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(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA**
1, Toyota-cho Toyota-shi
Aichi-ken 471(JP)

(72) Inventor: **Matsukura, Takanori**
c/o TOYOTA JIDOSHIA K. K. 1, Toyota-cho
Toyota-shi Aichi-ken(JP)

(72) Inventor: **Shiramizu, Kousuke**
c/o TOYOTA JIDOSHIA K. K. 1, Toyota-cho
Toyota-shi Aichi-ken(JP)

(72) Inventor: **Ooaki, Osamu**
c/o TOYOTA JIDOSHIA K. K. 1, Toyota-cho
Toyota-shi Aichi-ken(JP)

(72) Inventor: **Kudo, Masashi**
c/o TOYOTA JIDOSHIA K. K. 1, Toyota-cho
Toyota-shi Aichi-ken(JP)

(72) Inventor: **Takeuchi, Masahiko**
c/o TOYOTA JIDOSHIA K. K. 1, Toyota-cho
Toyota-shi Aichi-ken(JP)

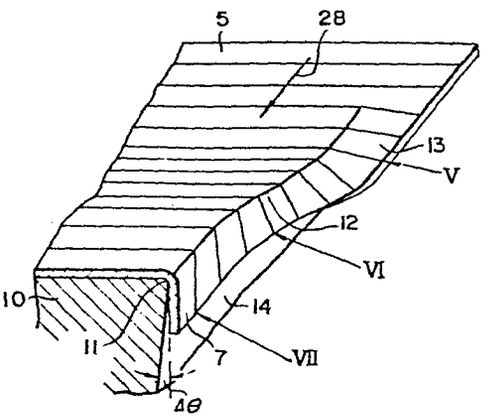
(72) Inventor: **Masaki, Masaru**
c/o TOYOTA JIDOSHIA K. K. 1, Toyota-cho
Toyota-shi Aichi-ken(JP)

(74) Representative: **Grams, Klaus Dieter, Dipl.-Ing. et al,**
Patentanwaltsbüro Tiedtke-Bühling-Kinne-
Grupe-Pellmann-Grams-Struif Bavariaring 4
D-8000 München 2(DE)

(54) **Method of bending plate materials.**

(57) Disclosed is a method of bending a plate material by means of an exclusive-use die shoe for the plate material to be worked and a versatile bending means having a pressing surface, wherein the edge portion of the die shoe (10) serves as a bending surface (11) for the plate material (5); the plate material (5) is mounted on and secured to the die shoe (10), bending means (15, 16, and 17; 18) are brought into contact with and pressed against a portion of the surface to be bent (13) of the plate material (5), moving the same along the surface to be bent, and bending the surface to be bent step by step. The bending means (15, 16, and 17) comprise a plurality of bending members, each bending member being formed in such a manner that the angle of each of the pressing surfaces (19, 20, and 21) thereof is formed such as to become gradually larger, and the bending members are used in sequence starting with the one having the pressing surface with the smallest angle. Or, the bending means (18) is a bending member having a pressing surface parallel to the axis of the bending member and is inclined against the plate material step by step.

FIG. 4



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METHOD OF BENDING PLATE MATERIALS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of bending plate materials, and more particularly to a method of bending metallic plate materials to form bent products with a U-shaped cross section.

2. Description of the Related Art

As methods of forming bent products such as those with a U-shaped cross section from metallic plates, stamping by the use of a die assembly comprising a punch and a die, roll forming by the use of rolls, and other similar methods are known. For instance, in the case of forming a bent product 1 having a flange portion 7 with an elongated portion 8 and a shrunk portion 9 such as the one shown in Fig. 1, such a product is formed by stamping with an exclusive-use die assembly. Fig. 2 shows a method of stamping, in which the left half portion thereof shows the state immediately before working. A plate material 5 is mounted on a die 6 whose surface conforms to the configuration of the plate material 5 to be worked. A punch 2 corresponding to the die 6 is lowered toward the plate material 5, and the plate material 5 is clamped between the punch 2 and a cushion

pad 4 provided with a cushion pin 3 therebelow. Furthermore, the plate material 5 is bent by the die 6 by lowering the punch 2, thereby forming a bent web portion 7 as shown in the right half portion of Fig. 2.

Fig. 3A shows a method which employs roll forming. The plate material 5 is continuously worked by a plurality of sets of rolls (in Fig. 3A, a first roll to a fourth roll) onstituted by vertical pairs of forming rolls, thereby forming the plate material 5 in sequence. Fig. 3B shows front elevational views illustrating each of the bending surface of the first roll to the fourth roll shown in Fig. 3A ("Puresu Kako Binran" (Stamping Handbook), pp. 248 – 265, published by Maruzen).

