impurities to be stored in the heat exchanger than would be the case without this temperature difference. Preferably, the temperature difference along a projection is not excessively large, for example does not exceed 30° C., since otherwise the heat exchanger may occupy too much space. In a structurally simple embodiment, the projections are pins.

The supporting member may be a partition between two spaces in which fluids having different temperatures flow. This is, for example, the case when a gas mixture to be fractionated is in heat-exchanging contact with at least one of the fractions produced. However, in certain cases it may be desirable for the amount of thermal energy which is withdrawn from the gas or the gas mixture to be in-

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dependent of circumstances relating to the fluid itself, that is to say independent of the amount of fluid supplied or of the fractions of which it consists. In this case particularly, according to a further embodiment of the invention the supporting member may have one side in heat-exchanging contact with a cooling agent contained in a space. This cooling agent may be the working fluid of a refrigerator, for example of a gas refrigerator.

It has also been found that, if the heat exchanger must remove water vapour and carbon dioxide from air, it is desirable, according to a further embodiment of the invention, for the part of the heat exchanger intended for the water vapour to be at least substantially horizontal while the part intended for the carbon dioxide extends substantially vertically.

The invention will now be described more fully with reference to some embodiments thereof.

Figures 1 and 2 show an embodiment in which the projections are pins.

Fig. 1 is a longitudinal sectional view taken along the line I—I of Fig. 2 and

Fig. 2 is a cross-sectional view taken along the line II—II of Fig. 1.

Figures 3 and 4 show an embodiment in which the projections are slitted pins.

Fig. 3 is a longitudinal sectional view taken along the line III—III of Fig. 4 and

Fig. 4 is a cross-sectional view taken along the line IV—IV of Fig. 3.

Fig. 5 shows a heat exchanger, of which part extends substantially horizontally and part substantially vertically.

The heat exchanger shown in Figures 1 and 2 comprises a supporting member 1 provided with projections 2, for example pins. An insulating wall 3 provides a duct 4 for the gas mixture, the projections 2 being disposed in the path of the gas mixture. The heat exchanger has an inlet aperture 5 and an outlet aperture 6 for the gas mixture to be cooled. One end of the supporting member 1 is in heat-exchanging contact with a cooling liquid contained in a space 7, for example liquid nitrogen. The heat extracted from the gas to be cooled is supplied by way of the pins 2 and the supporting member 1 to the liquid contained in the space 7 so that this liquid evaporates, the vapour being through a pipe 8 to a refrigerator (not shown) to be re-condensed. The condensate produced by the refrigerator can again be supplied to the space 7 through a pipe 9. The refrigerator may be a gas refrigerator, but naturally any suitable refrigerator can be used.

The supporting member is made from a material having a thermal resistance such that in normal operation there is a mean temperature difference of at the most 20° C. between the mean temperatures of the pins 2. In this embodiment, the mean temperature of the series of projections 2^a is at the most 10° C. higher than that of the series 2^b which again is 10° C. higher than that of the series 2^c, etc. The mean temperature is the arithmetic mean of the temperature at an end 10 of a projection and of the temperature at the point 11 at which a projection is attached to the supporting member 1. The temperature difference between these two points in each projection is at least 5° C. and preferably less than 30° C., in the embodiment shown, for example, 19° C.

The system operates as follows:

The gas or gas mixture is supplied to the heat exchanger through the aperture 5, for example by means of a blower (not shown). When the gas mixture is air, the undesirable constituents are water vapour and carbon dioxide. The air comes into contact with the pins 2, which are coldest at their bases, so that the air is cooled and water is formed. At a given instant, the air flows past pins having already a very low temperature at their bases, so that the water vapour from the air after being

condensed on preceding pins freezes to the bases of these pins. However, after some time such an amount of ice 12, which is shown by broken lines in Fig. 1, is frozen to the bases of pins 7 that the air is forced to flow along the tops of the pins. Consequently, a greater amount of air flows past these parts of the pins so that a greater amount of thermal energy is supplied to the pins. As a result, part of the ice adhering to the pins melts and the water produced flows down either to be discharged or to be frozen again to the cold lower ends of the pins. The air which flows past the tops of the pins, at a point to the right-hand side of the first-mentioned pins comes into contact with other pins having a temperature sufficiently low to cause ice to be formed, so that on the upper ends of these pins an amount of ice 13 settles, which is shown by dot-dash lines in the figures. When the passage at the upper ends of these pins becomes clogged, the air is forced to flow past the lower ends of the pins in this part of the heat exchanger. Only after the passage along these pins also has become blocked, the ice separator is clogged up.

In the part of the ice separator situated further to the right-hand side of the drawing, the carbon dioxide contained in the air can be similarly separated out, if required, provided the pins have a sufficiently low temperature.

