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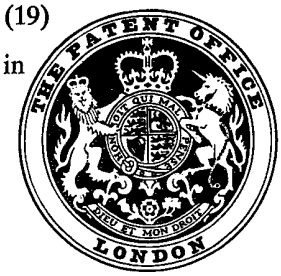

(54) IMPROVEMENTS IN OR RELATING TO PLATE TYPE EVAPORATORS

(71) We, HISAKA WORKS LIMITED, a Company organised and existing under the laws of Japan, of 4-banchi, 4-chome, Hirano-cho, Higashi-Ku, Osaka-Shi, osaka-fu, Japan, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to a plate type evaporator wherein a liquid to be evaporated is evaporated by a heating medium.

In an electric generating plant for generating power by circulating a working medium such as water or an organic material, a chemical plant for refining materials, a refrigerating machine and other equipment, an evaporator is used without exception. In many cases, the heat transmitting section of an evaporator used in such plant is in the form of a system of round pipes having smooth inner and outer surfaces or a system of horizontally or vertically disposed round finned-pipes with the fins attached to the outer side of the pipes for improving the rate of heat exchange.

However, in an evaporator having a system of round pipes as described above, it is extremely difficult to improve its performance for the following reasons.

(a). In cases where said round pipes are horizontally or vertically disposed and a heating medium is passed inside the pipes while a liquid to be evaporated is passed outside the pipes for heat exchange, the pipes have to be more densely arranged in order to lower the cost. As a result, the pressure loss of the heating medium is increased and the power required is also increased. Further, since the liquid to be evaporated is passed outside the pipes, instability of flow due to the so-called two-phase flow phenomenon is caused and depending upon the amount of the liquid to be evaporated there will be a part which does not at all contribute to heat transmission.

(b). In cases where a heating medium is passed inside the pipes while a liquid to be evaporated is passed outside the pipes for heat exchange, about half of the external area of the pipes does not contribute to heat transmission.

(c). In addition to the disadvantages described above, such pipe type evaporator requires much time and labour in drilling end plates for attaching the heat transmitting pipes and assembling the entire evaporator. Moreover, the heat transmitting pipes themselves are very expensive.

Further, in some chemical plants, a plate type evaporator which can be readily fabricated is used. However, in a known plate type evaporator, sets of plates each consisting of two are put together so that a heating medium and a liquid to be evaporated flow alternatively and since the liquid is supplied in one direction it is difficult to supply it uniformly over the wide and long heat transmitting surfaces. As a result, scale scorches and sticks to the surfaces of the plates on the evaporating side, greatly lowering the heat transmission effect and decreasing the available running time. Conversely, if a liquid to be evaporated is supplied over the entire heat transmitting surfaces, the thickness of the liquid film gradually increases in a longitudinal direction, greatly decreasing the heat transmitting effect.

The principal object of the present invention is to provide an evaporator capable of eliminating the above-described disadvantages of the conventional evaporator.

According to the invention, a plate type evaporator comprises a plurality of spaced apart, aligned plates, a series of separate compartments defined therebetween, the

plates being arranged in assemblies of four, each assembly comprising an inner compartment, for containing a liquid to be evaporated, and on each side thereof, an outer adjacent compartment for evaporation of the liquid, each inner plate of each assembly having distributed across its surface apertures for communication through the plate from the inner compartment to the outer adjacent compartment, and a further compartment for the passage of a heat transfer medium being defined between each outer plate of each assembly together with an adjacent outer plate of a next adjacent assembly.

An enclosing wall section may surround the plate assemblies or, alternatively, each plate may be provided with a continuous peripheral lip or ridge such that when the plates are clamped together the lips or ridges cooperate to space the surfaces of the plates apart and to form the desired compartments.

The present invention is fully described with reference to the accompanying drawings illustrating embodiments thereof and wherein;

Figure 1 is a perspective view of plates constituting one embodiment of a plate assembly;

Figures 2 and *3* are sectional views taken along the lines II-II and III-III in Figure 1, respectively, showing the plates in their assembled condition;

Figure 4 is a sectional view showing a modification of the plates shown in Figure 3;

Figure 5 is a perspective view of plates constituting another embodiment of a plate assembly; and

Figures 6 and *7* are sectional views taken along the lines VI-VI and VII-VII in Figure 5, respectively, showing the plates in their assembled condition.