According to the aforementioned method of stamping, however, the cost of the die assembly is increased since an exclusive-use die assembly is used for one type of bent products, and a large space for storing die assemblies is therefore required. Furthermore, large noise is generated at the time of working. Moreover, the aforementioned method of stamping has an additional drawback in that biting off is liable to occur (the surface of a plate material is liable to be galled by a die assembly). This galling phenomenon is particularly noticeable in the shrunk portion 9.

In contrast, the method which employs roll forming is superior to the aforementioned stamping in terms of noise,

galling, and other aspects. However, the application of this method is restricted to a workpiece which has a fixed cross-sectional shape and a bending line of which is straight or slightly curved. In other words, this method has a drawback in that it is impossible to form a bent product 1, whose bent line is not straight but curved as in the case of the one shown in Fig. 1, i.e., one having an elongated portion 8 and a shrunk portion 9.

SUMMARY OF THE INVENTION

The present invention is intended to overcome the problems of stamping which results from the fact that a die assembly is exclusively used for one type of bent products, namely, the problem of increased cost of die assemblies and the problems of the generation of noise at the time of work and of galling in relation to a workpiece. At the same time, the present invention is also intended to overcome the problem caused by the fact that formation of a workpiece with a curved bent line is impossible in the roll forming method.

According to the present invention, a die shoe is provided which has an edge portion serving as a bending surface for the plate material; the plate material is mounted on and secured to the die shoe with the surface thereof which is to be bent extending from the bending surface of

the die shoe; a versatile bending means having a pressing surface is provided; the bending means is brought into contact with and pressed against a portion of the surface of the plate material which is to be bent; the bending means is moved along the surface to be bent; and the same surface is bent by small degrees. Consequently, the plate material can be bent in correspondence with the shape of the bending surface formed at the edge portion of said die shoe as well as the shape of the bending means.

According to the present invention, since the plate material surface to be bent is worked by moving a bending means step by step, it is, first of all, possible to prevent generation of noise at the time of work and to preclude the occurrence of any galling of a workpiece. At the same time, it becomes possible simply by replacing die shoe to form not only a bent product with a bent line of straight configuration but also a bent product with a curved bent line, the formation of which has hitherto been possible only by using an exclusive-use die assembly. Thus, it becomes possible to obtain a versatile method. Furthermore, it becomes possible to effect a reduction in production cost by virtue of the above-mentioned versatility, and it hence becomes possible to effect production of a variety of products in small losts.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view which illustrates one example of a bent product;

Fig. 2 is a cross-sectional view illustrating a bending method in accordance with a conventional stamping method, in which the left half portion shows a state prior to the bending work, while the right half portion shows a state after the bending work;

Fig. 3A is a side elevational view illustrating a bending method in accordance with a conventional roll forming method, in which four pairs of rolls are used;

Fig. 3B is a front elevational view illustrating the bending surfaces of the first to fourth rolls shown in Fig. 3A;

Fig. 4 is a perspective view illustrating a bending method relating to the present invention;

Figs. 5 to 7 are cross-sectional views each illustrating a state in which the portions V, VI, and VII of Fig. 4 are being bent;

Fig. 8A, 8B and 8C are views similar to Figs. 5 to 7 in which single bending member is used;

Fig. 9 is a perspective view which illustrates another example of a bent product;

Fig. 10A is a perspective view of a flat plate material for forming the bent product as shown in Fig. 9; and

Fig. 10B is a perspective view of a plate with a bent web portion before forming a bent flange portion.

DETAILED DESCRIPTION OF THE INVENTION

Detailed description of the present invention will be made hereafter with reference to an embodiment shown in the attached drawings. Fig. 4 is a perspective view illustrating a bending method relating to the present invention. In the figure, an exclusive-use die shoe 10 with a configuration conforming to the shape of a plate material to be worked is shown, and the edge portion of the die shoe 10 is formed as a bending surface 11. The shape of the bending surface 11 is formed in a rectilinear shape in a case where a bending line 12 is a straight line, and in a corresponding shape as shown in the embodiment of the present invention in a case where the bending line 12 is cuved. The plate material 5 is mounted and secured on the die shoe 10 by means of a separate securing member (not shown) in such a manner that the surface to be worked 13 thereof extends from the bending surface 11. A side surface 14 consituting the bending surface 11 of the die shoe 10 is formed at an angle slightly smaller than the bending angle of the surface to be bent 13 of the plate material, and is arranged such that the angular difference $\Delta\theta$ therebetween will give the amount of spring back of the surface