The heat exchanger shown in Figures 3 and 4 operates on the same principle as described hereinbefore; parts corresponding to those of Figures 1 and 2 are designated by like reference numerals. Here, however, the gas to be cooled, which is supplied to the heat exchanger through the aperture 5 and leaves through the aperture 6, by way of a supporting member 14 is in heat-exchanging contact with a cold fluid which is supplied to the heat exchanger through an aperture 15 and leaves it through an aperture 16. A number of plate-shaped projections 17 provided with slits 18 are arranged on the member 14. The cold fluid which is supplied through the aperture 15 to the heat exchanger flows past projections 19 which are also attached to the support and thus is in heat-exchanging contact with the gas to be cooled. Here also, the thermal resistance of the supporting member 14 is so chosen that there is a mean temperature difference of at the most 20° C. between the adjacent projections 17 on which the constituents of the gas are separated out. In addition, during normal operation of the heat exchanger there is a temperature gradient of 5° C. along the length of the projections. This heat exchanger can be used if air to be fractionated must be purified, the air being cooled by heat-exchanging contact with one of the fractions produced in the gas-fractionating system, for example nitrogen. Similarly to what has been described with reference to Fig. 1, at the bases of the projections 17 having a sufficiently low temperature ice is formed, part of which subsequently, when the gas mixture is forced to flow past the upper parts of the projections, which parts, as has been described herein before, are at a higher temperature, melts off again. The small amount of water which does not freeze can be drawn off through small apertures 20.

In the construction shown in Fig. 5, a part 21 in which the water vapour is separated out is slightly inclined whereas a part 22, in which the carbon dioxide is separated out, extends vertically. In this embodiment also, the supporting member 1 is in heat-exchanging contact with a fluid having a low temperature which is contained in a space 7. On the member 1 a number of pins 23 which extend to a wall 24 are arranged at an angle to this member; in this embodiment also, the temperature gradient along each pin is at least 5° C. Due to the inclined position of the pins, the effective surface, with the same temperature gradient along a pin, exceeds that

of pins arranged at right angles to the support, while the corner at the transition of the parts 21 and 22 can be filled with pins in a structurally simple manner. Generally, it will be undesirable for the part 21 of the heat exchanger in which the water is separated out, to deviate from the horizontal position excessively, in order to prevent the melting water from collecting on the bottom of the heat exchanger without falling on the ice when dripping off the pins. Obviously, this dripping water can be drawn off by the use of a special construction, however, this will generally involve an additional complication of the heat exchanger. There is no such likelihood for the carbon dioxide, but on the contrary the gas to be cooled should move vertically in this part of the heat exchanger, so that the carbon dioxide can readily escape on heating.

What is claimed is:

1. A heat exchanger for separating out constituents of a gas by cooling comprising a hollow tube provided with an inlet and outlet for said gas, a strip-like supporting member in said tube, a plurality of projections in said supporting member arranged in the path of said gas and secured to only one interior wall of said hollow tube, each of said projections taken from the hot side of the tube to the cold side thereof being at the most 20° warmer than the next succeeding projection, at least a number of said projections having a thermal resistance such that during operation the ends more remote from the support are at a temperature at least 5° C. higher than the temperature at the points of attachment of the respective projections to said one interior wall, a thermal sink, said supporting member being directly connected to said thermal sink.

2. A heat exchanger as claimed in claim 1 wherein said projections are pins.

3. A heat exchanger as claimed in claim 1 further comprising a conduit adjacent to and in heat exchanging contact with said hollow tube, and a cooling agent traversing said conduit.

4. A heat exchanger for separating out constituents of a gas by cooling comprising a hollow tube provided with an inlet and outlet for said gas, a strip-like supporting member in said tube, a plurality of projections in said supporting member arranged in the path of said gas and secured to only one interior wall of said hollow tube, each of said projections taken from the hot side of the tube to the cold side thereof being at the most 20° warmer than the next succeeding projection, at least a number of said projections having a thermal resistance such that during operation the ends more remote from the support are at a temperature at least 5° C. higher than the temperature at the points of attachment of the respective projections to said one interior wall, said constituents of the gas to be separated out being water vapor and carbon dioxide, the part of the heat exchanger intended for said water vapor being positioned horizontally while the part of said heat exchanger intended for said carbon dioxide extending substantially vertically, a thermal sink, said supporting member being directly connected to said thermal sink.

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UNITED STATES PATENT OFFICE
CERTIFICATION OF CORRECTION

Patent No. 2,947,152

August 2, 1960

Aldert Teunis Bloem

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, line 9,
for "Claims priority, application Netherlands Nov. 6, 1955"
read -- Claims priority, application Netherlands Nov. 5, 1955 --.

Signed and sealed this 25th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents