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(54) IMPROVEMENTS IN OR RELATING TO
 CONDENSER HEAT EXCHANGE SURFACES

(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:—

10 The present invention relates to a condenser heat exchange surface of the plate or tube type.

Generally, many of the plate type condenser heat exchange surfaces now in use have been developed from the plate type condenser heat exchange surface for liquid-to-liquid use only. A critical factor in improving the heat exchange performance of such condensers is the film coefficient which represents the ease of heat conduction in a heat exchange surface. The film coefficient is defined as the heat conductivity of the liquid film divided by the thickness of the liquid film i.e., it relates to a condition in which condensate adheres to the heat transmitting surface. Thus, if steam is brought into contact with a relatively cool heat exchange surface, a film of condensate forms thereupon. As condensation continues, the condensate film becomes gradually thicker and eventually flows down along the heat exchange surface under its own weight and/or by the dynamic pressure of the steam. This liquid film merges with other liquid films at lower levels to become a thick downflow liquid film and the heat exchange surface covered with this downflow liquid film is prevented from contact with steam. Since the thickness of the liquid film is considerably increased, the film coefficient in that region of the surface is correspondingly decreased, greatly lowering the heat exchange performance. Therefore, in order to improve the heat exchange performance of the plate surface, it is necessary to take

measures to minimize the area of the downflow liquid film and to prevent the liquid film thickness from being greatly increased as the condensate flows downwardly over the plate surface.

As an example of such measure, the applicants have proposed in their copending patent application no. 7598/77 (serial no. 1 567 393) a heat exchange surface having a plurality of spaced longitudinal grooves several lines on the condensing and heat exchange surface separated by groups of inclined water collector grooves which communicated at their lower ends with the longitudinal grooves. In this arrangement, the condensate on the heat exchange surface is collected in the valleys of the longitudinal grooves by the action of surface tension and flows down along said valleys, and when its amount reaches a certain value, it flows into the water collectors. That is, the downflow liquid films are concentrated in the valleys of the longitudinal grooves, so that the film coefficient is maintained as a whole.

Such inclines and longitudinal water condensate collector grooves are arranged in a pattern on the heat exchange surface for collecting the condensate on the way and allowing it to flow down for discharge, thus occupying a considerable space in relation to the heat transmitting surface. From the standpoint of space, therefore, there has been a problem in connection with improving the overall coefficient of heat transfer.

The present invention has eliminated the disadvantages described above, and basically, according to the invention steps are arranged in a vertical row on a heat transmitting surface where condensate flows down as a liquid film, so as to allow the condensate to fall from the respective lower ends of said steps right down to the lowermost end of the heat transmitting surface.

Accordingly, the present invention is an elongate condenser heat exchange surface

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for the downward flow therealong of steam condensate in the form of a film, said surface having a plurality of lateral extending step like ridges from the vertically aligned protruding edges of which condensate may freely fall sequentially edge-to-edge down to a lowermost end of the heat exchange surface.

Since the condensate which forms on the heat exchange surface effectively falls down to the lower end of the heat transmitting surface under its own weight and/or by the dynamic pressure of steam and is then discharged thereupon, it is possible to stepwise stop the growth of the downflow liquid condensate on the heat transmitting surface without providing a specific condensation discharging mechanism such as a water collector. Further, the entire surface area of the heat exchanger is effectively used for heat exchange and condensation and the heat exchange efficiency is thereby improved.

The present invention is described further with reference to the accompanying drawings in which;

Figure 1 is a perspective view of a specific example of a condenser heat exchange surface according to one embodiment of the present invention;

Figure 2 is a longitudinal section of the heat transmitting surface shown in Figure 1;

Figures 3 and 4 are perspective views of modifications of the condenser heat exchanger surface shown in Figure 1;

Figure 5 is a perspective view showing a further embodiment of the invention in which the condenser heat exchange surface has longitudinal grooves;

Figure 6 is a longitudinal section of the condenser heat exchange surface shown in Figure 5;

Figure 7 is a perspective view of another embodiment of a condenser heat exchange surface having bights;

Figure 8 is a longitudinal section of the condenser heat exchange surface shown in Figure 7;

Figure 9 is a perspective view of a modification of the condenser heat exchange surface shown in Figure 7;

Figure 10 is a fragmentary perspective view of a pair of condenser heat exchange surfaces opposed to each other with a partition plate interposed therebetween, and,

Figures 11a to 11c are perspective views of specific examples of the partition plate shown in Figure 10.

