(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 350 899 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **89112770.6**

(51) Int. Cl.[4]: **B21D 39/03**

(22) Date of filing: **12.07.89**

(30) Priority: **13.07.88 JP 172645/88**

(43) Date of publication of application: **17.01.90 Bulletin 90/03**

(84) Designated Contracting States: **DE FR GB IT NL**

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(54) Anchor-bonded composite structures and method of production thereof.

(57) An anchor-bonded composite plate is produced by forcing anchor parts (6) of a cladding plate (2) into corresponding anchor cavities (5, 5a) with overhanging lips in a base plate (1) with sufficient force to plasticly deform the anchor parts and cause the same to fill the anchor cavities, thereby forming a positively locked anchor bond (7). The cladding plate (2) and the base plate (1) may be made of an aluminum alloy and a hard steel, respectively. The composite plate (8, 8a, 8b, 8c) thus produced is applicable as a reaction plate for a linear motor vehicle and as tank material of an LNG tanker.

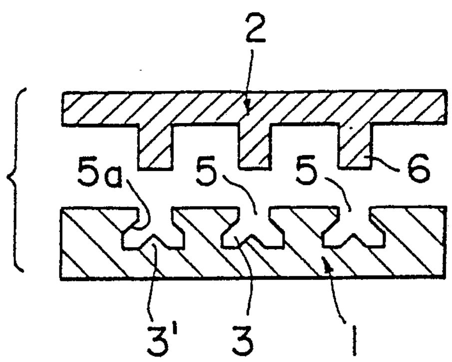

FIG. 1

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ANCHOR-BONDED COMPOSITE STRUCTURES AND METHOD OF PRODUCTION THEREOF

BACKGROUND OF THE INVENTION

This invention relates generally to composite structures each produced by joining two or more separate materials to form a single unitary structure. More particularly the invention concerns composite structures each fabricated by strongly joining a cladding plate to a substrate or base plate to obtain an integral structure. An example of such a cladding plate is made of aluminum or an alloy thereof. An example of the material for the base plate is steel. Examples of products which can be advantageously made of such composite structures are plate materials for tanks of LNG transport ships and reaction plates for linear motor vehicles.

More specifically, the invention relates to anchor bonded composite structures each comprising a hard substrate or base plate made of a material such as steel and a relatively soft cladding plate made of a material such as an aluminum alloy and having a plurality of anchor parts which are forced under great pressing force into corresponding anchor cavities in the base plate, whereby the two plates are joined firmly to form a unitary structure. The invention relates also to a process for producing these anchor bonded composite structures.

An important feature of the invention is that, at the deepest portion of each anchor cavity in the base plate, one or more overhanging parts are formed, whereby, when the corresponding anchor part of the cladding is forced under great pressing force into this anchor cavity, the anchor part undergoes plastic deformation to assume a sectional shape of the letter T or Y in inverted state which completely fills the anchor cavity. Thus a positively locking joint or anchor bond is produced. The anchor bonds of plural number join the two plates as an integral structure.

A review of some aspects of the pertinent prior art may be instructive for an understanding of the present invention. As is known, laminated metal structures are becoming widely used as materials in various machines, devices, and structures. Examples, as mentioned hereinbefore, are reaction plates for linear motor cars and tank materials of LNG transport vessels. All required characteristics such as mechanical strength, corrosion resistance, behavior relative to heat, and elongation/contraction properties cannot be completely satisfied by a plate material of a single substance. Accordingly it is becoming a widely spreading practice to use plate materials produced by firmly joining base plates of hard steel and cladding plates of soft aluminum alloy to obtain an integral plate structure.

However composite plate structures of the character described above have heretofore been produced by methods such as explosion pressure bonding. The use of such methods is inconveniently limited by the dimensions of the product such as thickness. Furthermore, these methods require much labor, whereby the production cost tends to rise.

Still another problem has been slippage at the interface between the two plates due to severe conditions of use such as vibration over a long period.

SUMMARY OF THE INVENTION

It is an object of this invention to provide anchor-bonded composite structures, each of a base plate and a cladding plate anchor bonded into an integral plate structure, which are not accompanied by the problems encountered heretofore and to provide a method of producing the composite structures. More specifically, it is an object of the invention to provide, at low cost, anchor-bonded structures which possess high resistance to shearing between the base plates and their cladding plates, and which retain their original performance without change over a long period of use.

According to this invention in one aspect thereof, there are provided composite structures each of which is produced by anchor bonding into an integral plate structure a base plate of steel and a cladding plate of aluminum, and in which the two plates are joined in a locked state by anchors integral with the cladding plate forcibly inserted into and plasticly deformed in corresponding anchor cavities formed in the base plate, the anchors and/or the anchor cavities having overhanging or catching parts affording a positive locking or anchoring joint between the two plates. Alternatively, anchor cavities to be mutually confronting and aligned are formed with overhanging parts respectively in the base plate and the cladding plate and then filled with a rivet-like or hour-glass-shaped anchor pin. The anchor cavities are formed by any suitable process such as forging, rolling, or machining.

The nature, utility, and further features of this invention will be more clearly apparent from the following detailed description with respected to preferred embodiments of the invention when read in conjunction with the accompanying drawings, which are briefly described below, and in which sectional views are taken in planes perpendicular to the plane of the outer surface of the cladding plate or the base plate.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a sectional view showing one example of a base plate and a corresponding cladding plate according to this invention prior to their being anchor bonded;

FIG. 2 is a sectional view of the same base plate and cladding plate in anchor-bonded state as an integral structure;

FIG. 3 is a plan view of the base plate;

FIG. 4 is a side view of the base plate as viewed from the right in FIG. 3;

FIG. 5 is a side view of the base plate as viewed from below in FIG. 3;

FIG. 6 is a sectional view of the anchor bonded structure as viewed in the same direction as in FIG. 5;

FIG. 7 is a sectional view of the same structure as viewed in the same direction as in FIG. 4;

FIG. 8 is a sectional view indicating the process of anchor bonding of a cladding plate to a base plate;

FIG. 9 is a sectional view showing the anchor-bonded unitary structure;

FIG. 10 is a perspective view showing another example of the base plate;

