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Description

[Technical Field]

5 **[0001]** The present invention relates to a method of forming plates into curved parts (more specifically, curved frame parts). More particularly, the present invention relates to a forming method, according to the preamble of claim 1 (see for example AU-A-63924 73), that makes it possible to form high-strength steel sheets having a tensile strength (TS) that is greater than or equal to 590 MPa into curved parts.

10 [Background Art]

[0002] Curved parts have hitherto been obtained by press forming single metal plates. In the press forming, various forming modes including drawing, stretch forming, stretch flanging, and bending are combined. (The press forming will hereunder be referred to as "conventional press forming.") Further, a method of bending forming a cylindrical material (PTL 1), a roll forming technology (PTL 2), and bending forming using a hollow part (PTL 3 and PTL 4) are proposed. As an example of reinforcing curved parts, a method of filling with resin foam (PTL 5) is proposed.

[Citation List]

20 [Patent Literature]

[0003]

PTL 1: Japanese Unexamined Patent Application Publication No. 9-30345
 25 PTL 2: Japanese Unexamined Patent Application Publication No. 11-129045
 PTL 3: Japanese Unexamined Patent Application Publication No. 8-174047
 PTL 4: Japanese Unexamined Patent Application Publication No. 2005-1490
 PTL 5: Japanese Unexamined Patent Application Publication No. 11-348813

30 [Summary of Invention]

[Technical Problem]

35 **[0004]** Increasing the strength of a steel sheet in accordance with the demand for reducing weight causes at the same time a reduction in drawing ability, stretch forming ability, and stretch flanging ability on the steel sheet. Therefore, in conventional pressing forming, defects, such as cracks or wrinkles, occur. In particular, as the shape becomes complex, there are cases where curved parts cannot be obtained. For example, if portions 50A and 50B (which are curved in an X direction and a Y direction in plan view, and in a Z direction) of a curved part 50 shown in Fig. 11 is formed by performing conventional press forming on a single high-strength steel sheet having a tensile strength (TS) that is greater than or equal to 590 MPa, wrinkles occur in a planar section (such as a wrinkle section in Fig. 11), and cracks occur in a vertical wall at a side surface or in flanges (such as a crack section in Fig. 11). Here, it is possible to suppress the occurrence of cracks/wrinkles up to a certain extent by changing the shapes of parts or optimizing forming conditions of, for example, a blank holder. However, in such a method, in order to satisfy the need of reducing weight, there is a limit with regard to achieving a higher tensile strength (TS) that is greater than 980 MPa.

45 **[0005]** A method of obtaining high-strength curved parts by performing bending forming or roll forming on cylindrical materials is disclosed (PTL 1 to PTL 4). From the viewpoints of formability of the materials and process constraints, it is difficult to obtain complex curved shapes, and there are serious productivity problems such as an increase in the number of processes. For example, when low-strength materials are used, complex shapes can be easily obtained, but parts have insufficient strength. Therefore, there are, for example, technologies for obtaining reinforcing effects by filling with resin foam (PTL 5). However, from the viewpoints of costs, production, and recycling, it is actually not easy to say that such technologies are necessarily useful technologies.

50 **[0006]** That is, in conventional forming methods, when single high-strength steel sheets are used as materials, forming into desired curved parts cannot be performed by one-piece press forming, or, when single low-strength steel sheets are used as materials, forming into curved parts can be performed, but the parts have insufficient strength, thereby making it necessary to, for example, increase the number of reinforcing parts, as a result of which weight is increased.

[Solution to Problem]

[0007] The present invention for solving the aforementioned problems provides a method according to the independent claim 1. In dependent claim 2 a preferred embodiment of the method of the invention is defined.

[Advantageous Effects of Invention]

[0008] According to the present invention, since the material is bent and deformed almost without being variously deformed by drawing, stretch forming, and stretch flanging, it is possible to perform one-piece pressing forming of a single high-strength steel sheet into portions of the curved part. In addition, as a result of the shape of the curved part, which is a target to be formed, being reflected in the outline of the blank, it is possible to expect easy obtainment of parts having high strength and having a complex curved shape that could not be hitherto obtained, enlargement of space due to a reduction in the cross section of the parts, and a large reduction in weight because, for example, plate thickness is reduced and reinforcing parts are not used.

[Brief Description of Drawings]

[0009]

[Fig. 1] Fig. 1 is a schematic view of a preferred embodiment of the present invention.

[Fig. 2] Fig. 2 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiment).

[Fig. 3] Fig. 3 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiments).

[Fig. 4] Fig. 4 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiments).

[Fig. 5] Fig. 5 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiments).

[Fig. 6] Fig. 6 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiments).

[Fig. 7] Fig. 7 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiments).