One embodiment of the present invention is shown in Figures 1 and 2. In this embodiment, an otherwise smooth, generally upright condenser heat exchange surface 1 is provided with saw-tooth-like ridges 2 in such a manner that the peak edges 2' of

said ridges 2 are located in a substantially vertical common plane. More particularly, the surface 1 is formed with a plurality of vapour condensing sections 3 defined by the inclined upper surfaces of the ridges 2, the lowermost edges of said vapour condensing sections 3 being the peak edges 2' of said ridges 2.

The process of condensation of steam on the surface 1 constructed in the manner described above is as follows.

When steam is passed onto the surface 1, thin films of condensate form on the vapour condensing sections 3 and begin to flow downwardly thereon as they become gradually larger. Such a film becomes gradually thicker toward its lower region. When such a film approaches the lower edges 2' of a ridge 2 of the vapour condensing section 3, it is slowed down because of the presence of a sudden change in surface direction at the ridge 2 and collects in that place. As the condensate which collects at the edge 2' of the ridge 2 increases in amount, its weight eventually overcomes the surface tension so that it falls by gravity in a drip 4 from the edge 2'. This drip 4 touches the outer edge of the next lower ridge and merges with the condensate there. In this manner, it gradually grows large until it falls down to the lowermost end of the surface 1, and it is thereafter discharged from a discharging channel (not shown) to the outside of the apparatus. That is, the condensate falls from the lower edges 2' of the ridges 2 like raindrops and they are finally collected at the lowermost end of the heat exchange surface 1 and discharged therefrom. Thus, it is seen that there is no need to provide a specific water collector or the like on the heat transmitting surface. In addition, the length of the vapour condensing sections 3 should be such that the downflow liquid film does not become too thick at the lower end.

Figures 3 and 4 show modifications of the above-described heat transmitting surface 1. In Figure 3, the numeral 5 designates projections downwardly directed at the required places on the outer edges 2' of ridges 2. The projections 5 are intended to collect and act as a form for the discharge of the condensate which forms on the ridges 2 by providing localised surface discontinuities at which surface tension effects are undermined and to allow it to fall in a drip therefrom under gravity. Since such projections determine the positions from which drips fall, the overall design is facilitated. Whereas the surface 1 described above is generally smooth, Figure 4 shows a surface 1' having a plurality of shallow longitudinal grooves 6. The combination of longitudinal grooves 6 and ridges 2 is an improvement over longitudinal grooves simpliciter, and since the positions from which drips fall are

controlled by the lower ends of the longitudinal grooves 6, advantageous effects similar to those of said projections 5 can be obtained.

5 In the two embodiments described above, the invention has been applied to condenser heat exchange surfaces 1, 1' on which a downflow liquid film forms over the entire area, but for a condenser heat exchange surface on which a downflow liquid film forms locally, the invention takes, for example, a form shown in Figures 5 and 6. Thus, a condenser heat exchange surface indicated at 7 is of the type having longitudinal
10 grooves 8 for collecting condensate and allowing it to flow down, wherein the condensate collects in the valleys 8' of the longitudinal grooves under the action of surface tension and then flows down. Such valleys 8' are provided in the regions where local downflow liquid films forms with projection-like steps 9 at predetermined intervals, as shown. As a result of this arrangement, the condensate which collects in the valleys 8' of the longitudinal grooves 8 runs onto the steps 9 and then falls in a drip
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Now, in the case of a steam passageway in a usual condenser, the steam flows downward while it condenses on the condenser heat exchange surface. The rate of flow of this steam is higher toward the upper position of the heat exchanger surface and the dynamic pressure of the steam greatly influences the condition in which the condensate flows down.
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Thus, a condenser heat exchange surface construction utilizing the dynamic pressure of steam for discharging the condensate will now be described with reference to Figures 7 through 10.
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In Figures 7 and 8, the condenser heat exchange surface is designated at 11 and has grooves 12 in a vertical row in several steps on the side facing the steam passageway. The grooves 12 correspond to the above-described steps 9 and may be formed by simply bending a flat plate into a wavy form. The grooves 12 are arranged so that their lower edges 12' are in a common vertical plane. When steam is fed into a steam passageway defined by said heat exchange surface 11, the steam flows downalong the curved surface, with part of the steam condensed in the grooves 12. Then the dynamic pressure of the steam blown against the grooves 12 acts to blow off the condensate in the lower edges 12' of the bights 12 in the direction of an extension of each curve and eventually the condensate is scattered from the lower edges 12' of the bights 12 into the air inside the steam passageway and then falls. In this way, the condensate is scattered into the air and discharged before its thickness is greatly increased. Since
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the effect of discharging of condensate into the air by the dynamic pressure of steam is higher toward the upper region of the heat transmitting surface 11, it is preferable that the grooves 12 be not of the same shape but have a curvature adapted to the local conditions.
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While the grooves 12 have been shown as having a smooth surface, they may be improved into the form shown in Figure 9, wherein grooves 13 are provided with longitudinal grooves 14. In this case, the merits afforded by the longitudinal grooves 14 are added, enabling the condensate not only to be discharged more effectively but also to be discharged into the air from predetermined positions at the groove edges. This is also convenient from the standpoint of design.
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While the condenser heat exchange surface 11 described above has been shown as existing on only one side of the steam passageway, in practice two such opposed condenser heat exchange surfaces are provided. Therefore, when a pair of condenser heat exchange surfaces having grooves are positioned close to each other in face-to-face relation, scattered condensate would adhere to the opposite sides, lowering the film coefficient on such surfaces. A solution to this problem is shown in Figure 10, wherein a pair of heat transmitting surfaces 11a, 11b having bights 14a, 14b, respectively are opposed to each other with a partition 15 in the form of a plate interposed therebetween. Obviously, the function of the partition 15 is to prevent the condensate scattered from the grooves 14a, 14b of the heat transmitting surfaces 11a, 11b from adhering to the opposite surfaces and to allow the condensate to flow down along the partition 15 for discharge. Further, according to the droplet form of scattered condensate, the partition 15 may be porous as shown in Figure 11a or perforated as shown in Figure 11b or it may be provided with a number of longitudinal slits 16 as shown in Figure 11c.
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The foregoing description refers to the generally flat plate type condenser heat exchange surface, but it is clear that the present invention is also effectively applicable to curved plate or tube type condenser heat exchange surfaces.