FIG. 11 is a plan view of an anchor-bonded structure with a base plate similar to that in FIG. 10, the view being partly in section taken along the interface between the cladding plate and the base plate;

FIG. 12 is a sectional view taken along the line XII-XII in FIG. 11;

FIG. 13 is a sectional view taken along the line XIII-XIII in FIG. 11;

FIG. 14 is a sectional view taken along the line XIV-XIV in FIG. 11;

FIG. 15 is a plan view of the base plate prior to anchor bonding;

FIG. 16 is a sectional view taken along the line XVI-XVI in FIG. 15;

FIG. 17 is a sectional view taken along the line XVII-XVII in FIG. 15;

FIG. 18 is a sectional view taken along the line XVIII-XVIII in FIG. 15;

FIG. 19 is a sectional view indicating a rolling process for forming a base plate;

FIG. 20 is a sectional view taken along the line XX-XX in FIG. 19;

FIG. 21 is a sectional view indicating a rolling process for leveling and finishing the base plate;

FIG. 22 is a plan view of a base plate;

FIG. 23 is a sectional view taken along the line XXIII-XXIII in FIG. 22;

FIG. 24 is a plan view, partly in section of the corresponding cladding plate;

FIG. 25 is a sectional view taken along the line XXV-XXV in FIG. 24;

FIG. 26 is a sectional view taken along the line XXVI-XXVI in FIG. 24;

FIG. 27 is a sectional view taken along the line XXVII-XXVII in FIG. 24;

FIG. 28 is a perspective view of still another example of a base plate according to the invention;

FIG. 29 is an enlarged fragmentary sectional view of the same base plate;

FIG. 30 is a perspective view of the corresponding cladding plate;

FIG 31 is an enlarged fragmentary sectional view of the same cladding plate;

FIGS. 32, 33, and 34 are similar sectional views indicating the process of anchor bonding the base plate and cladding plate showing in FIGS. 28 and 30 by means of a rivet-like anchoring material;

FIG. 35 is a perspective view of a base plate with spot or intermittent anchor cavities;

FIG. 36 is an enlarged fragmentary sectional view of the same base plate;

FIGS. 37, 38, and 39 are respectively a plan view and sectional views in orthogonal directions showing a forming plate placed on a base plate;

FIGS. 40 and 41 are sectional views indicating a process for forming an anchor cavity with the use of the forming plate and a leveling plate;

FIG. 42 is a plan view of a milling tool holder with extendable/retractable cutting tools for forming an anchor cavity in a base plate;

FIGS. 43 and 44 are sectional views indicating the process of forming the anchor cavity with the tool;

FIGS. 45, 46, and 47 are respectively a plan view and sectional views showing an anchor cavity formed by the process; and

FIGS. 48, 49, and 50 are sectional views indicating a process for forming anchor cavities in the form of linear rows by means of rolls.

DETAILED DESCRIPTION OF THE INVENTION

The structures shown in the drawings illustrate examples of composite structures which are designed to serve as reaction plates for supporting and propelling by induction the chassis of a linear motor car. Each of these composite structures comprises, essentially a steel base plate 1 and an aluminum alloy cladding plate 2 joined tightly by anchor bonding to the base plate to form the unitary composite structure. More specifically the two plates are anchor bonded at their respective anchor parts as will now be described in detail with respect to several examples constituting preferred embodiments of the invention.

As shown in FIGS. 1 through 7, the steel base plate 1 is a square plate, and the cladding plate 2 of aluminum is of the same shape in plan view. On one flat face of the base plate 1 when it is being prepared, a number of parallel and spaced-apart grooves 3, 3, ... of specific width, spacing and cross-sectional shape are formed in a first direction (these grooves being referred to hereinafter as first grooves), as shown in FIGS. 1, 3, and 5. Also on the same face of the base plate 1 are formed a number of parallel and spaced-apart grooves 4, 4, ... of specific narrow width and spacing are formed in a second direction perpendicular to the first direction (these narrow grooves being referred to hereinafter as second grooves). Each of the first grooves 3, 3, ... has a split-bottom shape with a ridge-like projection 3 , similar to the capital letter Y in inverted state, whereby an anchor cavity 5 with overhanging lips 5a is formed along that first groove between each pair of adjacent second grooves.

In the preparation of the cladding plate 2, protruding ribs 6, 6, ... of grid network form to become anchor parts are formed integrally on one (bottom) face of the cladding plate 2 in positions to be in alignment with corresponding anchor grooves 3, 3, ... and 4, 4, ...

Then, in the process of assembling the two plates 1 and 2, they are mutually registered so that the protruding ribs 6, 6, ... are aligned in coincidence with corresponding anchor grooves 3 and 4 and then pressed together. As a result, the protruding ribs 6, 6, ... of the cladding plate 2 are forced into their respective anchor grooves 3 and 4 in the base plate 1 and, undergoing plastic deformation, bite into the grooves to become locked therein. Thus an integrally anchor-bonded composite structure 8 to serve as a reaction plate is obtained as shown in FIGS. 2, 6, and 7. The two plates 1 and 2 are thus joined at their joint interface by anchor bonds 7 and 7a which exhibit extremely high resistance to shearing forces in the aforementioned first and second directions and high bonding strength. Therefore, there is no possibility of slippage occurring between the base plate 1 and the cladding plate 2 in any direction during use.

This high strength is exhibited also with respect to vibrations and thermal action.

In another example as shown in FIGS. 8 through 18, instead of the first and second anchor grooves 3 and 4 of straight-line form in the preceding example, only first anchor grooves 3a as shown in FIGS. 10 and 11 are used. Each of these grooves 3a is formed by plastic deformation to have flanking walls of curved wave-like shape. Furthermore, anchor depressions or holes 9, 9, ... of inwardly tapering shape are formed in the same face of the base plate 1 on opposite sides of each anchor groove 3a at specific spacing intervals. A cladding plate 2 which is similar to that in the preceding example and has protruding ribs 6 to align with respective anchor grooves 3a is prepared and pressed under great pressure against the base plate 1. As a result, the cladding plate 2 is integrally joined to the base plate 1 by anchor bonds 7 to produce a unitary composite structure 8a as shown in FIGS. 12, 13, and 14. In this composite structure 8a, also, there is no possibility of slippage in the first and/or second directions between the cladding plate 2 and the base plate 1 due to causes such as vibration and thermal action. Thus a composite structure 8a of stable mechanically bonded state is obtained.