[Fig. 8] Fig. 8 is a schematic view of a preferred embodiment of the present invention (differing from the already mentioned embodiments).

[Fig. 9] Fig. 9 is a sectional view of various exemplary sectional shapes of curved parts.

[Fig. 10] Fig. 10 is a schematic view of examples of how folding lines are formed.

[Fig. 11] Fig. 11 is a schematic view of an exemplary curved part formed by conventional press forming.

[Description of Embodiments]

[0010] Figs. 1 to 8 are schematic views of different, preferred embodiments of the present invention.

[0011] Figs. 1 and 2 each show an exemplary case in which a curve of a curved part 30 in a longitudinal direction is along folding lines in only one of two opposite directions. Further, in Fig. 1, the sectional size is constant in the longitudinal direction of the part, and, in Fig. 2, the sectional size changes in the longitudinal direction of the part. Figs. 3 and 4 each show an exemplary case in which a curve of a curved part 30 in the longitudinal direction along folding lines changes from either one of two opposite directions to the other one of the two opposite directions. Further, in Fig. 3, the sectional size is constant in the longitudinal direction of the part, and, in Fig. 4, the sectional size changes in the longitudinal direction of the part. Figs. 5, 6, 7, and 8 each show an exemplary case in which a curve of a curved part 30 in the longitudinal direction is such that the curved part 30 is continuously curved in only one of two opposite directions (Figs. 7 and 8 each show an exemplary case in which the curved part has a warped sectional shape in the longitudinal direction). Further, in Fig. 5, the sectional size is constant in the longitudinal direction of the part, and, in Figs. 6, 7, and 8, the sectional size changes in the longitudinal direction of the part.

[0012] In these embodiments, two blanks 1 and 2 have the same planar shape, and the planar shape thereof has a side-bend outline corresponding to the curve of the curved part 30, which is a target to be formed, in the longitudinal direction of the curved part 30. It goes without saying that the blanks 1 and 2 may be previously provided with working holes or beads, etc. In a bending process, the blanks 1 and 2 are each bent into a sectional shape corresponding to a division portion of a sectional shape of the curved part 30, so that portions 10 and 20 constituting the curved part 30 are formed. Reference numerals 1F and 2F denote portions corresponding to flanges of the blanks 1 and 2, or denote the

flanges of the portions 10 and 20. In Figs. 1 to 8, broken lines and dotted lines that are formed in regions of the shapes of the blanks 1 and 2 represent mountain folding and valley folding, respectively, and indicate places corresponding to bend portions (protrusion edges and recess edges) formed by bending in the bending process. In the bending process according to the present invention, using a die, the blanks are press bended so that forming portions of the blanks become bend portions that are in correspondence with target parts. By the press bending, forming materials primarily undergo deformation of bending forming, and are formed into target shapes.

[0013] Next, in a joining process, the portions 10 and 20 are joined together, to obtain the curved part 30. Joining methods may be any one of, for example, welding, caulking, riveting, and adhesion using an adhesive.

[0014] Although the embodiments shown in Figs. 1 to 6 are those in which the blanks are formed into a part sectional shape shown in Fig. 9(a), the present invention is not limited thereto. It is obvious that the present invention is applicable to cases in which, for example, as shown in Fig. 9(b), the blanks are formed into a part sectional shape that is the reverse of that in Fig. 9(a) at the left and right sides; or, as shown in Fig. 9(c), the blanks are formed into a part sectional shape so that the flanges 2F of only the structural portion 20 are bent. The embodiments shown in Figs. 7 and 8 are those in which the blanks are formed into a part sectional shape shown in Fig. 9(d).

[0015] Although, the embodiments shown in Figs. 1 to 6 and Fig. 8 use two blanks having the same planar shape for one curved part, the present invention is not limited thereto. It is obvious that the present invention is applicable to a case in which three or more blanks are used for one curved part, with at least one of the blanks having a planar shape that differs from the planar shapes of the remaining blanks.

[0016] Further, in the present invention, in order to increase position precision of the bend portions during the bending, folding lines are previously provided in portions of the blanks where the mountain folding and the valley folding are performed. The present invention is not only limited to (continuously) forming the folding lines along an entire bending processing portion. The folding lines may be (intermittently) formed in only portions of the bending processing portion according to the circumstances. As a method of forming the folding lines, it is desirable to use, for example, coining. Another example thereof is a method of continuously transferring the unevenness of a roller surface to surfaces of the materials. Suitable forms of folding lines may be provided by forming V grooves, such as that shown in Fig. 10(d), in a linear form (10(a)), a broken-line form (10(b)), or a dotted-line form (10(c)), or in a combination of any of these forms. According to the method of the present invention, the depth of the V grooves is less than or equal to 20% of the thickness of a metal plate (abbreviated as "plate thickness"). If the depth of the V grooves exceeds 20% of the plate thickness, the strength of the parts required for, for example, the frame of an automobile may be reduced, or cracks may be formed in the bend portions; and, in a high-strength metal material, it is not easy to form the grooves deeply, thereby causing serious production and cost problems.

