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Fortsættes ...

DESCRIPTION

[0001] The present invention relates to a plate for use as heat-exchanging plate and to a method for producing the plate.

[0002] Heat-exchanging plates that are built into heat exchangers or the like are required to exhibit high heat transfer properties. In order to enhance heat transfer properties, it suffices to expand the surface area of the plate through formation of micron-order fine irregularities on the surface of the plate. For instance, Patent Literature 1 and Patent Literature 2 disclose the following technologies as methods for transferring micron-order fine irregularities onto the surface of a plate.

[0003] The method for transfer onto a metal plate surface disclosed in Patent Literature 1 involves pressing a transfer portion having irregularities, which has been transferred to the outer peripheral face of transfer rolls, against a metal sheet that is transported by transport rolls. In this method, transferred portions of irregular shape identical to those of the transfer portions of the transfer rolls become formed on the surface of the metal sheet.

[0004] A plate of a heat-exchanging plate disclosed in Patent Literature 2 is a plate for a heat-exchanging plate, the plate being constituted by a titanium-made flat plate having fine irregularities formed on the surface, and being obtained through press working, as a post-process, of the flat plate. In this plate, the irregularities on the surface thereof are set in such a manner that a shape parameter defined as height (μm) of projections × [width (μm) of recesses / pitch (μm) between adjacent projections / angle (deg) of projections] is 0.94 or smaller.

[0005] In the technology disclosed in Patent Literature 1, the heat-exchanging plate has enhanced heat transfer properties by virtue of the increased surface area achieved through formation of micron-order fine irregularities on the surface of the flat plate. In many instances, however, plates (flat plate) having fine irregularities formed on the surface are rarely used as they are (i.e. with irregularities remaining thereon), as heat-exchanging plates.

[0006] Ordinarily, a plurality of projections having a height ranging from several mm to several cm (for instance, angular projections referred to as "herringbone") is formed by press working on the surface of the heat-exchanging plate. In the technology disclosed in Patent Literature 1, therefore, the fine irregularities formed on the surface of the plate for the heat-exchanging plate are flattened during press working. It is accordingly desirable to enhance the press formability of the plate.

[0007] Therefore, Patent Literature 2 discloses a technology for solving the issue of press formability of the above plates.

[0008] In the technology disclosed in Patent Literature 2, press formability of the plate is enhanced by defining a shape parameter of the irregularities that are formed on the surface of the heat-exchanging plate. When built into a heat exchanger, the projections formed on the plate promote turbulence and forced convection, to thereby enhance condensation thermal transfer.

[0009] The condensation thermal transfer achieved by the heat-exchanging plate is significantly affected by the discharge of the generated liquid. In the uneven shape (projection shape) of the plate formed using the technology of Patent Literature 2, however, the effect of discharge of the generated liquid may in some instances be weaker than expected (i.e. smaller discharge amount of generated liquid), since the generated liquid spreads out on account of surface tension. Heat transfer properties in a condensation thermal transfer process are thus hard to enhance in the plate formed using the technology of Patent Literature 2.

[0010] Further, the turbulence-promoting effect in the heat-exchanging plate may in some instances be weaker than expected on account of the low height and divided shape (i.e. not a shape of contiguous projections) of the uneven shape that is formed according to the technology of Patent Literature 2. In the uneven shape of Patent Literature 2, moreover, the contact surface area with a medium during condensation of a gas into liquid is small due to the liquid film that forms in the condensation process, and thus the effect of promoting condensation thermal transfer may be weaker than expected.

[0011] That is, the heat-transfer performance of the heat-exchanging plate that is built into the heat exchanger is lowered by the liquid film that is generated when the heat exchanger is operated. In the production of the plate for a heat-exchanging plate, therefore, the design of the plate must ensure that the generated liquid film is discharged with good efficiency and that the film is thin.

[0012] Patent Literature 3 reveals a heat exchanger plate made of metal, provided with a secondary pattern. The heat exchanger plate is additionally provided with a primary pattern impressed on the secondary pattern wherein the primary pattern includes a plurality of first and second ridges formed into V-shapes by the first ridges and the second ridges. The step of impressing the primary and secondary patterns onto the material may be a stamping operation, a rolling operation, a pressing operation or an embossing operation.

Patent Literature 1: Japanese Unexamined Patent Publication No. 2006-239744

Patent Literature 2: Japanese Unexamined Patent Publication No. 2013-76551

Patent Literature 3: US 2011/0174473 A1

[0013] It is an object of the present invention to provide a plate for a heat-exchanging plate of enhanced heat-transfer performance that allows a liquid film generated during the operation of a heat exchanger to be efficiently drained, allows forming irregularities such that the thickness of the liquid film is reduced, and allows enhancing heat-transfer performance without collapse of the irregularities; and a method for producing the plate.

[0014] The plate for a heat-exchanging plate of the present invention is a plate for a heat-exchanging plate of a condenser, the plate being constituted by a metallic flat plate having irregularities formed on a surface thereof, the heat-exchanging plate being obtained through press-working, which is implemented as a post-process, of the flat plate to yield thereafter the heat-exchanging plate, wherein the irregularities include a plurality of projections that are formed at a predetermined spacing; the plurality of projections includes first ridges disposed at an angle +θ with respect to the width direction of the plate and second ridges disposed at an angle -θ with respect to the width direction of the plate, the projections being formed into V-shapes by the first ridges and the second ridges, and respective tops being formed at portions at which the ends of the first ridges and the ends of the second ridges intersect each other; the height of the projections is set to be 0.02 mm or greater and 0.1 mm or less; the width of the projections is set to be 0.08 mm or greater and 1 mm or less; the value of θ is set to be 10° or greater and 80° or less; the width of recesses between the projections is set to be 0.1 mm or greater and 1 mm or less; and the pitch P_1 between adjacent projections is set to be 0.2 mm or greater and 2 mm or less, wherein a groove portion is formed along a longitudinal direction of the plate, at respective tops of the V-shapes.

[0015] The method for producing a plate for a heat-exchanging plate of the present invention is a method for producing the plate for a heat-exchanging plate of a condenser as defined above, the plate being constituted by a metallic flat plate having irregularities formed on a surface thereof, the heat-exchanging plate being obtained through press-working, which is implemented as a post-process, of the flat plate to yield thereafter the heat-exchanging plate , the method comprising: forming the irregularities on the surface such that the irregularities include a plurality of projections formed at a predetermined spacing; and forming, when forming the irregularities, the plurality of projections such that the plurality of projections includes first ridges disposed at an angle +θ with respect to the width direction of the plate and second ridges disposed at an angle -θ with respect to the width direction of the plate, the projections are formed into V-shapes by the first ridges and the second ridges, and respective tops are formed at portions at which the ends of the first ridges and the ends of the second ridges intersect each other, the method further comprising: forming a groove portion along the longitudinal direction of the plate, at respective tops of the V-shapes.

Brief Description of Drawings

[0016]

[Fig. 1] Fig. 1 is a diagram illustrating schematically an uneven shape formed on a plate for a heat-exchanging plate according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a plan-view diagram (enlarged-view diagram of A in Fig. 1) illustrating the shape of projections formed on the plate according to the embodiment of the present invention.

[Fig. 3] Fig. 3 is a cross-sectional diagram of Fig. 2 along line III-III.

[Fig. 4] Fig. 4 is a diagram for explaining the dimensions of the uneven shape of the plate according to the embodiment of the present invention.

[Fig. 5] Fig. 5 is a cross-sectional diagram for explaining the dimensions of the shape of the projections formed on the plate according to the embodiment of the present invention, being an enlarged cross-sectional diagram of portion B in Fig. 4.

[Fig. 6] Fig. 6 is a diagram illustrating data of experiments performed in order to derive a shape parameter.

[Fig. 7] Fig. 7 is a diagram illustrating results of a condensation heat-transfer performance test.

[Fig. 8] Fig. 8 is a diagram illustrating a relationship between a shape parameter of projections formed on a plate and an improvement rate of condensation thermal transfer properties.