In another example as shown in FIGS. 19 through 27, first grooves 3 are formed in the base plate 1 by annular protruding parts 10a of a rolling roll 10. At the same time, projections 13 of truncated triangular shape in section are formed with a specific spacing pitch on the bottoms of the first grooves 3 by grooves 12, 12 formed with a specific spacing in the circumferential direction on the protruding parts 10a of the roll 10. Then, as shown in FIG. 21, the surface of the base plate 1 is rolled by another rolling roll 10b thereby to flatten the upwardly rising parts 11 formed on the two edges at the upper part of each first groove 3. In this manner anchor cavities 5 having overhangs can be formed. Thus, as shown in FIGS. 22 and 23, projections 13 of the shape of a truncated triangle in section are formed with a specific spacing in the longitudinal direction of the anchor cavities 5.

Then, similarly as in the preceding examples, by pressing the cladding plate 2 against the base plate 1, the anchors 6 are forced into engagement into the anchor cavities 5 thereby to produce a mechanically integrated structure 8b of the two plates.

In the instant example, the anchor bond 7 produced by the forcible fitting of the anchors 6 of the cladding plate 2 into the anchor cavities 5 of the base plate 1 is further prevented from undergoing slippage in the longitudinal direction by the projections, 13, 13, ..., whereby its resistance to shear stress is further increased.

In the forming of the anchor cavities 5 in the base plate 1 in each of the above described examples, a rolling roll as indicated in FIGS. 19, 20, and 21 is used. However, these anchor cavities are not limited to a pattern of linear rows but may be in a pattern of intermittent or spotty cavities. In one example of such anchor cavities as shown in FIGS.

28 through 34, tapered anchor cavities 5a and 5b having overhanging parts as shown in FIGS. 29 and 31 are formed respectively in the base plate 1 and the cladding plate 2 at coincidently aligned positions which are in a regular pattern as shown in FIGS. 28 and 30. Each anchor cavity 5a in the base plate 1 can thus be coaxially aligned with a corresponding anchor cavity or hole 5b in the cladding plate as shown in FIG. 32.

Then, as indicated in FIG. 33, an anchor pin 14 is inserted into the aligned anchor cavities 5a and 5b and is pressed by means of a rolling roll 10b or means such as a press, forcing the anchor pin 14 into the anchor cavities 5b and 5a. As a result, the anchor pins 14 are plasticly deformed to fill the anchor cavities, whereby an anchor bond 7a is formed, each as shown in FIG. 34, and the cladding plate 2 and the base plate 1 are mechanically bonded to form a unitary structure 8c.

Another mode of producing an anchor bonded structure is illustrated in FIGS. 35 through 41. In this example, the base plate 1 is fabricated, as indicated in FIGS. 37, 38, and 39, by placing a forming plate 16 with a circular hole formed therethrough on a position on the base plate 1 where an anchor cavity 5a is to be formed, placing a punch 14 of a diameter smaller than that of the circular hole 15 on the base plate 1 concentrically with the circular hole 15, and applying a punching force on the punch 14 thereby to force metal of the base plate 1 to rise upward and thus to form an upwardly raised mound 17, a punched hole 18 being formed at the same time in the base plate 1. Thereafter, as indicated in FIG. 41, a leveling plate 19 is placed over the region of the base plate 1 thus processed and pressed thereagainst. As a result, the upwardly raised mound 17 is forced to flow inward, and an anchor cavity 5a of an overhanging shape is formed as shown in FIG. 36. In this manner, a plurality of intermittent anchor cavities 5a spaced apart in a regular pattern are formed in the base plate 1 as shown in FIG. 35.

Still another mode of forming spot anchor cavities 5b will now be described with reference to FIGS. 42 through 47. A circular hole 22 is first formed in the base plate 1 by suitable means such as a milling machine. Then a rotary tool holder 20 comprising a rotor 21 and a plurality of cutting tools 23, 23, ... retractably imbedded in the lower periphery of the rotor 21 is inserted coaxially into the hole 22 as shown in FIG. 43. The rotary tool holder 20 is then rotated as the cutting tools 23, 23, ... are progressively extended outward as indicated in FIG. 44 thereby to mechanically form an anchor cavity 5b of overhanging shape as shown in FIGS. 5, 46, and 47.

Irrespective of whether the anchor cavities are to be anchor cavities 5a of linear row form or whether they are to be anchor cavities 5b of spot form, they can be formed in overhanging shape by rolling in the following manner. By means of annular protruding parts 10a of a rolling roll as shown in FIGS. 19 and 20 referred to hereinbefore and as indicated in FIG. 48, a pressing force is imparted to the base plate 1 thereby to form first grooves 3 (or second grooves 4). At the same time, forced up parts 17 are formed on the upper surface of the base plate 1 on both sides of each protruding part 10a. Then, according to the conventional process, the forced up parts 17 are abruptly flattened in the succeeding stage by means of a plan roll for leveling thereby to form anchor cavities of overhanging shape. As a consequence, the overhanging shape has been irregular, or has collapsed.

In contrast, according to this invention, the forced up parts 17 are rolled by means of a forming roll 10c as indicated in FIG. 49, whereby they are caused to flow and bend gently inward. Finally, as indicated in FIG. 50, these parts are leveled by a plain roll 10b. As a result, all of the anchor cavities 5a are formed into overhanging shape accurately and consistently exactly as designed.

The modes of practicing this invention are, of course, not limited to the above described examples thereof. For example, in the process of fitting and joining the anchors of the cladding plate with the anchor cavities of the base plate, a suitable industrial adhesive or a corrosion resistant material can be applied to either one or both of the parts to be engaged in contact of the two materials. By such a measure, the mechanical joining strength of the two metals as a unitary structure can be even further increased, and galvanic corrosion can be prevented. Thus various modes of practice of this invention are possible.

Furthermore, in addition to the application of this invention to reaction plates of linear motor cars and tank plate materials of LNG transport vessels, its application to various machinery parts and structural members is possible.

