

May 15, 1962

J. H. BERTIN ETAL
HEAT EXCHANGERS

3,034,769

Filed Oct. 18, 1957

2 Sheets-Sheet 1

Fig. 1

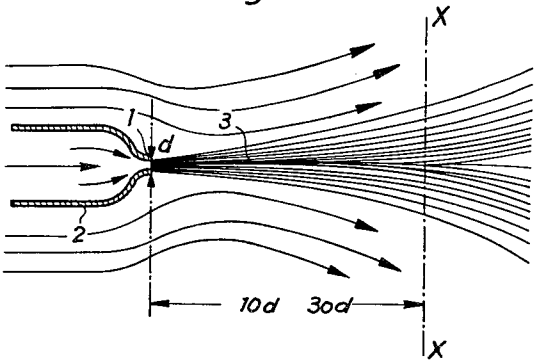


Fig. 2

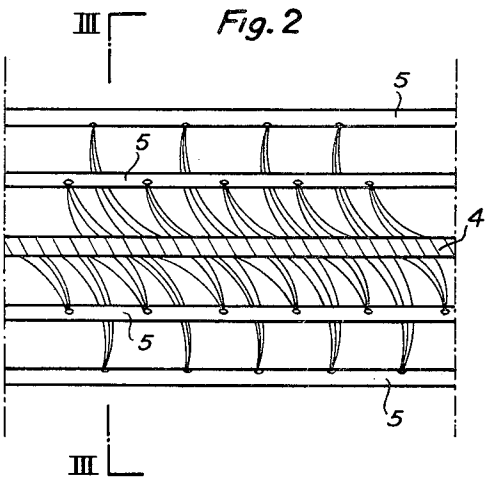


Fig. 3

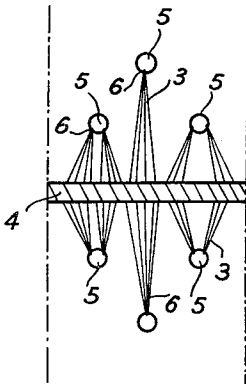
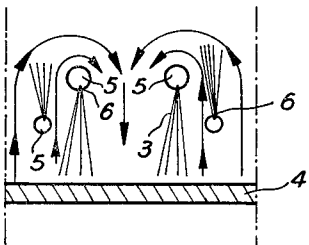


Fig. 4



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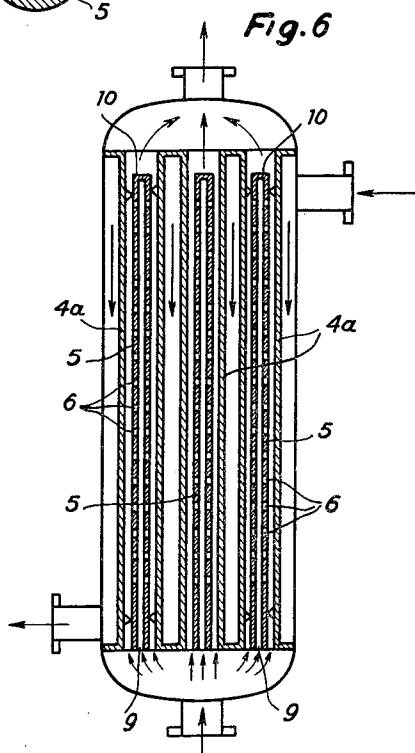
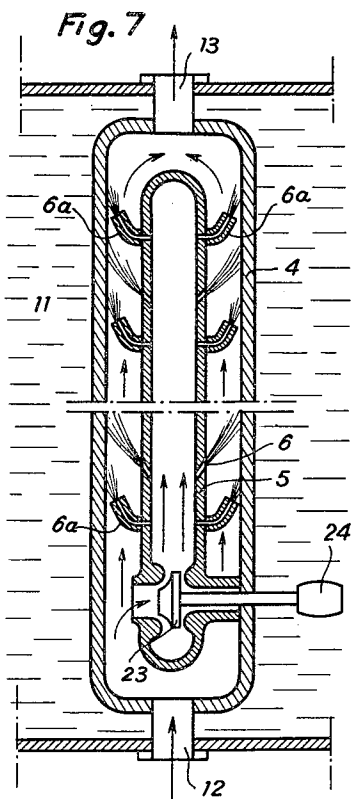
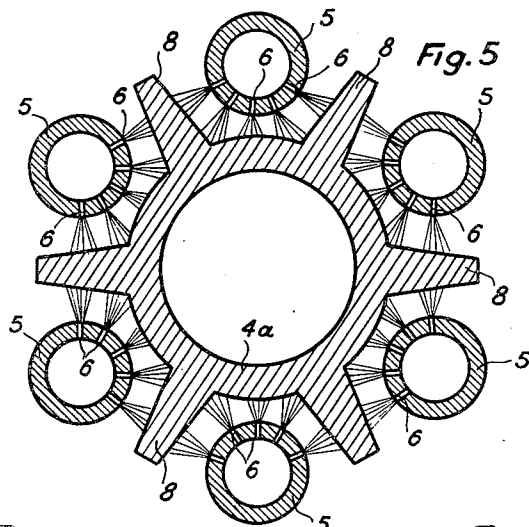
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HEAT EXCHANGERS