WHAT WE CLAIM IS:

1. An elongate condenser heat exchange surface for the downward flow therealong of steam condensate in the form of a film, said surface having a plurality of laterally extending step-like ridges from the vertically aligned protruding edges of which condensate may freely fall sequentially edge-to-edge down to a lowermost end of the heat exchange surface.
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2. A condenser heat exchange surface as claimed in Claim 1, wherein the ridges
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are of curved section such that condensate which forms on the edges may be scattered into the volume space of the condenser by the dynamic pressure of steam.

- 5 3. A condenser heat exchange surface as claimed in Claim 2 wherein an opposed pair of such surfaces, spaced apart, is separated by a partition such that condensate which forms on the edges of the ridges may be
10 scattered against the partition by the dyna-

mic pressure of the steam and flow on the partition to discharge.

4. A condenser as claimed in Claim 1 substantially as hereinbefore described with reference to, and as shown in, the accom- 15 panying drawings.

REGINALD W. BARKER & CO
(Patent Agents to the Applicants)

13, Charterhouse Square,
London. EC1M 6BA

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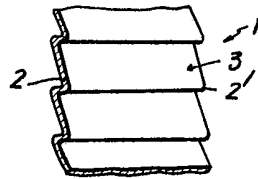
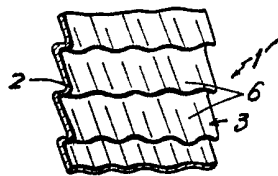
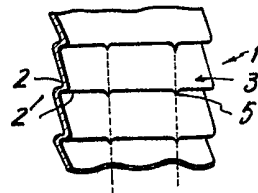
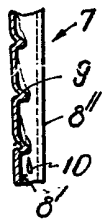
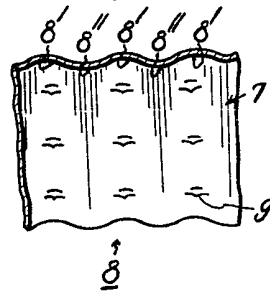
Fig. 2*Fig. 1**Fig. 4**Fig. 3**Fig. 6**Fig. 5*

Fig. 7

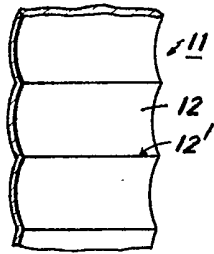


Fig. 8



Fig. 9

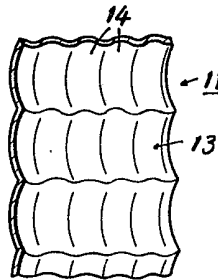


Fig. 10

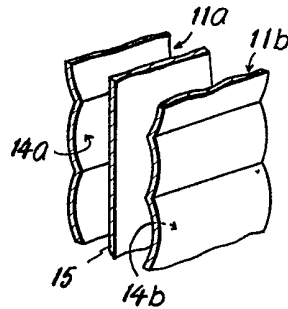


Fig. 11a

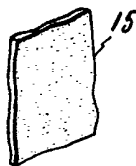


Fig. 11b

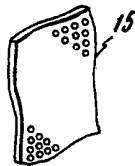


Fig. 11c