[0017] A plate for a heat-exchanging plate according to an embodiment of the present invention and a method for producing the plate will be explained next in detail with reference to accompanying drawings.

[0018] A plate 1 for a heat-exchanging plate according to the embodiment of the present invention is constituted by a metallic flat plate (for instance, titanium material) having irregularities formed on the surface. The plate 1 may be subjected to press working, as a post-process, to yield thereafter a heat-exchanging plate (PHE plate). The heat-exchanging plate, which exhibits high heat-transfer performance in a condensation thermal transfer process, is built into a heat exchanger or the like. A plurality of projections having for instance a jagged shape generally referred to as herringbone becomes formed on the surface of the heat-exchanging plate through press working of the plate 1.

[0019] Fig. 1 is a diagram illustrating schematically the uneven shape formed on the plate 1 before yielding the heat-exchanging plate according to the embodiment of the present invention. In Fig. 1, the up-and-down direction on the paper is taken as the longitudinal direction or length-wise direction of the plate 1, and the left-right direction on the paper as the width direction of the plate 1.

[0020] Fig. 2 is a plan-view diagram (enlarged-view diagram of portion A of Fig. 1) illustrating the shape of projections 2 formed on the plate 1. Fig. 3 is a cross-sectional diagram along line III-III in Fig. 2.

[0021] As illustrated in Fig. 1, irregularities are formed on the surface 1a of the plate before yielding the heat-exchanging plate according to the embodiment of the present invention. The irregularities have a plurality of projections 2 that are formed at a predetermined spacing. The spaces between the plurality of projections 2 constitute recesses 3. The projections 2 include first ridges 2a and second ridges 2b. The first ridges 2a are disposed at an angle +θ with respect to the width direction of the plate 1. That is, the first ridges 2a extend in a rectilinear fashion in a direction at +θ with respect to the width direction of the plate 1. The second ridges 2b are disposed at an angle -θ with respect to the width direction of the plate 1. That is, the second ridges 2b extend in a rectilinear fashion in a direction at -θ with respect to the width direction of the plate 1. The projections 2 are formed into V-shapes by the first ridges 2a and the second ridges 2b.

[0022] In further detail, the first ridges 2a and the second ridges 2b are disposed alternately in the width direction of the plate 1. The ridges are formed in such a manner that an extension line from one end of each of the first ridges 2a and an extension line from one end of the second ridges 2b intersect each other. The ridges are formed in such a manner that an extension line from the other end of the first ridges 2a and an extension line from the other end of the second ridges 2b intersect each other.

[0023] Specifically, the first ridges 2a and the second ridges 2b adjacent thereto in the projections 2 are formed to a V-shape in a plan view, and respective tops 4 are formed at portions at which the ends of the first ridges 2a and the ends of the second ridges 2b intersect each other. In the present embodiment, however, the first ridges 2a and the second ridges 2b are spaced apart from each other, since as described below a groove portion 5 is formed in the tops 4.

[0024] The plurality of first ridges 2a is disposed at equal spacings in the longitudinal direction of the plate 1, and the plurality of second ridges 2b is disposed likewise at equal spacings in the longitudinal direction of the plate 1.

[0025] The term V-shape in the present embodiment denotes a shape such as that of the cutting edges of saw teeth, in a plan view, i.e. a shape in which ridges oriented in different directions are disposed alternately in a continuous succession. In the plate 1, specifically, the first ridges 2a extending in a straight line are disposed obliquely with respect to the width direction by the angle +θ, while the second ridges 2b extending in a straight line are disposed obliquely with respect to the width direction by the angle -θ. That is, the leftward and downward first ridges 2a, and the rightward and downward second ridges 2b adjacent to the first ridges 2a are disposed alternately in the width direction of the plate 1. The first ridges 2a are connected to other first ridges 2a via the second ridges 2b, and the second ridges 2b are connected to other second ridges 2b via the first ridges 2a.

[0026] The V-shaped projections 2 are formed in plurality that are juxtaposed, in a plan view, at a predetermined spacing in the longitudinal direction of the plate 1.

[0027] As illustrated in Fig. 3, the V-shaped projections 2 are made up of a plurality of side walls erected in the thickness direction of the plate 1, and top walls (top edges) that join the respective side walls. The projections 2 in the present embodiment have been explained as having a substantially rectangular shape in a cross-sectional view, but the projections 2 formed on the surface 1a of the plate 1 may have for instance a substantially trapezoidal shape or substantially angular shape, other than a substantially rectangular shape. That is, the projections 2 may adopt any cross-sectional shape so long as the below-described dimensions of the projections 2 are satisfied.

[0028] Groove portions 5 are additionally formed in the plate 1 that is used in the heat-exchanging plate according to the present invention. Each groove portion 5 is formed so as to extend along the longitudinal direction of the plate 1, at the tops 4 at which there intersect the first ridges 2a and the second ridges 2b that make up the projections 2.

[0029] As illustrated in Fig. 2, the groove portion 5 (longitudinal groove portion) formed in the plate is formed so as run rectilinearly through the plurality of tops 4 which are disposed in the length-wise direction on the plate 1. Specifically, the groove portion 5 is formed cutting off the tops 4 of the first ridges 2a and the second ridges 2b in the projections 2. As a result, any two given recesses 3 positioned flanking a respective projection 2 communicate with each other via the groove portion 5. The longitudinal groove portion 5 is set to be wider than the recesses 3 (transversal groove portion) formed between the V-shaped projections 2 and projections 2 adjacent thereto. In Fig. 1 and Fig. 2, the width of the longitudinal groove portions 5 has been depicted as smaller than the width of the recesses 3, for convenience.

[0030] In summary, the surface shape of the plate 1 for a heat-exchanging plate according to the present invention is a shape such as that of the draining grooves (tread patterns) that are carved in the contact patch of tires used in automobiles or the like. The transversal groove portions (recesses) 3 are formed so as to open in the width direction with respect to the longitudinal groove portions 5 that are formed in the longitudinal direction of the plate 1.

[0031] With the plate 1 having the uneven shape, which is formed on the surface 1a, in a case where the plate 1 is used as a heat-exchanging plate, flow of condensate generated in the heat exchanger can be regulated and the condensate can be discharged quickly in the length-wise direction of the plate 1 (heat-exchanging plate) using the longitudinal groove portions 5, while condensation thermal transfer properties can be enhanced through promotion of turbulence and forced convection.

[0032] The dimensions of the uneven shape on the surface of the plate 1 according to the embodiment of the present invention described above will be explained next in detail on the basis of experimental results.

[0033] Fig. 4 is a diagram for explaining the dimensions of the uneven shape formed on the plate 1. Fig. 5 is a diagram for explaining the dimensions of the shape of the projections 2 formed on the plate 1 (enlarged diagram of portion B in Fig. 4, illustrating a partial cutaway cross-section of portion B). Fig. 6 is a diagram illustrating data of experiments performed in order to derive a shape parameter. Fig. 7 is a diagram illustrating results of a condensation heat-transfer performance test. Fig. 8 is a diagram illustrating a relationship between a shape parameter of the projections 2 formed on the plate 1 and an improvement rate of condensation thermal transfer properties.

[0034] As illustrated in Fig. 4 and Fig. 5, prescribed dimensions are set for the uneven shape of the surface of the plate 1.

[0035] Specifically, the height h of the projections 2 is set to be 0.02 mm or greater and 0.1 mm or less, and the width Wa of the projections 2 is set to be 0.08 mm or greater and 1 mm or less. The angle θ formed by the projections 2 with respect to the width direction of the plate 1 is set to be 10° or greater and 80°or less. The width Wb of the recesses 3 is set to be 0.1 mm or greater and 1 mm or less.

[0036] The projection pitch P_1 being the pitch between mutually adjacent projections 2 is set to be 0.2 mm or greater and 2 mm or less. That is, the projection pitch P_1 can be regarded as a combination of the width Wa of the projections 2 and the width Wb of the recesses 3 (projection pitch P_1 = width Wa of projections 2 + width Wb of recesses 3).