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1 Claim. (Cl. 257—73)

The present invention relates to improvements in heat exchangers in which the heat of a fluid is to be transmitted through a solid wall to a second fluid having a lower temperature; a definition of this kind being furthermore entirely relative, since in certain exchangers, the final aim is to heat a fluid, whilst in others the object is, on the contrary, to cool a fluid.

This improvement consists in ensuring the renewal of the molecules of fluid which are in contact with the exchange wall by the stirring and induction effects created in the fluid by means of auxiliary jets suitably situated and distributed, discharging into the said fluid.

This improvement may be carried into effect on one side or the other of the exchange wall and even on both sides; the fluid forming the auxiliary jets may be the same as that into which the jets are discharged, or it may be a different fluid.

In order to create the jets, conduits may be provided for example, which extend at a suitable distance from the exchange wall, the conduits being pierced with nozzles in the form of holes or slots.

The description which follows below with reference to the accompanying drawings (which are given by way of example only and not in any sense by way of limitation) will make it quite clear how the invention may be carried into effect.

FIG. 1 illustrates the effect of induction produced by a small jet discharging into the centre of a fluid.

FIG. 2 is an illustration of a principle, and shows a partial cross-section of an exchanger to which the invention is applied, the cross-section being made parallel to the flow of the fluids on each side of the exchange wall.

FIG. 3 is a transverse cross-section taken along the line III—III of FIG. 2.

FIG. 4 is a transverse cross-section which illustrates an alternative form of embodiment.

FIG. 5 shows in transverse cross-section a further alternative form of the invention, applied to an exchanger comprising one or a number of tubes with fins.

FIG. 6 shows in axial cross-section a complete exchanger embodying the application of a further alternative form.

FIG. 7 shows in axial cross-section an element of an exchanger comprising a further alternative form.

FIG. 1 shows a nozzle 1, having a circular section for example, connected to a chamber 2 which contains a fluid under a sufficiently high pressure with respect to that of the surrounding medium for the fluid in this chamber to flow into the ambient medium in the form of a jet 3. Experience has shown that there is produced in the ambient medium, around this jet, a zone of induction in which the ambient fluid is set in motion as indicated by the arrows. The masses displaced in this way become relatively very great in the zones, the distance of which from the nozzle 1 are of the order of $10d$ to $30d$, where d is the diameter of the nozzle. The ratio of the rate of flow of the induced ambient fluid and of the inducing jet which pass through a plane such as $x-x$, at right angles to the direction of the jet, can attain 100 and more.

It is this phenomenon which the invention makes use of to improve the efficacy of heat exchangers by producing, through its intermediary, a local destruction and a simultaneous renewal of the limit layers of the fluids in con-

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tact with the exchange walls. It is in fact known that it is in these limit layers that the main thermal exchanges take place between these walls and the fluid, and that these exchangers are actually retarded increasingly as the limit layers become thicker and less mobile.

In the form of embodiment shown in FIGS. 2 and 3, there is seen at 4 the exchange wall, assumed to be flat for the convenience of the drawing, but which may of course have any other form. The fluids in exchange of heat circulate on each side of this wall, in opposite directions (circulation in counter-flow). On each side of the wall and parallel thereto are provided, in the midst of the fluids, conduits such as 5 pierced with small nozzles 6 which face the exchange wall, the distance between these nozzles and the wall being a multiple of the diameter of the nozzles, as indicated above. These conduits convey a fluid, which is in general the same as that in the midst of which they are installed, but which is a total pressure greater than the static pressure of the ambient fluid at the outlet of the said nozzles. In this way, a large number of small jets 3 are formed and directed towards the exchange wall. It follows from the explanations given in connection with FIG. 1, that if the distance of the conduits 5 to the wall 4 is suitable, the jets constantly induce towards this wall large masses of the fluid into which they are discharged. The final result is that the layer of fluid in contact with the wall 4, which layer tends to move at a reduced speed and to be stagnant along this wall (thereby impeding the exchange of heat and generating a temperature gradient in the midst of the fluid itself) is dispersed and replaced in a constant manner by fresh molecules. On the side of the hot fluid, there is obtained a constant arrival at the wall of molecules which have the full temperature of the hot fluid, and which have the maximum aptitude for the supply of heat. In a symmetric manner, on the side of the cold fluid, molecules constantly arrive at the wall which have the lowest temperature, and which thus have the maximum aptitude for the reception of heat. The efficiency of the exchanger can be greatly improved by the forced convection thus produced, without this convection taking place to the detriment of the total pressure of each of the fluids in exchange of heat. It is simply necessary to supply energy so as to increase suitably the level of pressure in the conduits 5. The fluid conveyed in these conduits will in general be a portion of the main fluid, at the same temperature as the main fluid, put under pressure by an auxiliary apparatus such as a small compressor. The energy expended by the operation is small, since the disorientated kinetic energies (with respect to the general direction of the flow of each of the main fluids) are associated only with limited fractions of the fluid.