to be worked 13. Figs. 5 to 7 show versatile bending members 15, 16, and 17 which are used for the bending work in accordance with the present invention. The bending members 15, 16, and 17 have pressing surfaces 19, 20, and 21 and are arranged such as to move along the surface to be bent 13 (i.e., in the direction of the arrow 28 in Fig. 4) while coming into contact with and pressing a portion of the surface to be bent 13. Each bending member 15, 16, and 17 is formed such as to be split in many stages (split into n) so that the angles θ_1, θ_2, ..., θ_n of the pressing surfaces 19, 20, and 21 thereof will become gradually larger. By using these bending members 15, 16, and 17 in sequence, the arrangement is such that edge waves are prevented from being formed at the edge portions by gradually enlarging the bending angles of the surface to be bent 13 from the flat state, i.e., by preventing the bending angles from changing abruptly. Although fixed guides may be used as the bending members 15, 16, and 17, in the present embodiment thery are formed with the structure of rotating rolls and are arranged such that their frictional resistance will become small at the time when the bending members are moved along the surface to be bent 13.

In the embodiment as shown in Figs. 5, 6 and 7, the bending members 15, 16, 17 each having a pressing surface inclined by angle θ_1, θ_2 ... θ_n against the axis of the

bending member, respectively, are used. However, as shown in Figs. 8A, 8B and 8C, a bending member 18 having a pressing surface parallel to the axis of the bending member may be used by inclining the bending member by angle θ_1, θ_2 ... θ_n step by step against the plate material.

A method of bending a plate material will be described on the basis of the aforementioned embodiment. The plate material 5 is mountd on and secured to the die shoe 10, and the bending member 15 is first brought into contact with and pressed against the surface to be bent 13 of the plate material 5. Then, the surface to be bent 13 is bent by moving the bending member 15 along the surface to be bent 13. Next, the bending member 15 is replaced with the bending member 16, and bending work is carried out in a manner similar to that described above. Further, bending work is carried out step by step by the bending member 17 so as to obtain an intended final bending angle, thereby finishing the plate material into a desired bent product.

The foregoing description has illustrated the example of forming a bent product having a flat web surface and a bent flange surface. In case of forming a bent product 31 having a curved web surface portion 35 as shown in Fig. 9, a plate material 5 as shown in Fig. 10A is bent to form a web portion 35 as seen in Fig. 10B. Thereafter, a flange portion 37 with an elongated portion 38 and a shrunk portion

39 is formed by the aforementioned method, so that a bent product 31 as shown in Fig. 9 is formed.

WHAT IS CLAIMED IS:

1. A method of bending a plate material by means of an exclusive-use die shoe for said plate material to be worked and a versatile bending means having a pressing surface, characterized in that the edge portion of said die shoe (10) serves as a bending surface (11) for said plate material (5) and said plate material (5) is mouned on and secured to said die shoe (10), bending means (15, 16, and 17; 18) being brought into contact with and pressed against a portion of said surface to be bent (13) of said plate material (5), the same being moved along said surface to be bent, and said surface to be bent being bent step by step.

2. A method of bending a plate material according to claim 1, wherein said bending means (15, 16, and 17) comprise a plurality of bending members, each bending member being formed in such a manner that the angle of each of the pressing surfaces (19, 20, and 21) thereof is formed such as to become gradually larger, and said bending members are used in sequence starting with the one with the pressing surface having the smallest angle.

3. A method of bending a plate material according to claim 1, wherein said bending means is a bending member (18) having a pressure parallel to the axis of the bending member and said bending member is inclined against the plate material step by step.

4. A method of bending a plate material according to any one of claims 1 through 3, wherein said bending means (15, 16, and 17; 18) are formed with the structure of rotating rolls.