[0037] The width Wc of the longitudinal groove portion 5 may be set to be 0.5 mm or greater and 500 mm or less. The width pitch P_2 being the pitch between mutually adjacent longitudinal groove portions 5 may be set to be 5 mm or greater and 1000 mm or less.

[0038] The irregularities of the surface 1a of the plate 1 may be formed in such a manner that a shape parameter defined as "height h (mm) of the projections 2 × width Wb (mm) of the recesses 3 × [width Wc (mm) / width pitch P_2 (mm) of the longitudinal groove portions 5]" is 0.0025 mm^2 or greater.

[0039] An explanation follows next on the rationale behind such dimensions of the uneven shape of the plate 1.

[0040] The inventors of the present application focused on a shape parameter of the uneven shape "height h (mm) of the projections 2 × width Wb (mm) of the recesses 3 × [width Wc (mm) / width pitch P_2 (mm) of the longitudinal groove portions 5]" in order to optimize the height h of the projections 2, the width Wa of the projections 2, the angle θ of the projections 2, the width Wb of the recesses 3, the projection pitch P_1 of adjacent projections 2, the width Wc of the longitudinal groove portions 5, and the width pitch P_2 of the adjacent longitudinal groove portions 5, when producing the plate 1 for a heat-exchanging plate.

[0041] To optimize the uneven shape, the inventors of the present application produced a plurality of plates 1 having different dimensions of the uneven shape, and examined an improvement rate on condensation heat-transfer performance of each plate 1.

[0042] As illustrated in Fig. 6, there were produced seventeen plates 1 of dissimilar uneven shape dimensions. In the plate 1 denoted by number 0 in Fig. 6, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.04 mm, width Wa of the projections 2: 0.125 mm, width Wb of the recesses 3: 0.6 mm, projection pitch P_1 of adjacent projections 2: 0.725 mm, angle θ of the projections 2: 45°, width Wc of the longitudinal groove portions 5: 4 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 20 mm.

[0043] From the dimensions of the uneven shape, there are the derived a parameter A (h×Wb) of 0.024 mm^2 and a parameter B (Wc/P_2) of 0.2. In turn, a shape parameter " (A×B):h×Wb×[Wc/P_2]" of 0.0048 mm^2 is derived from parameters A and B.

[0044] As illustrated in Fig. 7, the plate 1 (number 0) having the above uneven shape exhibited a heat transfer coefficient U, in a heat exchanger, of 1044 (W/m^2K). The plate 1 (number 0) exhibited an improvement of 16% with respect to the heat transfer coefficient U (900 (W/m^2K)) of a conventional (smooth-surface) plate (working example).

[0045] In the plate 1 denoted by number 1 in Fig. 6, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.05 mm, width Wa of the projections 2: 0.1 mm, width Wb of the recesses 3: 0.4 mm, projection pitch P_1 of adjacent projections 2: 0.5 mm, angle θ of the projections 2: 45°, width Wc of the longitudinal groove portions 5: 4 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 13.5 mm.

[0046] From the dimensions of the uneven shape, there are the derived a parameter A (h×Wb) of 0.02 mm^2 and a parameter B (Wc/P_2) of 0.2963. A shape parameter "h×Wb×[Wc/P_2]" of 0.0059 mm^2 is derived from parameters A and B.

[0047] The plate 1 (number 1) having the above uneven shape exhibited an improvement of 20.6% in condensation heat-transfer performance as compared with a conventional plate (working example).

[0048] In the plate 1 denoted by number 2 in Fig. 6, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.04 mm, width Wa of the projections 2: 0.1 mm, width Wb of the recesses 3: 0.4 mm, projection pitch P_1 of adjacent projections 2: 0.5 mm, angle θ of the projections 2: 45°, width Wc of the longitudinal groove portions 5: 4 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 13.5 mm.

[0049] From the dimensions of the uneven shape, there are the derived a parameter A (h×Wb) of 0.016 mm^2 and a parameter B (Wc/P_2) of 0.2963. The shape parameter "h×Wb×[Wc/P_2]" of 0.0047 mm^2 is derived from parameters A and B.

[0050] The plate 1 (number 2) having the above uneven shape exhibited an improvement of

10% in condensation heat-transfer performance as compared with a conventional plate (working example).

[0051] The plates 1 denoted by number 3 to number 13 in Fig. 6 exhibited likewise improvements of 5% or more in condensation heat-transfer performance as compared with a conventional plate, similarly to the plate 1 denoted by number 0 to number 2 (working examples).

[0052] In the plate denoted by number 14 in Fig. 6, by contrast, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.03 mm, width Wa of the projections 2: 0.1 mm, width Wb of the recesses 3: 0.3 mm, projection pitch P_1 of adjacent projections 2: 0.4 mm, angle θ of the projections 2: 45°, width Wc of the longitudinal groove portions 5: 2 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 9 mm.

[0053] From the dimensions of the uneven shape, there are the derived a parameter A (h×Wb) of 0.009 mm^2 and a parameter B (Wc/P_2) of 0.2222. A shape parameter "$h×Wb×[Wc/P_2]$" of 0.002 mm^2 is derived from parameters A and B.

[0054] The plate (number 14) having the above uneven shape exhibited merely an improvement of only 3.4% in condensation heat-transfer performance as compared with a conventional plate (comparative example).

[0055] As in the case of the plate denoted by number 14, the plates denoted by number 15 and number 16 in Fig. 6 exhibited virtually no improvement in condensation heat-transfer performance as compared with a conventional plate (comparative examples).

[0056] As Fig. 8 reveals, the inventors of the present application found that the shape parameter defined as "height h (mm) of the projections 2 × width Wb (mm) of the recesses 3 × [width Wc (mm) / width pitch P_2 (mm) of the groove portions 5]" for irregularities formed on the surface 1a of the plate must be 0.0025 mm^2 or greater in order to improve the condensation heat-transfer performance of the plate 1 by 5% with respect to conventional instances.

[0057] As described above, the plate 1 for a heat-exchanging plate according to the embodiment of the present invention allows promoting accumulation and discharge of condensate by virtue of the fine uneven shape, being a combination of V-shapes and longitudinal grooves, that are formed on the surface of the plate.

[0058] By prescribing the dimensions of the projections 2, it becomes possible to reduce the thickness of the condensate film and increase thereby the surface area of contact with the medium during condensation of a gas into liquid, and to form the fine uneven shape of the surface without collapsing during press working.

[0059] That is, the plate 1 according to the embodiment of the present invention allows producing a heat-exchanging plate the condensation heat-transfer performance of which is far superior to that of conventional plates.

[0060] A method for producing the plate 1 for a heat-exchanging plate described above will be explained next.

[0061] To produce the plate 1, first, determination is made on the material, plate thickness and external dimensions of the plate 1, the shape of the irregularities that are formed on the surface 1 a of the plate, as well as the dimensions of the shape, taking into consideration the desired dimensions, plate thickness and so forth of the heat-exchanging plate that is the final product.

[0062] When establishing the shape and shape dimensions of the irregularities that are to be formed on the surface 1a of the plate, the shape of the irregularities is prescribed to be a V-shape, and there are prescribed the dimensions of the projections 2, the dimensions of the recesses 3, the pitch P_1 of the projections 2, the dimensions of the longitudinal groove portions 5 and the pitch P_2 of the longitudinal groove portions 5 in the V shape.

[0063] Regarding more specifically the dimensions of the projections 2, the height h is set to lie in the range from 0.02 mm to 0.1 mm, the width Wa is set to lie in the range from 0.08 mm to 1 mm, and the angle θ is set to lie in the range from 10° to 80°. Regarding the dimensions of the recesses 3, the width Wb is set to lie in the range from 0.1 mm to 1 mm. The pitch P_1 between projections 2 and other projections 2 adjacent thereto is set to lie in the range from 0.2 mm to 2 mm.

[0064] Regarding the dimensions of the groove portions 5, the width Wc may be set to lie in the range from 0.5 mm to 500 mm, and the width pitch P_2 between groove portions 5 and other groove portions 5 adjacent thereto may be set to be 5 mm or greater and 1000 mm or less.