According to this invention, in a composite structure comprising basicly an integrally bonded base plate of steel and a cladding plate of aluminum such as a reaction plate of a linear motor car or a tank material of an LNG transport vessel, an anchor-bond integral joining can be obtained mechanically by the fitting and engagement of anchors of a cladding plate in corresponding anchor cavities in a base plate. For this reason, by the fitting and engagement in two orthogonal directions of these anchor cavities and anchors, the resistance to shear stress in the longitudinal direction is remarkably increased, and the initial bonding strength is maintained unchanged with lapse of time, whereby the functional performance of the resulting structure is continually maintained.

Furthermore, the bonding function of the bonded structure is made uniform, and the performances of bonded structures of long length or large areas can be further improved.

In the production of these bonded structures, by using measures such as rolling with rolls, machine processing, or forging, the forming of the anchor cavities or the fitting of the anchors into the anchor cavities is facilitated. Therefore, the production cost can be lowered, and precision can be greatly improved.

Claims

1. An anchor-bonded composite plate structure of a base plate (1) and a cladding plate (2) joined to form an integral plate structure (8, 8a, 8b, 8c) by the anchoring engagement of a plurality of anchors (7) of the cladding plate in corresponding anchoring cavities (5) in the base plate, characterized in that each of said anchor cavities (5) is formed to have overhanging parts (5a) at the deepest part thereof, and the corresponding anchor (7) is forcibly thrust into and plasticly deformed in the anchor cavities to fill the same and form a positively locked joint.

2. An anchor-bonded composite plate structure as claimed in claim 1 in which the bottom of each of said anchor cavities (5) is formed to have a ridge-like projection (3′).

3. An anchor-bonded composite plate structure as claimed in claim 1 or 2 in which the anchor cavities (5) are grouped in rows, the anchor cavities in each row being joined consecutively by a common groove, which is of wave-like bent shape as viewed in plan view of the base plate (1).

4.An anchor-bonded composite plate structure as claimed in any one of claims 1 to 3 in which transverse grooves (4) are formed in the base plate (1) in directions to intersect said anchor cavities (5).

5.An anchor-bonded composite plate structure as claimed in any one of claims 1 to 4 in which the anchor cavities are in the form of grooves (3a) each with an outer opening of a width as viewed in plan view varying in the longitudinal direction of the groove.

6.An anchor-bonded composite plate structure as claimed in any one of claims 1 to 5 in which the anchor cavities (5) are in the form of grooves, and anchor holes (9) are formed at specific intervals in the base plate (1) along opposite sides of each groove.

7. An anchor-bonded composite plate structure of a base plate (1) and a cladding plate (2) joined to form an integral plate structure by the anchoring engagement of a plurality of anchor pins (14), which are independent of said base plate and of said cladding plate, in anchor cavities (5a) formed in the base plate and simultaneously in respectively coaxially aligned anchor cavities (5b) formed in the cladding plate, characterized in that each anchor cavity (5a or 5b) is of frustoconical shape with the base thereof at the deepest part thereof, and each anchor (7a) is of hourglass shape.

8. An anchor-bonded composite plate structure as claimed in claim 7 in which the anchor cavities (5a and 5b) in the base and cladding plates are of a specific plural number and are distributed uniformly over the plane of the interface between said plates (1 and 2).

9. A method of producing an anchor-bonded composite plate structure of a base plate (1) and a cladding plate (2) joined to form an integral laminated structure (8, 8a, 8b, 8c) by the anchoring engagement of a plurality of anchor parts of the cladding plate in corresponding anchoring cavities formed in the base plate, characterized by the steps of forming said anchor cavities (5) in a specific pattern in one surface of said base plate (1), forming said anchor parts (6) on one surface of said cladding plate (2) at positions to be aligned with respective anchor cavities of the base plate, placing the base and cladding plates (1, 2) together with the anchor parts (6) aligned with and confronting respective anchor cavities (5), and pressing said plates (1, 2) together with sufficient force to cause the anchor parts (6) to fit into and be plasticly deformed in respective anchor cavities (5) thereby to fill the same and form a positively locked anchor bond (7).

10. A method of producing an anchor-bonded composite plate structure, characterized by the steps of: forming anchor cavities in a first form of grooves (3) with raised rims (11) on opposite sides of each groove (3) in one surface of a base plate (1) by the rolling operation of a forming roll (10); plasticly deforming said raised rims (17) of each groove toward the center of that groove by means of the inclined surfaces (25) of a Vee-shaped groove formed around the cylindrical surface of a second forming roll (10c); leveling said surface into a flat surface by means of a cylindrical roll (10b) thereby to form said anchor cavities in a final form of grooves each with overhanging lip parts on opposite sides thereof; and pressing against the base plate (1) a cladding plate (2) having anchor parts (6) in positions respectively aligned with said anchor cavities with sufficient force to cause the anchor parts to fit into and be plasticly deformed in respective anchor cavities thereby to fill said cavities and form a positively locked anchor bond.

11. A method of producing an anchor-bonded composite plate structure as claimed in claim 9 in which said anchor cavities are formed in the base

plate (1) by a machining process.

12. A method of producing an anchor-bonded composite plate structure as claimed in claim 9 in which said anchor cavities are formed in the base plate (1) by a forging process.