In Figure 1, four plates constituting a plate assembly are designated by the reference characters A, B, C and D. An evaporator itself, as shown in Figures 2 and 3, is constituted by putting together a plurality of plate assemblies 1 each consisting of four plates. Figures 2 and 3 show different sections in order to clarify the paths of flow of a heating medium and a liquid to be evaporated.

The four plates A, B, C and D constituting the plate assembly 1 each have a wall section 2 extending around the outer periphery of the plate surface so that when the plates are put together, the required spaces may be defined between adjacent plates. Thus, between the two inner plates B and C opposed to each other inside the plate assembly, an introducing space E for a liquid to be evaporated is defined by the wall section 2. Further, between the inner plates B, C and the outer plates A, D disposed outside said inner plates, evaporating spaces F, F are defined by the wall sections 2, 2. Further, between said outer plates A, D and the outer plates D, A of plate assemblies 1 adjacent thereto, heat transmitting spaces G, G into which a heating transfer medium is fed are defined by the wall sections 2, 2.

The inner plates B and C are each formed with a number of apertures or ducts 3 of the required shape distributed over the entire area thereof in the required arrangement, said ducts 3 establishing communication between the liquid introducing space E and the evaporating spaces F, F. Such ducts 3 are large in size on the liquid introducing side, i.e., in a region near the plate bottom and gradually decreased toward the top. In this connection, as shown in Figure 4, it would be possible to increase the spacing of the introducing space E on the liquid feeding side and gradually decrease it toward the top while maintaining the size of the ducts 3 unchanged.

The introducing space E, evaporating spaces F, F and heat transmitting spaces G, G will now be described with reference to the paths in which a liquid to be evaporated, steam from said liquid and a heating medium flow.

Figures 1 to 4 illustrate an embodiments in which holes which define the passageways for the respective fluids are formed in the plates. Thus, the plate D has an inlet 4 and an outlet 5 for a heating medium disposed on a diagonal, i.e., at the lower left corner and the upper right corner and inside the wall section 2, as seen in Figure 1, said inlet and outlet communicating with the heat transmitting space G defined between said plate D and the plate A of an adjacent plate assembly. The plates A, B and C have communication holes 6 and 7 at positions corresponding to the inlet 4 and outlet 5 of the plate D. These communication holes 6 and 7 are separated by the outer wall sections 2 and inner wall sections 8 so as not to communicate with the surfaces of the plates A, B and C.

The plate D is also formed with an inlet 10 for a fluid to be evaporated and an outlet 11 for steam disposed on the other diagonal, i.e., at the lower right corner and the upper left corner and inside the wall section 2, said inlet and outlet being separated from the surface of the plate. At a position corresponding to the inlet 10 of the plate D, the plates A and C have a communication hole 12 similarly separated by the inner fence 9 and the plate B has an inlet 13 not separated by a fence. Further, at a position corresponding to the outlet 11 of the plate D, the plates A, B and C each have a communication hole 14.

In operation, a heat transfer medium for

heating the liquid to be evaporated is introduced into the heat transmitting space G between the outer plate A of a plate assembly on one side and the outer plate D of an adjacent plate assembly on one side through the heat transfer medium inlet 4 of the outer plate D of said adjacent plate assembly and flows upward while heating the heat transmitting surfaces of the plates A and D and flows out of the communication hole 7 in the upper region of the plate A, as indicated by broken-line arrows in Figure 2.

Another portion of the heat transfer medium, passing through the communication holes 6 of the plates A, B and C, flows into the heat transmitting space G on the other side of the plate assembly 1 through the heat transfer medium inlet 4 of the outer plate D. Similarly, it flows upward in the heat transmitting space G while heating the plate D and the outer plate A of the other adjacent plate assembly and then in the upper region of the plates it meets the first-mentioned portion of the heat transfer medium which has finished its heat exchange operation and these portions flow together into the communication hole 7 in the plate A of the adjacent plate assembly.

Thus, a heat transfer medium entering the evaporator at one side thereof is distributed to the heat transmitting spaces G in the plurality of grouped plate assemblies 1, in the manner described above, and portions of the heat transfer medium which have finished their heat exchange operation flow transversely whilst joining in the upper region of the plates until all the medium is discharged from the other side of the evaporator.