[0065] The dimensions of the irregularities may be set so that the value derived from the shape parameter defined as "height h (mm) of the projections 2 × width Wb (mm) of the recesses 3 × [width Wc (mm) / width pitch P_2 (mm) of the groove portions 5]" is 0.0025 mm^2 or greater.

[0066] On the basis of the above items thus defined, a metallic flat plate (for instance, titanium material) that constitutes the plate 1 is prepared, and the plate 1 is formed to a predetermined size. A lubricating layer formed on the surface 1a of the plate is removed by a laser processing method, and the portion having had the layer removed therefrom is pickled, to form thereby irregularities and produce the plate 1 for a heat-exchanging plate.

[0067] By resorting to the production method of the present embodiment to form the irregularities, it becomes possible to form a fine uneven shape (microscopic irregularities) being a combination of V-shapes and longitudinal grooves on the surface, and to produce a plate 1 of very good heat transfer properties (very high heat transfer rate).

[0068] The embodiment disclosed herein is, in all features thereof, exemplary in nature, and is not meant to be limiting in any way.

[0069] The production method of the present embodiment is appropriate for producing a plate 1 for a heat-exchanging plate in which a flat plate made of titanium is utilized, but can also be resorted to in order to produce a plate 1 for a heat-exchanging plate in which a plate made of an aluminum alloy or a high-tensile plate is utilized. That is, a plate of any material may be used in the method for producing a plate 1 for a heat-exchanging plate of the present embodiment, so long as the plate is made of metal.

[0070] In particular, features not explicitly described in the embodiments disclosed herein, for instance operational conditions, working conditions, various parameters, as well as dimensions, weight, volume and so forth of constructions are features that do not depart from the scope of ordinary implementation by a person skilled in the art, and take on values that can be easily conceived of by a normal person skilled in the art.

[0071] As mentioned above, the plate for a heat-exchanging plate of the present invention is a plate being constituted by a metallic flat plate having irregularities formed on a surface thereof, and the heat-exchanging plate being obtained through press-working, which is a post-process, of the flat plate, wherein the irregularities include a plurality of projections that are formed at a predetermined spacing; and the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to the width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, the projections being formed into V-shapes by the first ridges and the second ridges.

[0072] A groove portion is formed along the longitudinal direction of the plate, at respective tops of the V-shapes.

[0073] The height of the projections is set to be 0.02 mm or greater and 0.1 mm or less; the width of the projections is set to be 0.08 mm or greater and 1 mm or less; the value of θ is set to be 10° or greater and 80° or less; the width of recesses between the projections is set to be 0.1 mm or greater and 1 mm or less; and the pitch P_1 between adjacent projections is set to be 0.2 mm or greater and 2 mm or less.

[0074] Preferably, the width of the groove portion may be set to be 0.5 mm or greater and 500 mm or less.

[0075] Preferably, the groove portion may be formed in plurality, and the width pitch P_2 between adjacent groove portions may be set to be 5 mm or greater and 1000 mm or less.

[0076] Preferably, the irregularities of the surface of the plate may be set such that a shape parameter defined as "height (mm) of the projections × width (mm) of recesses between projections × [width (mm) / width pitch P_2 (mm) of the groove portions]" is 0.0025 mm^2 or greater.

[0077] As mentioned above, the method for producing a plate for a heat-exchanging plate of the present invention is a method for producing a plate being constituted by a metallic flat plate having irregularities formed on a surface thereof, and the heat-exchanging plate being obtained through press-working, which is a post-process, of the flat plate, the method including: forming the irregularities on the surface such that the irregularities include a plurality of projections formed at a predetermined spacing; and forming, when forming the irregularities, the plurality of projections in such a manner that the plurality of projections includes first ridges disposed at an angle +θ with respect to the width direction of the plate and second ridges disposed at an angle - θ with respect to the width direction of the plate, and the projections are formed into V-shapes by the first ridges and the second ridges.

[0078] A groove portion is formed along the longitudinal direction of the plate, at respective tops of the V-shapes.

[0079] The height of the projections is set to be 0.02 mm or greater and 0.1 mm or less; the width of the projections is set to be 0.08 mm or greater and 1 mm or less; θ is set to be 10° or greater and 80°or less; the width of recesses between the projections is set to be 0.1 mm or greater and 1 mm or less; and the pitch P_1 between adjacent projections is set to be 0.2 mm or greater and 2 mm or less.

[0080] Preferably, the width of the groove portion may be set to be 0.5 mm or greater and 500 mm or less.

[0081] When forming the groove portion in plurality, preferably, the width pitch P_2 between adjacent groove portions may be set to be 5 mm or greater and 1000 mm or less.

[0082] Preferably, the irregularities of the surface of the plate may be designed such that a shape parameter defined as "height (mm) of the projections × width (mm) of recesses between projections × [width (mm) / width pitch P_2 (mm) of the groove portions]" is 0.0025 mm^2 or greater.

[0083] The plate for a heat-exchanging plate and the method for producing the plate of the present invention allow a liquid film generated during the operation of a heat exchanger to be efficiently discharged, allow forming irregularities such that the thickness of the liquid film is reduced, and allow enhancing heat-transfer performance without collapse of the irregularities.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP2006239744A [0012]
- JP2013076551A [0012]
- US20110174473A1 [0012]

P A T E N T K R A V

1. Plade (1) til en varmevekslende plade af en kondensator, hvor pladen (1) er udgjort af en metallisk flad plade som har uregelmæssigheder dannet på en overflade (1a) deraf, hvor den varmevekslende plade opnås ved pressebearbejdning, som er implementeret som en efterbehandling, af den flade plade for derefter at frembringe den varmevekslende plade, hvor uregelmæssighederne indbefatter en flerhed af fremspring (2) som er dannet med en forudbestemt indbyrdes afstand;

hvor flerheden af fremspring (2) indbefatter første ribber (2a) anbragt med en vinkel +θ i forhold til en bredderetning af pladen (1) og anden ribber (2b) anbragt med en vinkel -θ i forhold til bredderetningen af pladen (1), hvor fremspringene (2) er dannet som V-forme ved de første ribber (2a) og de anden ribber (2b) og respektive toppe (4) er dannet ved dele ved hvilke enderne af de første ribber (2a) og enderne af de anden ribber (2b) skærer hinanden;

højden af fremspringene (2) er indstillet til at være 0,02 mm eller større og 0,1 mm eller mindre;

bredden af fremspringene (2) er indstillet til at være 0,08 mm eller større og 1 mm eller mindre;

værdien af θ er indstillet til at være 10° eller større og 80° eller mindre;

bredden af fordybninger (3) mellem fremspringene (2) er indstillet til at være 0,1 mm eller større og 1 mm eller mindre; og

afstanden P_1 mellem tilstødende fremspring (2) er indstillet til at være 0,2 mm eller større og 2 mm eller mindre,

hvor en rilledel (5) er dannet langs en længderetning af pladen (1) ved respektive toppe (4) af V-formene.

2. Plade (1) til en varmevekslende plade ifølge krav 1, hvor bredden af rilledelen (5) er indstillet til at være 0,5 mm eller større og 500 mm eller mindre.

3. Plade (1) til en varmevekslende plade ifølge krav 1 eller 2, hvor rilledelen (5) er dannet i flerhed, og

breddeafstanden P_2 mellem tilstødende rilledele (5) er indstillet til at være 5 mm eller større og 1000 mm eller mindre.

4. Plade (1) til en varmevekslende plade ifølge krav 3, hvor uregelmæssighederne af overfladen af pladen (1) er indstillet således at en formparameter som er defineret som "højde (mm) af fremspringene (2) × bredde (mm) af fordybningerne (3) mellem fremspring (2) × [bredde (mm) / breddeafstand P_2 (mm) af rilledelene (5)]", er 0,0025 mm^2 eller større.