Many other embodiments can of course be envisaged within the scope of the invention.

FIG. 4 shows an alternative form in which some of the small nozzles 6 are directed away from the exchange wall, so as to create alternate paths of the main fluid, moving first towards the wall and then away from the wall, this facilitating the renewal of the layer in contact with the wall.

In FIG. 5, there is shown in transverse cross-section an exchanger tube 4a provided with fins 8 and surrounded by six auxiliary conduits 5 pierced with orifices 6 for the injections of auxiliary fluid. Some of the orifices are directed in particular towards the re-entrant angles of the tube with fins, in which angles the limit layer is the most developed.

It is also possible to combine the auxiliary conduits 5 with the main tube by drilling them for example at the interior of the fins 8, the orifices drilled on each fin discharging auxiliary jets towards the adjacent fins and the

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wall of the tubes. In this case, it has been assumed that the fluid in which the tube with fins is immersed is a gas, whilst the interior of the tube with fins contains a liquid, the exchanges of which with the wall are sufficient without there being any need to arrange inside the tube any device in accordance with the invention.

FIG. 6 shows a counter-flow exchanger which comprises a nest of main tubes 4a, each containing along its axis a perforated auxiliary conduit 5. The over-pressure in these auxiliary conduits arises from the fact that the loss of pressure in them is less great than in the annular space left between each of these conduits and the corresponding tube 4a. The auxiliary conduits are thus open on the upstream side at 9 and closed at the other extremity 10.

In FIG. 7, there is shown in axial cross-section an exchange element, the wall 4 of which has a tubular form or even a flattened form extending at right angles to the plane of the drawing. This element is assumed to be immersed in a liquid 11. It has passing through it a gas which enters at 12 and passes out at 13. It contains internally one or a number of auxiliary conduits 5, in which a part of the gas is introduced at over-pressure by a centrifugal fan 23 driven by an electric motor 24 (of course, instead of having one fan per conduit, there could be provided a single fan for a number of conduits).

The blowing orifices or nozzles 6 are inclined in the direction of the general flow of the gas, between the conduits 5 and the wall 4.

This inclination thus gives to the auxiliary jets a component in the same direction as the general flow, which re-accelerates this overall flow and reduces the total loss of pressure of the exchanger. All the energy absorbed by the exchanger can even be transmitted to the gas by this simple means, which enables any fan to be eliminated on the general flow and improves the energy balance sheet of the whole system, by reason of the distribution of the driving action to the very parts where they are most necessary, and of the elimination of all excess speeds which are not useful to the thermal exchanges.

Some of the orifices 6 are even carried by elbowed conduits 6a discharging into the limit layer attached to the wall 4, which applies a direct re-acceleration to this layer by blowing.

The invention is applicable to all kinds of apparatus in

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which calories or frigories are to be exchanged: recuperators of gas turbines, boilers, economisers, steam condensers, heaters, exchangers of nuclear reactors, etc.

What we claim is:

A heat exchanger comprising, in combination, means defining a generally tubular heat-transfer partition adapted to contain a first flowing stream of fluid and to have a second flowing stream of fluid at a different temperature exteriorly of it, said partition forming an enclosure to confine said first flowing stream and to keep it out of direct contact with said second flowing stream, whereby said partition is effective to separate said first and said second flowing streams of fluid at different temperatures, a plurality of tubes disposed around said partition and aligned in substantially parallel relationship to said partition, said tubes being disposed close to said partition and being bathed by said outer second flowing stream of fluid, the portion of each of said tubes adjacent said partition being formed with a plurality of nozzles, said nozzles communicating with the inside of said tubes and facing directly towards said partition, and means for supplying pressure fluid to the inside of said tubes whereby to cause a plurality of jets to issue from said nozzles and impinge upon the outer surface of said partition, radiating fins formed on the outer surface of said generally tubular partition and extending between successive tubes whereby substantially to screen said tubes from each other, all of said fins having nozzles directed toward them with some of said nozzles of said tubes being directed towards one side of a fin and others of said nozzles of said tubes being directed towards the other side of a fin, whereby each side of each fin has nozzles directed toward it and has jets impinging on it.

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