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FIG.1

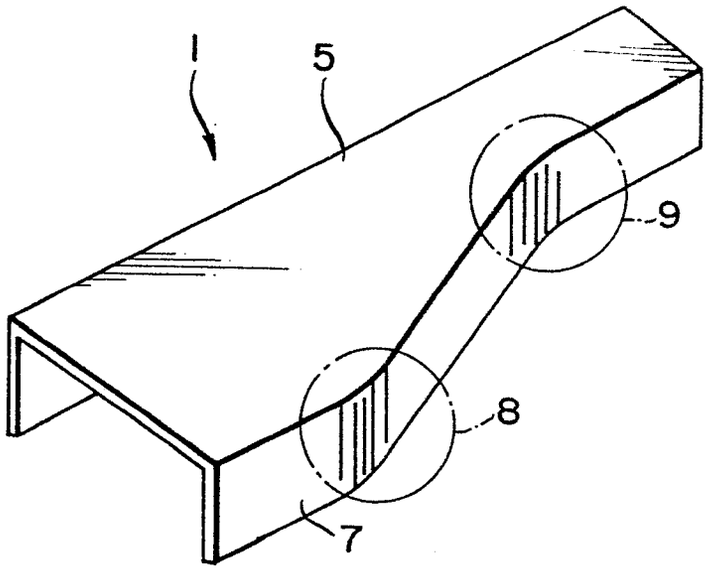
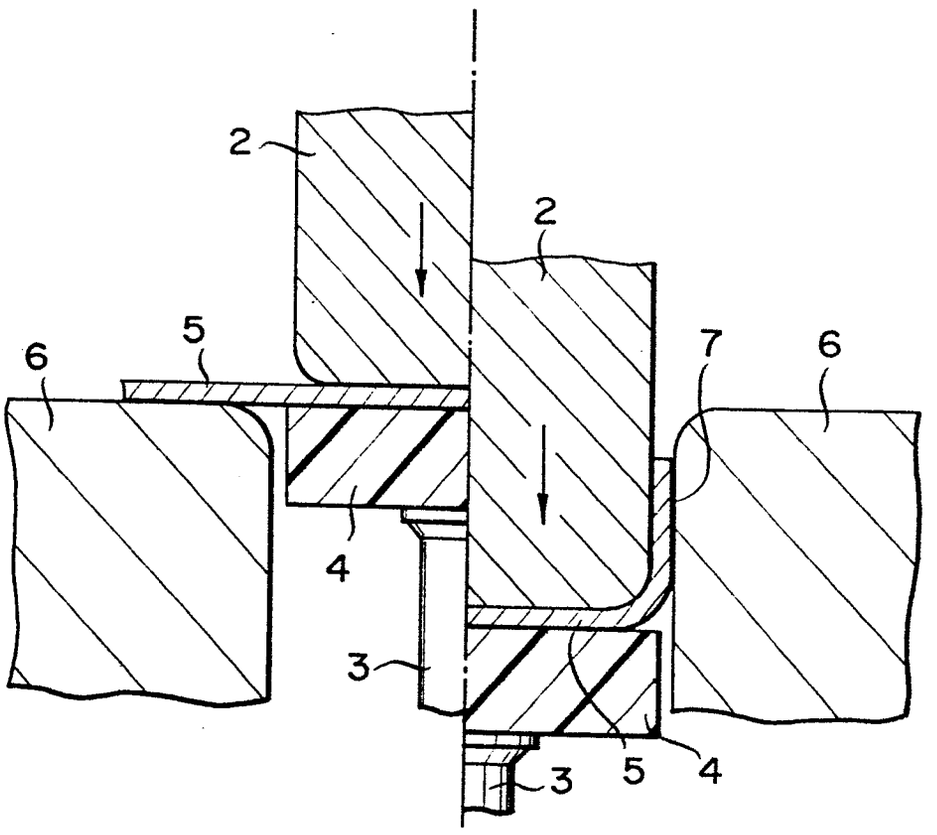


FIG.2



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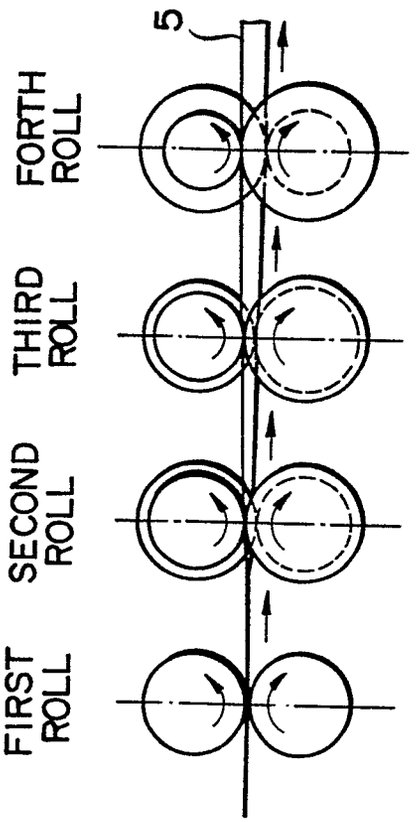