5. Fremgangsmåde til at fremstille pladen (1) til en varmevekslende plade af en kondensator ifølge et hvilket som helst af krav 1 til 4, hvor pladen (1) er udgjort af en metallisk flad plade som har uregelmæssigheder dannet på en overflade (1a) deraf, hvor den varmevekslende plade opnås ved pressebearbejdning, som er implementeret som en ef-

terbehandling, af den flade plade for derefter at frembringe den varmevekslende plade,

hvilken fremgangsmåde omfatter:

at danne uregelmæssighederne på overfladen (1a) således at uregelmæssighederne indbefatter en flerhed af fremspring (2) som er dannet med en forudbestemt indbyrdes afstand; og

at danne, når uregelmæssighederne dannes, flerheden af fremspring (2) således at flerheden af fremspring (2) indbefatter første ribber (2a) anbragt med en vinkel +θ i forhold til en bredderetning af pladen (1) og anden ribber (2b) anbragt med en vinkel -θ i forhold til bredderetningen af pladen (1), hvor fremspringene (2) er dannet som V-forme ved de første ribber (2a) og de anden ribber (2b) og respektive toppe (4) er dannet ved dele ved hvilke enderne af de første ribber (2a) og enderne af de anden ribber (2b) skærer hinanden,

hvilken fremgangsmåde yderligere omfatter:

at danne en rilledel (5) langs en længderetning af pladen (1) ved respektive toppe (4) af V-formene.

6. Fremgangsmåde ifølge krav 5, hvor bredden af rilledelen (5) er indstillet til at være 0,5 mm eller større og 500 mm eller mindre.

7. Fremgangsmåde ifølge krav 5 eller 6, hvor når rilledelen (5) dannes i flerhed, er breddeafstanden P_2 mellem tilstødende rilledele (5) indstillet til at være 5 mm eller større og 1000 mm eller mindre.

8. Fremgangsmåde ifølge krav 7, hvor uregelmæssighederne af overfladen af pladen (1) er udformet således at en formparameter som er defineret som "højde (mm) af fremspringene (2) × bredde (mm) af fordybningerne (3) mellem fremspring (2) × [bredde (mm) / breddeafstand P_2 (mm) af rilledelene (5)]", er 0,0025 mm^2 eller større.