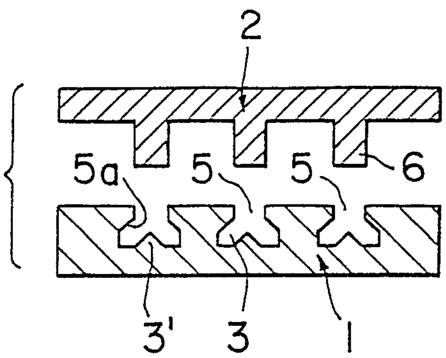

FIG. 1

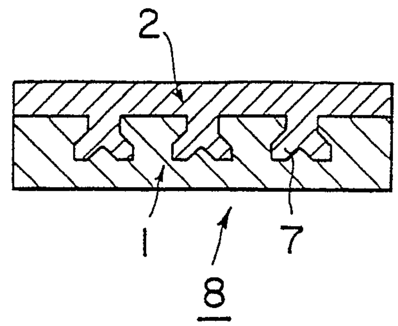

FIG. 2

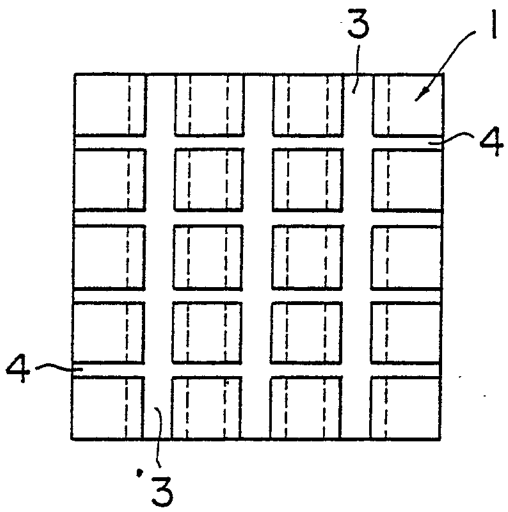

FIG. 3

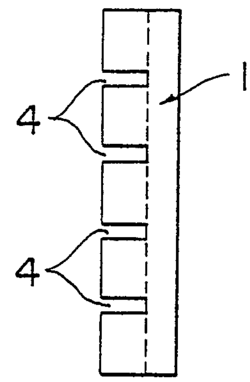

FIG. 4

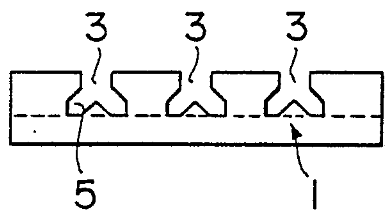

FIG. 5

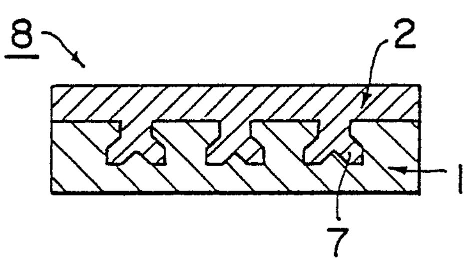

FIG. 6

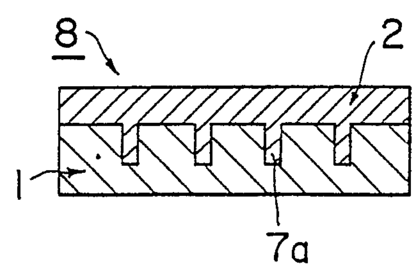

FIG. 7

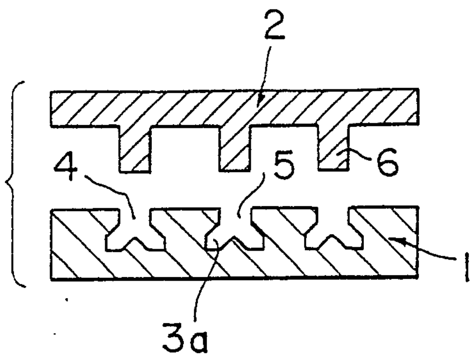

FIG. 8

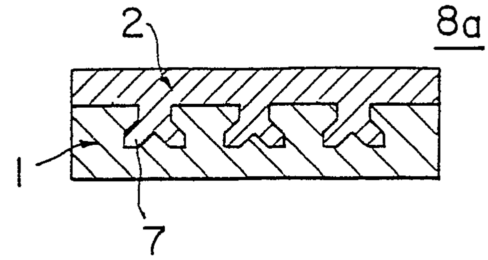

FIG. 9

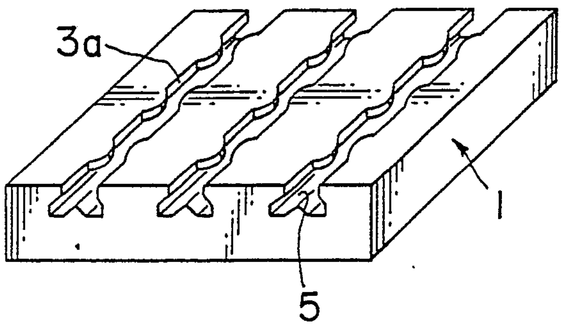

FIG. 10

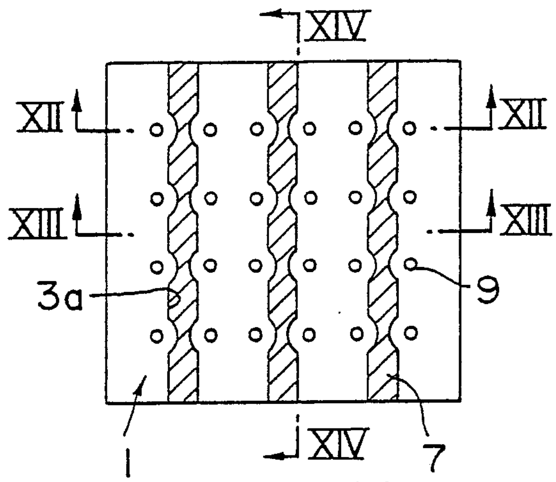

FIG. 11

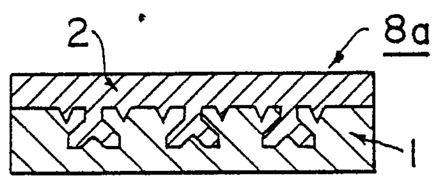

FIG. 12

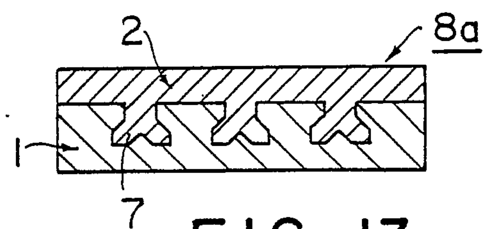