On the other hand, during this, a portion of a liquid to be evaporated passes through the communication hole 10 in the outer plate D of the adjacent plate assembly and the communication hole 12 of the outer plate A and flows into the central introducing space E, through the liquid inlet 13 of the plate B, and then it is spouted through the ducts 3 in the plates B and C into the evaporating spaces F, F and splashes against the surfaces of the plates A and D, whereupon it is evaporated on said plate surfaces by heat exchange with said heating medium through plates A and D, the resulting steam flowing out of the steam outlet 11 of the outer plate D of the plate assembly 1.

Thus, in a manner similar to that for said heat transfer medium, the liquid to be evaporated enters the evaporator at one side thereof and is distributed to the introducing spaces E of the plate assemblies, and in the evaporating spaces F it is evaporated by heat exchange with the heating medium; the resulting streams of steam flow transversely and join together in the upper region of the plates whereupon they are discharged from the other side of the evaporator.

Figures 5 to 7 illustrate another embodiment of the invention wherein, instead of the liquid inlets 10, 12, 13 and the steam outlets 11, 14 in the embodiment described above, the wall sections 2 are partly cut away to provide inlets 13′ and outlets 14′ corresponding thereto.

In this case, a liquid to be evaporated is distributed to the plate assemblies from below through the inlets 13′ and the resulting steam is discharged from the outlets 14′, 14′ in the upper region. In addition, the path of flow of the heating medium is not different from that defined in the preceding embodiment. In such an arrangement, since the liquid inlets 13′ and steam outlets 14′ can be provided by only partly cutting away the wall sections 2 of the plates A, B and C, there is obtained the advantage of a simple arrangement.

As has been described so far, according to the present invention, a liquid to be evaporated is introduced into the central introducing space E in a plate assembly, and spouted into the evaporating spaces F, F on opposite sides through the ducts 3 formed in the plates B and C defining said introducing space E, and splashes against the heat transmitting surfaces of the plates A and D opposed to and disposed outside the plates B and C. Therefore, it follows that a liquid with a high degree of supercooling is fed directly to the plates A and D over their entire surfaces and that the liquid films on the plates A and D are disturbed by air bubbles rising from the lower region of the plates. Thus the entire evaporating spaces F, F contribute to the overall heat transmission, with a consequent inhibition of scale scorching and sticking as previously described with reference to known evaporators.

WHAT WE CLAIM IS:

1. A plate type evaporator comprising a plurality of spaced apart aligned plates, a series of separate compartments defined therebetween, the plates being arranged in assemblies of four, each assembly comprising an inner compartment, for containing a liquid to be evaporated, and on each side thereof an outer adjacent compartment for evaporation of the liquid, each inner plate of each assembly having distributed across its surface apertures for communication through the plate from the inner compartment to the outer adjacent compartment, and a further compartment for the passage of a heat transfer medium being defined between each outer plate of each assembly, together with an adjacent outer plate of a next adjacent assembly.

2. A plate type evaporator as claimed in Claim 1 wherein an enclosing wall section

surrounds the plate assemblies to help define said compartments.

3. A plate type evaporator as claimed in Claim 1 wherein each plate is provided with a continuous peripheral lip or ridge such that when the plates are pressed together the lips or ridges of adjacent plates cooperate to space the surfaces of the plates apart and to define said compartments.

4. A plate type evaporator as claimed in Claim 1, substantially as hereinbefore described with reference to the accompanying drawings.

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1565869 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