DRAWINGS

FIG.1

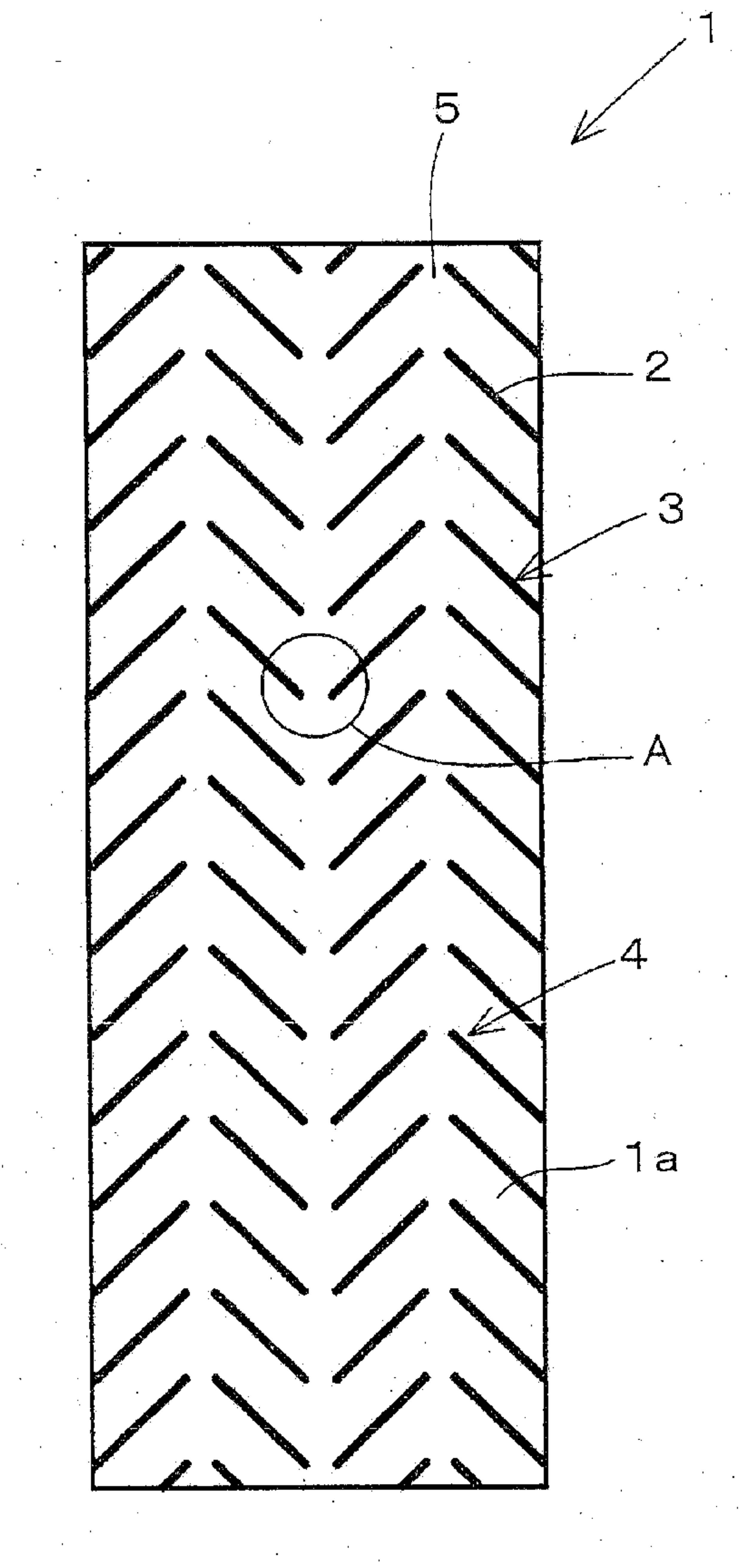


FIG.2

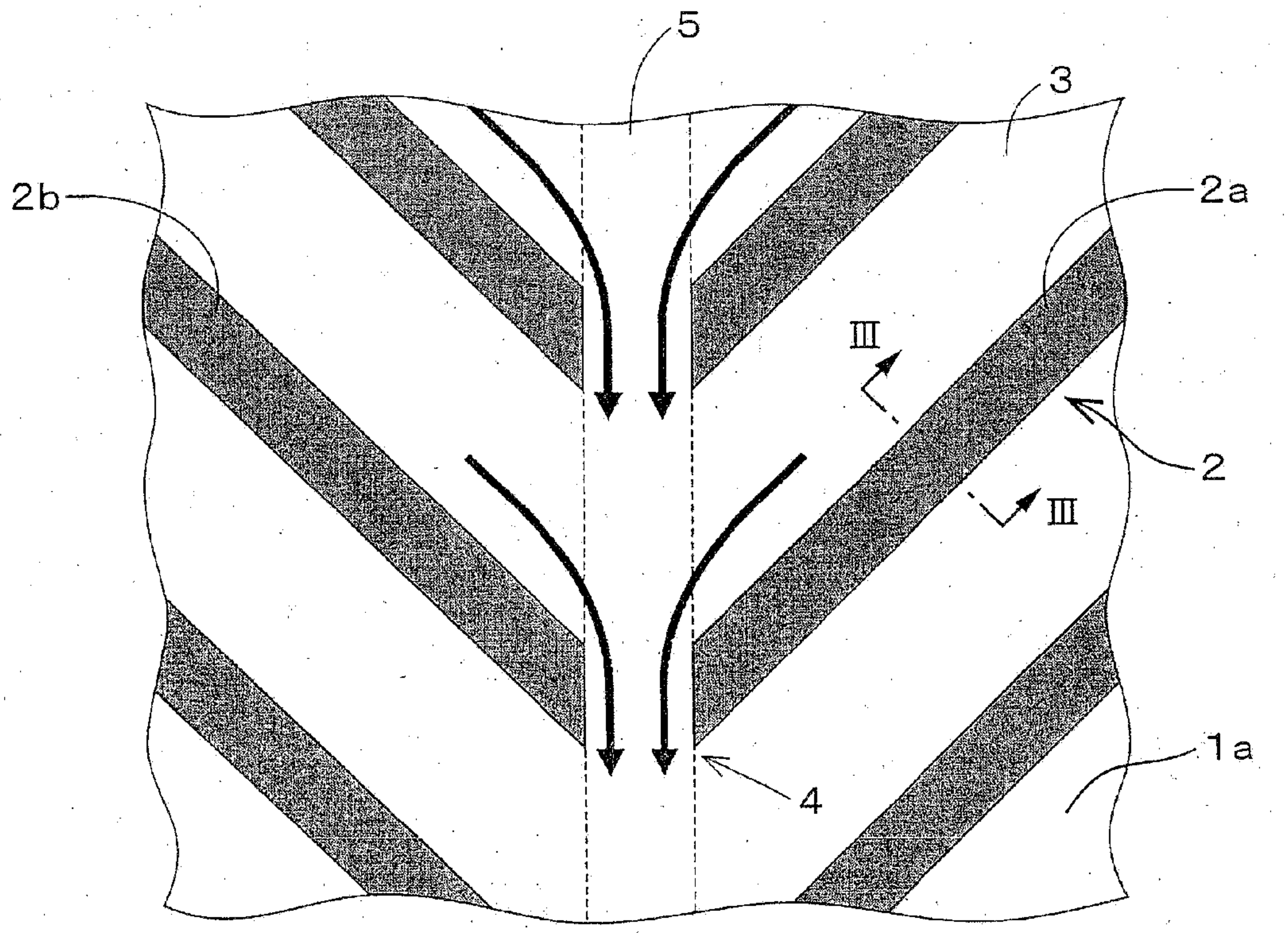


FIG.3

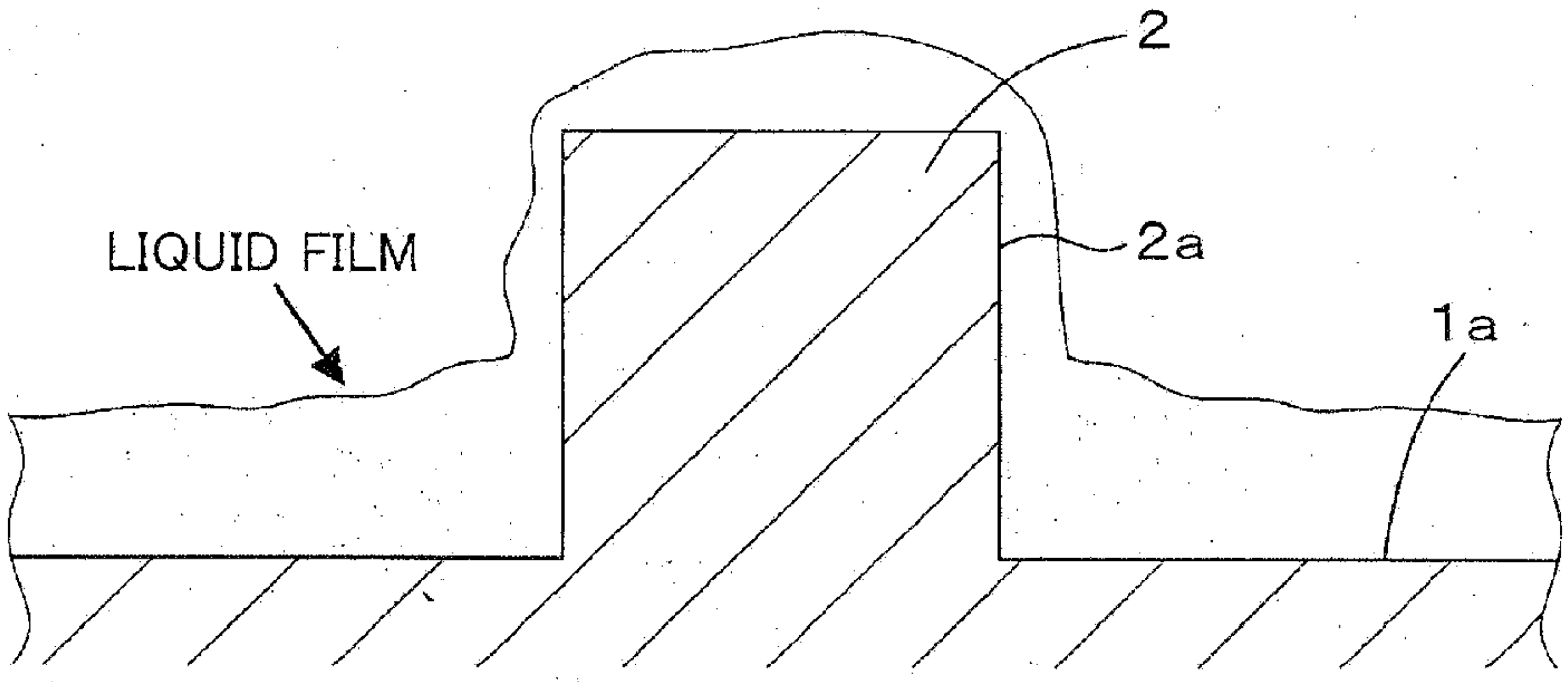


FIG.4

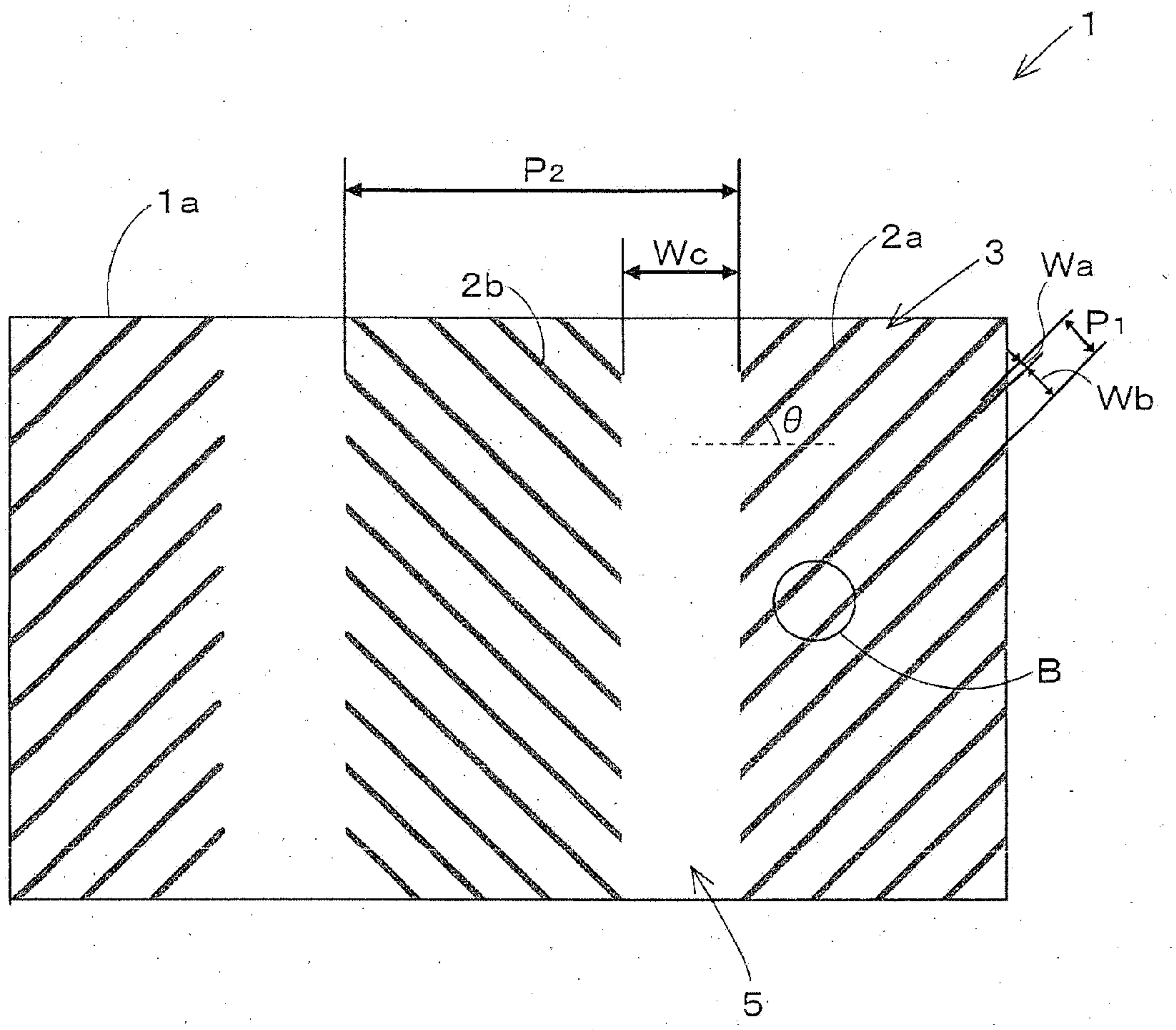


FIG.5

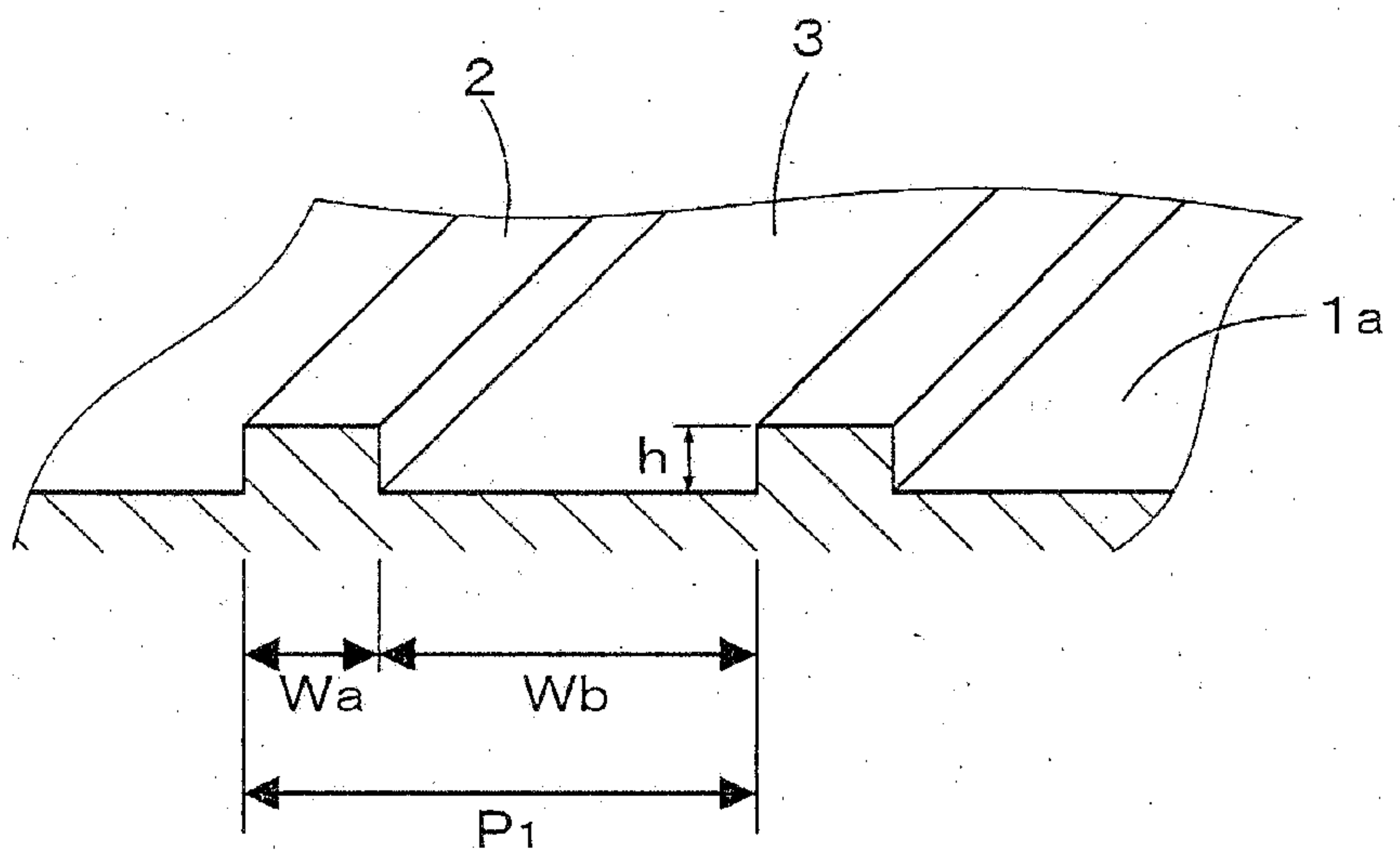


FIG.6

	PROJECTION HEIGHT h	PROJECTION WIDTH Wa	RECESS WIDTH Wb	PROJECTION -RECESS PITCH P_1	ANGLE θ	GROOVE WIDTH Wc	GROOVE PITCH P2	PROJECTION HEIGHT x RECESS WIDTH A=h×Wb	GROOVE WIDTH/ GROOVE PITCH B=Wc/P_2	A×B	IMPROVEMENT RATE OF CONDENSATION HEAT-TRANSFER PERFORMANCE	
	(mm)	mm	mm	mm	°	mm	mm	mm^2			%	
0	0.04	0.125	0.6	0.725	45	4	20	0.024	0.2	0.0048	16	EXAMPLE
1	0.05	0.1	0.4	0.5	45	4	13.5	0.0200	0.2963	0.0059	20.6	EXAMPLE
2	0.04	0.1	0.4	0.5	45	4	13.5	0.0160	0.2963	0.0047	10.0	EXAMPLE
3	0.03	0.1	0.4	0.5	45	4	13.5	0.0120	0.2963	0.0036	9.3	EXAMPLE