FIG. 13

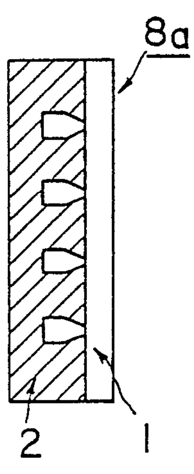

FIG. 14

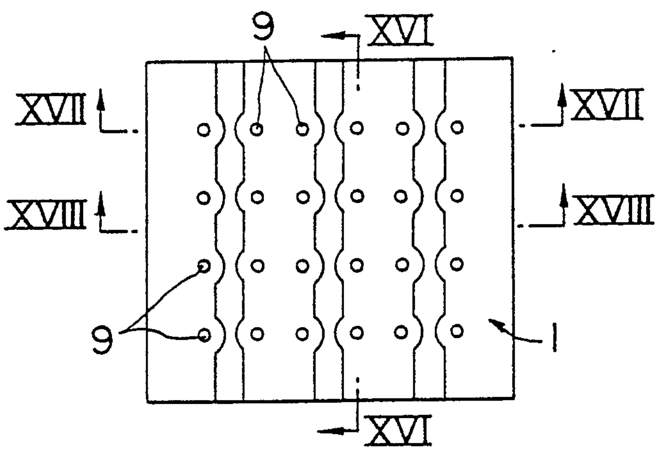

FIG. 15

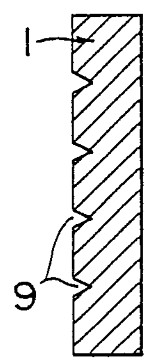

FIG. 16

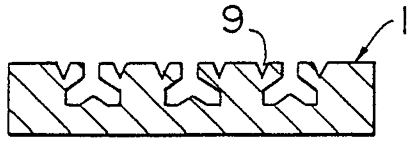

FIG. 17

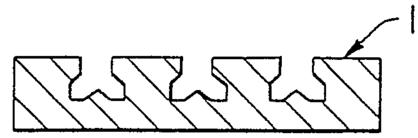

FIG. 18

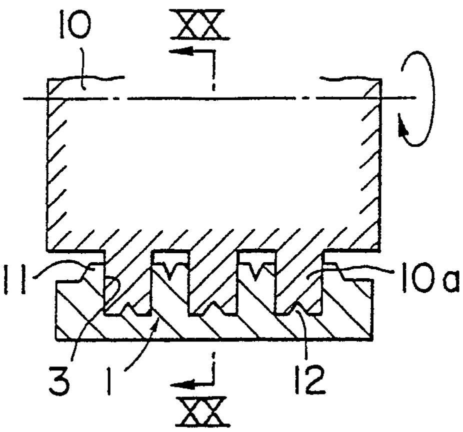

FIG. 19

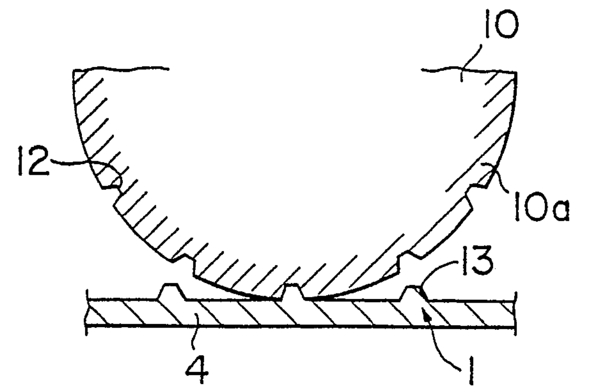

FIG. 20

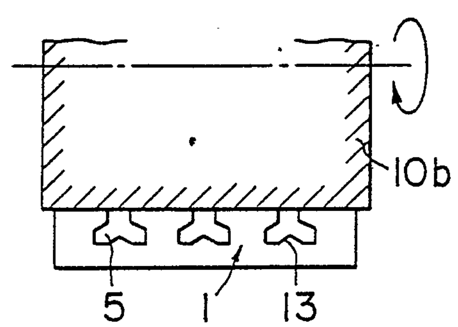

FIG. 21

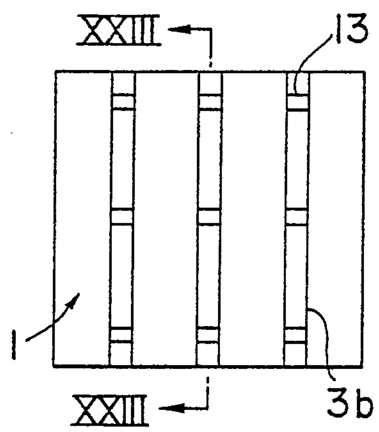

FIG. 22

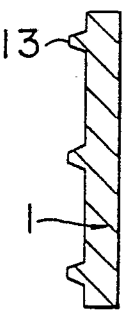

FIG. 23

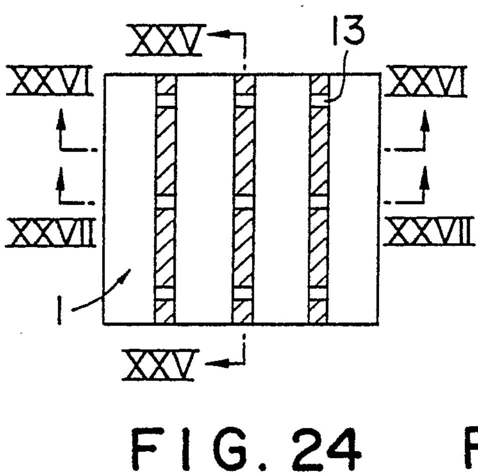

FIG. 24

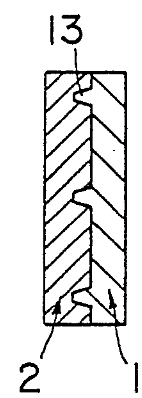

FIG. 25