FIG. 3A

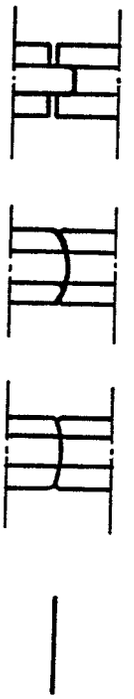

FIG. 3B

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FIG. 4

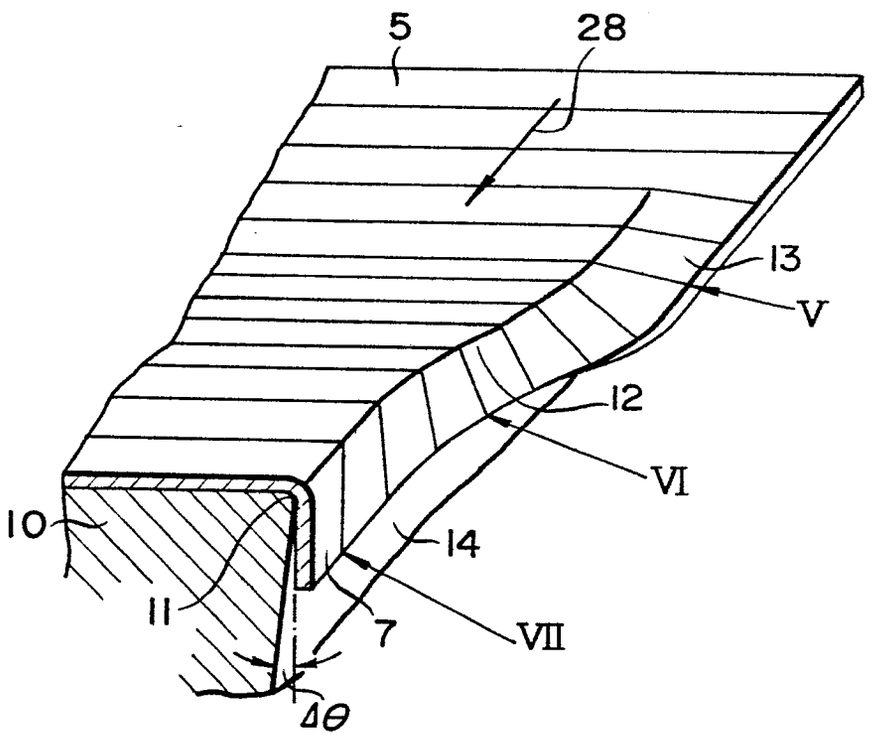

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FIG. 5

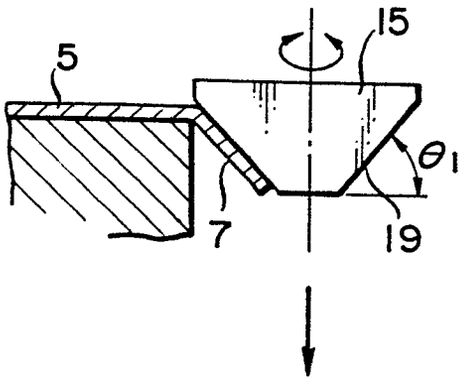

FIG. 6

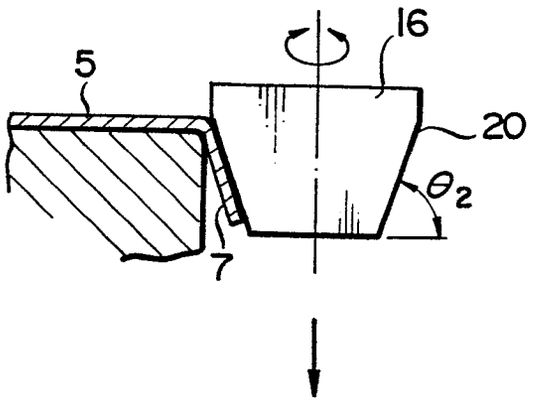

FIG. 7

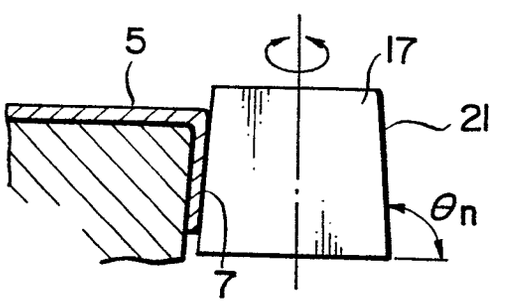