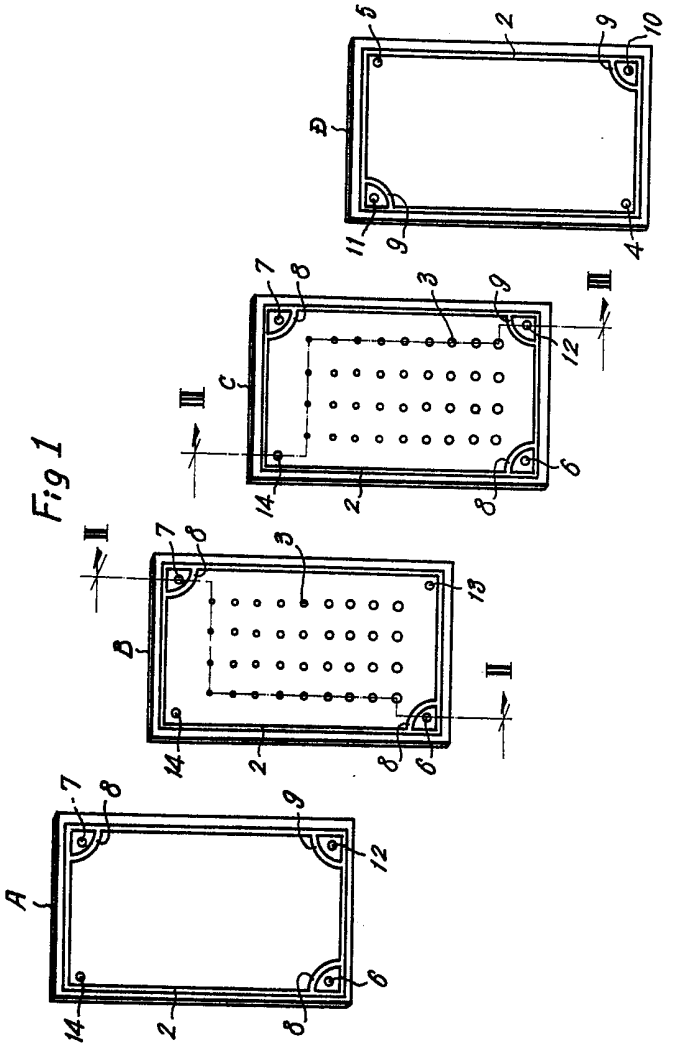

Fig 3

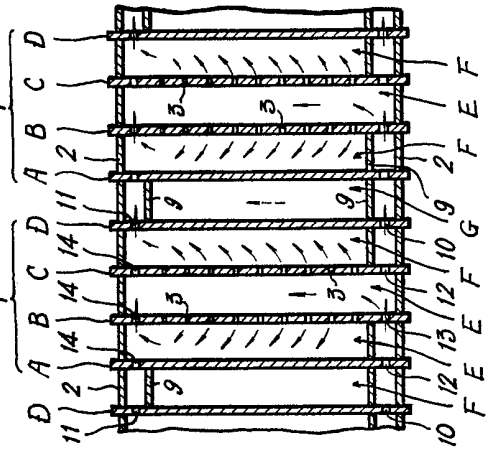

Fig 2

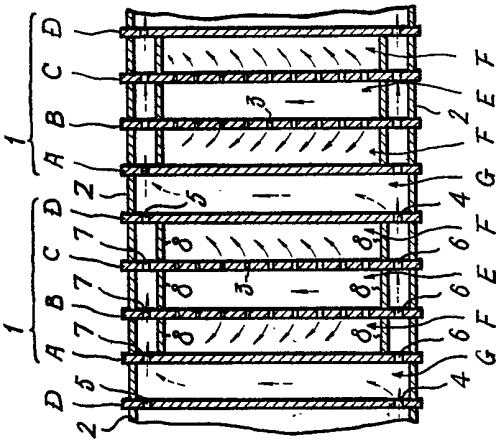

Fig 7

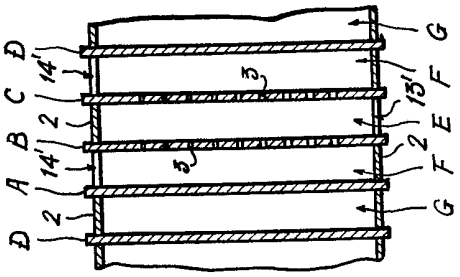

Fig 6

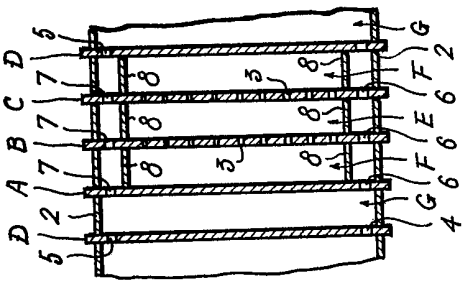

Fig 4

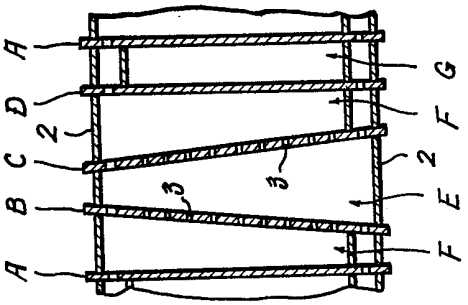

Fig 5