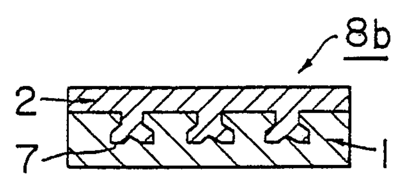

FIG. 26

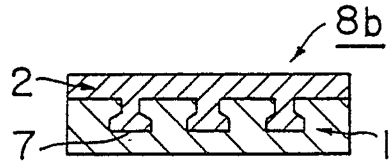

FIG. 27

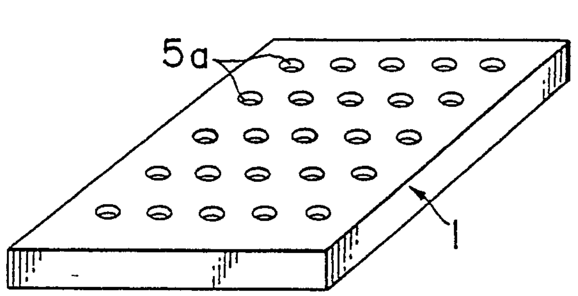

FIG. 28

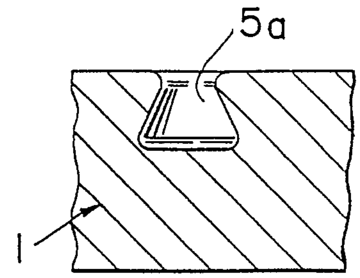

FIG. 29

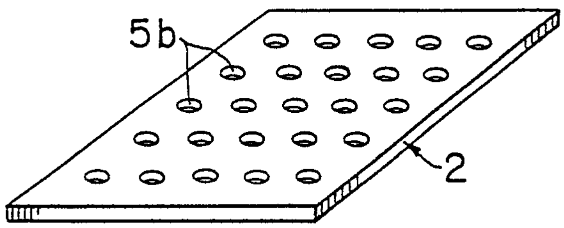

FIG. 30

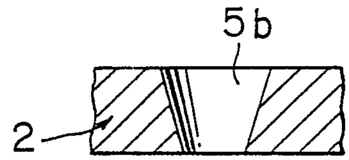

FIG. 31

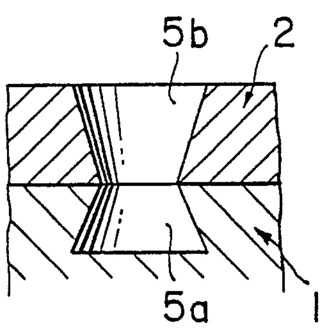

FIG. 32

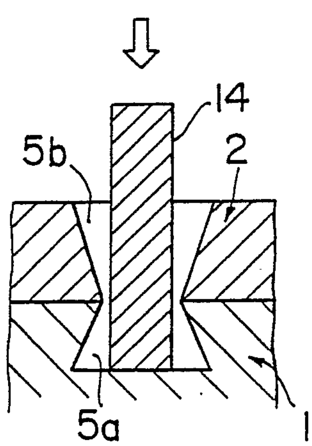

FIG. 33

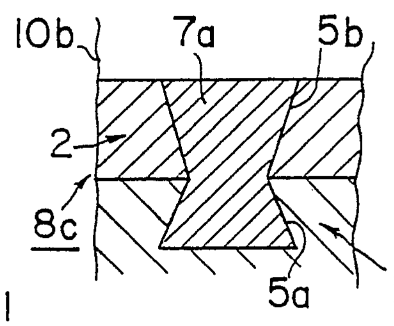

FIG. 34

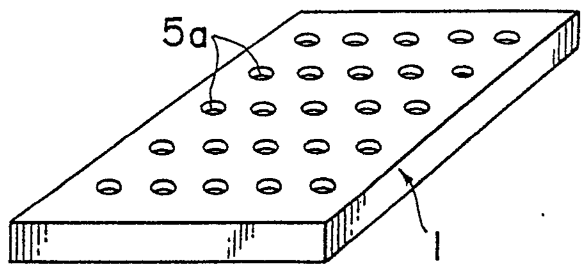

FIG. 35

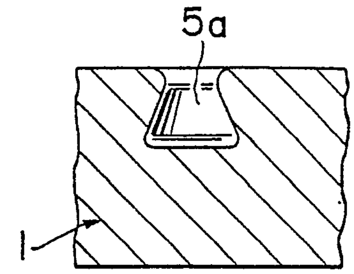

FIG. 36

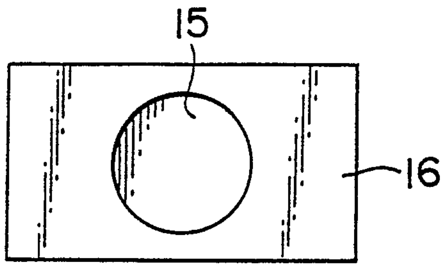

FIG. 37

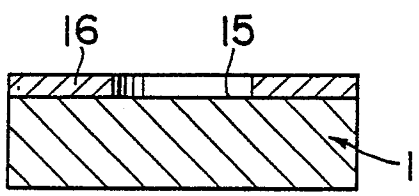