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FIG. 8A

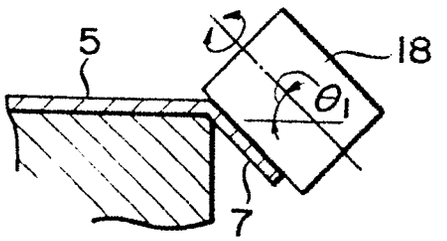

FIG. 8B

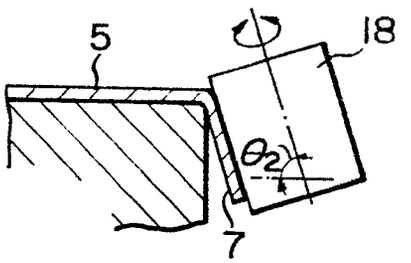

FIG. 8C

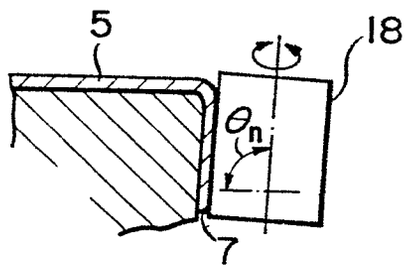

FIG. 9

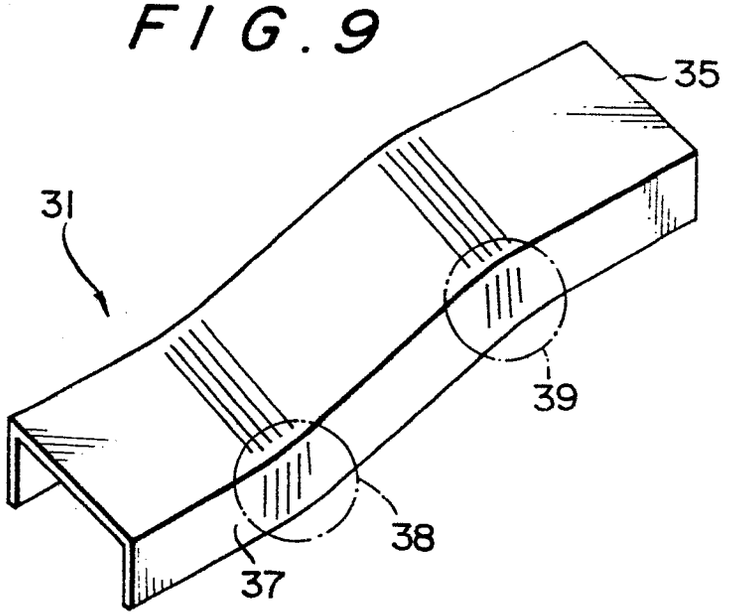

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FIG. 10A

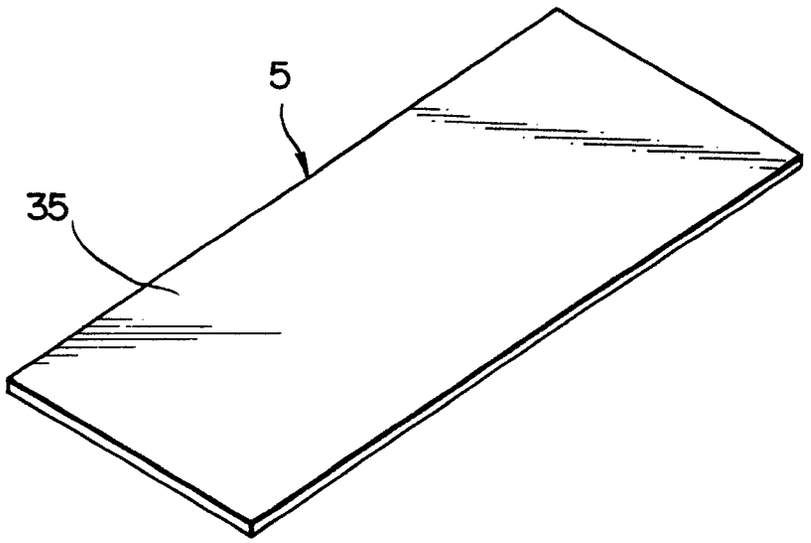

FIG. 10B