4	0.03	0.1	0.4	0.5	40	4	13.5	0.0120	0.2963	0.0036	10.3	EXAMPLE
5	0.03	0.1	0.4	0.5	30	4	13.5	0.0120	0.2963	0.0036	10.1	EXAMPLE
6	0.03	0.1	0.5	0.6	45	4	13.5	0.0150	0.2963	0.0044	11.8	EXAMPLE
7	0.03	0.1	0.6	0.7	45	4	13.5	0.0180	0.2963	0.0053	10.1	EXAMPLE
8	0.03	0.1	0.6	0.7	30	4	13.5	0.0180	0.2963	0.0053	7.7	EXAMPLE
9	0.03	0.1	0.4	0.5	45	4	9	0.0120	0.4444	0.0053	6.4	EXAMPLE
10	0.03	0.1	0.6	0.7	30	4	9	0.0180	0.4444	0.0080	7.6	EXAMPLE
11	0.03	0.1	0.4	0.5	45	4	13.5	0.0120	0.2963	0.0036	5.4	EXAMPLE
12	0.03	0.1	0.4	0.5	45	4	9	0.0120	0.4444	0.0053	6.0	EXAMPLE
13	0.03	0.1	0.4	0.5	45	2	9	0.0120	0.2222	0.0027	7.8	EXAMPLE
14	0.03	0.1	0.3	0.4	45	2	9	0.0090	0.2222	0.0020	3.4	COMP. EX.
15	0.03	0.1	0.1	0.2	45	2	9	0.0030	0.2222	0.0007	1.8	COMP. EX.
16	0.03	0.1	0.4	0.5	45	1	9	0.0120	0.1111	0.0013	4.5	COMP. EX.