FIG. 38

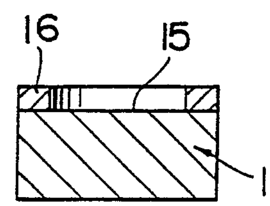

FIG. 39

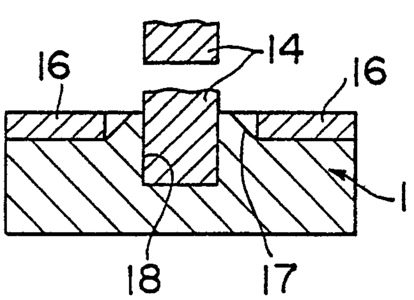

FIG. 40

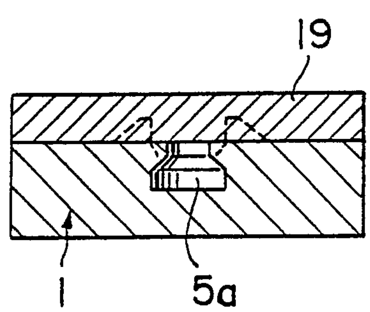

FIG. 41

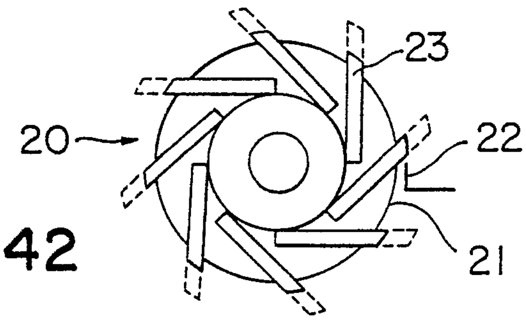

FIG. 42

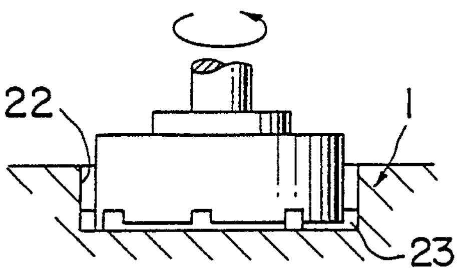

FIG. 43

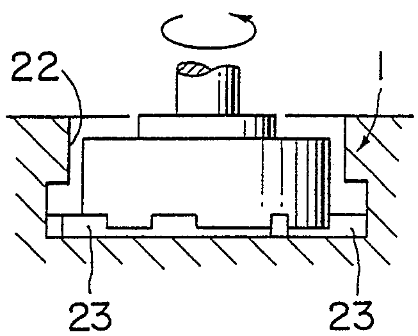

FIG. 44

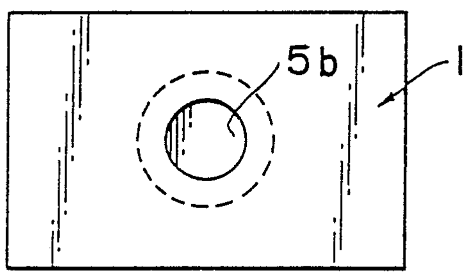

FIG. 45

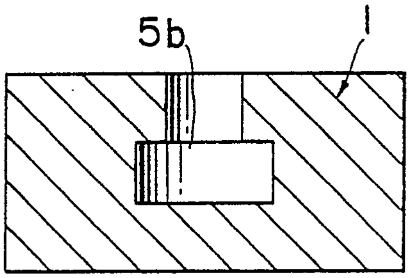

FIG. 46

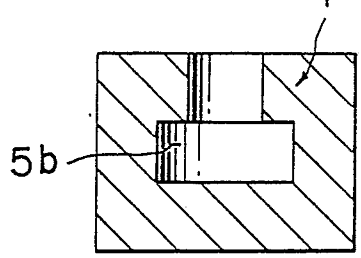

FIG. 47

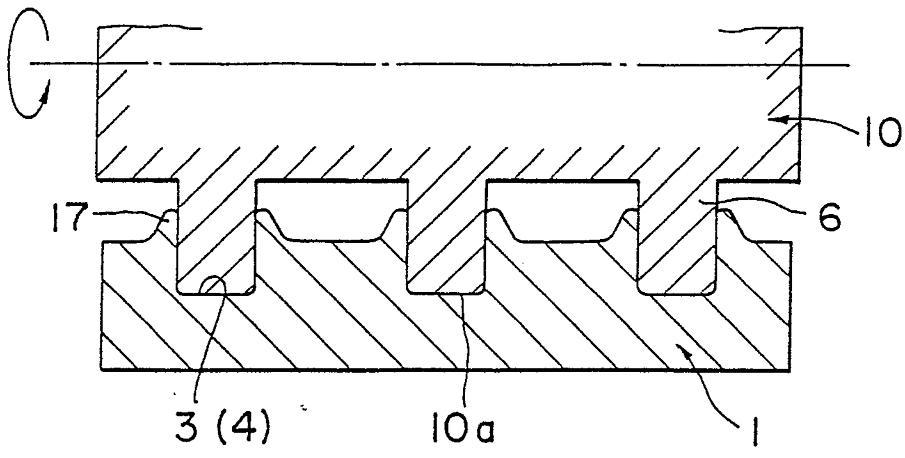

FIG. 48

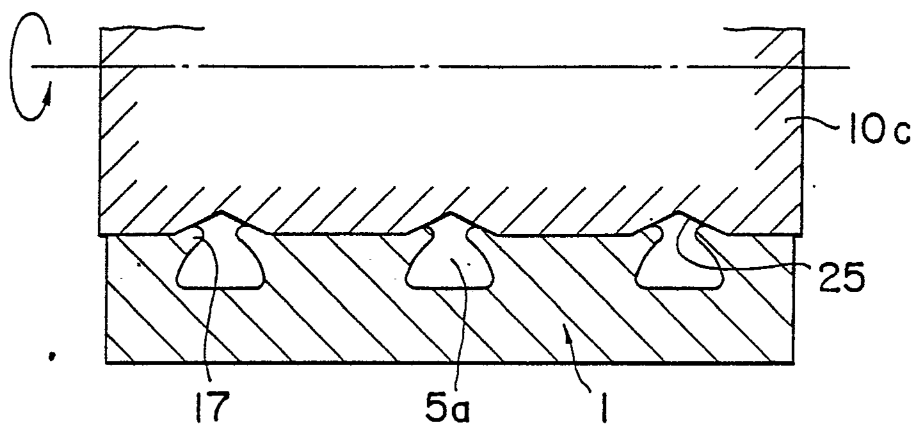

FIG. 49

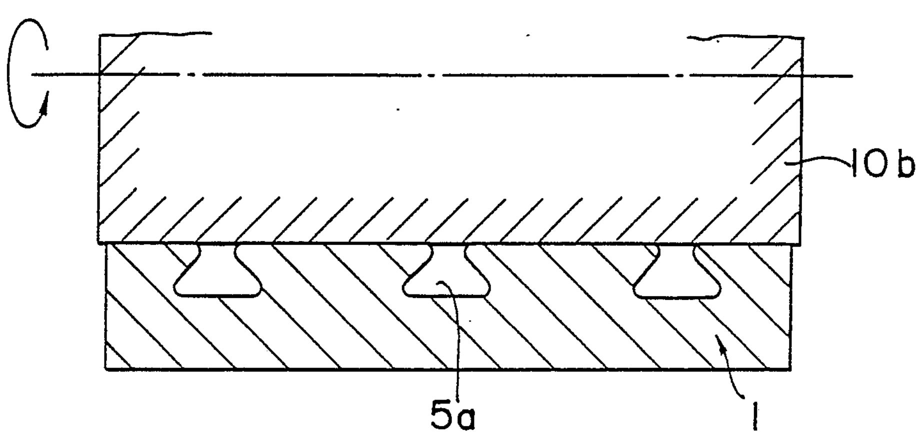

FIG. 50