FIG.7

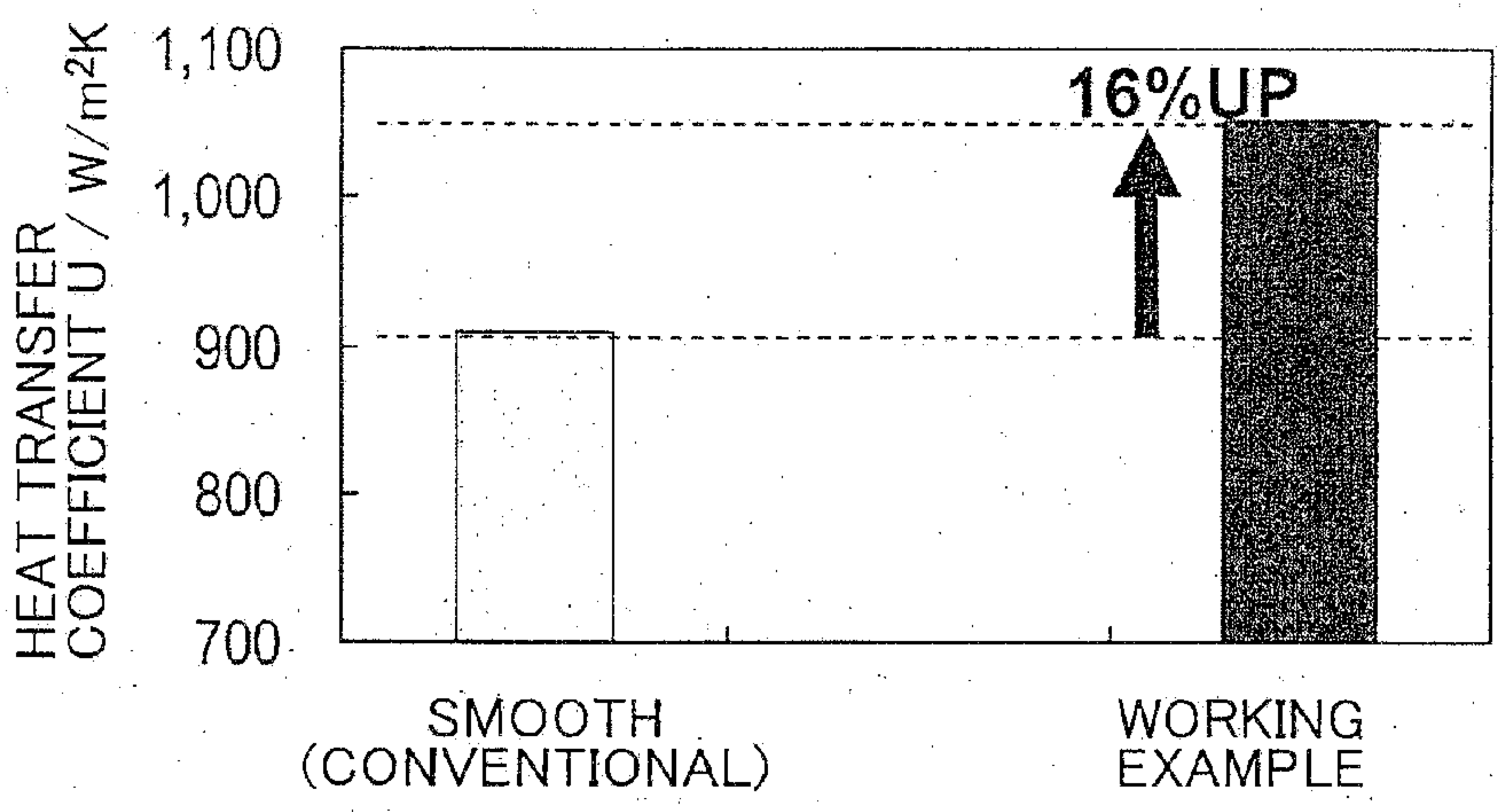
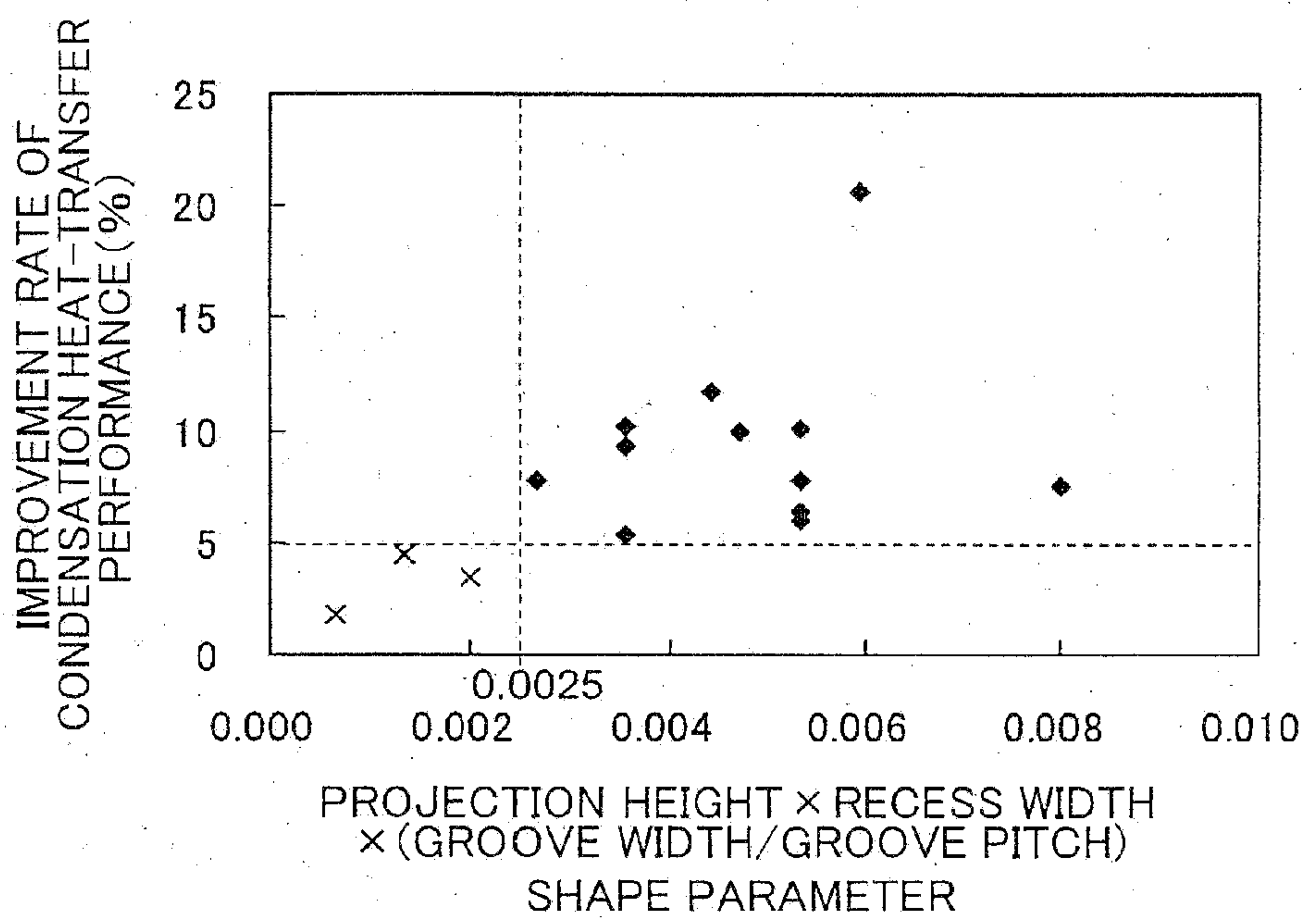

HEAT TRANSFER
COEFFICIENT U / W/m²K
1,100
1,000
900
800
700
16%UP
SMOOTH
(CONVENTIONAL)
WORKING
EXAMPLE

FIG.8


IMPROVEMENT RATE OF CONDENSATION HEAT-TRANSFER PERFORMANCE (%)
25
20
15
10
5
0
0.0025
0.000
0.002
0.004
0.006
0.008
0.010
PROJECTION HEIGHT × RECESS WIDTH × (GROOVE WIDTH/GROOVE PITCH)
SHAPE PARAMETER