[0017] When the curvature radius of the bend portions is large, a plurality of long and narrow grooves may be formed parallel to each other.

[0018] When there are localized portions where wrinkles or cracks are very likely to be formed due to localized excessive stretching or compression during bending (for example, when there are a plurality of localized portions at portions of the blanks corresponding to the flanges that are likely to be subjected to excessive stretch flanging or shrink flanging), previously forming cuts in such localized portions makes it possible to more reliably prevent the formation of cracks and wrinkles, which is desirable.

[First Examples]

[0019] Blanks formed of thin steel sheets (material symbols A, B, and C) having plate thicknesses and tensile properties (yield strength YS, tensile strength TS, elongation EI) shown in Table 1 were formed into curved parts by forming methods based on Table 2, and the shapes of the obtained curved parts were visually observed, to evaluate the forming methods. The results are as shown in Table 2. In conventional press forming according to a comparative example, wrinkles are formed in the wrinkle section and cracks are formed in the crack section shown in Fig. 11, whereas in the examples of the present invention, curved parts substantially having target shapes and without having cracks or wrinkles were obtained.

[Table 1]

MATERIAL SYMBOL	PLATE THICKNESS (mm)	YS (MPa)	TS (MPa)	EI (%)
A	1.6	710	990	17
B	1.6	810	1190	13
C	1.6	1300	1500	9

[Table 2]

No.	MATERIAL SYMBOL	FORMING METHOD	RESULT OF FORMING		REMARKS
1	A	CONVENTIONAL PRESS FORMING	NO GOOD	CRACKS/WRINKLES PRODUCED	COMPARATIVE EXAMPLE
2	A	METHOD ILLUSTRATED IN FIG. 1	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
3	A	METHOD ILLUSTRATED IN FIG. 4	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
4	A	METHOD ILLUSTRATED IN FIG. 7	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
5	B	CONVENTIONAL PRESS FORMING	NO GOOD	CRACKS/WRINKLES PRODUCED	COMPARATIVE EXAMPLE
6	B	METHOD ILLUSTRATED IN FIG. 3	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
7	B	METHOD ILLUSTRATED IN FIG. 6	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
8	B	METHOD ILLUSTRATED IN FIG. 8	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
9	C	CONVENTIONAL PRESS FORMING	NO GOOD	CRACKS/WRINKLES PRODUCED	COMPARATIVE EXAMPLE
10	C	METHOD ILLUSTRATED IN FIG. 5	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
11	C	METHOD ILLUSTRATED IN FIG. 2	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION
12	C	METHOD ILLUSTRATED IN FIG. 7	GOOD	NO CRACKS/WRINKLES PRODUCED	EXAMPLE OF PRESENT INVENTION

EXAMPLES 2

[0020] Folding lines provided by V grooves (whose depths are shown in Table 3) in a linear form, a broken-line form, or a dotted-line form, such as those shown in Fig. 10, were previously formed in blanks formed of thin steel sheets (material symbols A, B, and C) having plate thicknesses and tensile properties (yield strength YS, tensile strength TS, extension EI) shown in Table 1. Then, the blanks were formed into curved parts using forming methods based on Table 3, and the shapes of the obtained curved parts were visually observed, to evaluate the forming methods. The results are as shown in Table 3. In the examples of the present invention, cracks or wrinkles were not produced, and curved parts whose shapes more closely matched the target shapes compared to the curved parts in the first examples of the present invention (that is, curved parts whose dimensional precisions were good) were obtained.

[Table 3]

No.	MATERIAL SYMBOL	V GROOVE	V GROOVE: DEPTH (%)	FORMING METHOD	RESULT OF FORMING	DIMENSIONAL PRECISION	REMARKS
1	A	LINEAR FORM	7	METHOD ILLUSTRATED IN FIG. 1	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
2	A	LINEAR FORM	6	METHOD ILLUSTRATED IN FIG. 2	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
3	A	BROKEN-LINE FORM	12	METHOD ILLUSTRATED IN FIG. 3	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
4	A	BROKEN-LINE FORM	19	METHOD ILLUSTRATED IN FIG. 4	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
5	A	DOTTED-LINE FORM	10	METHOD ILLUSTRATED IN FIG. 5	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
6	A	DOTTED-LINE FORM	16	METHOD ILLUSTRATED IN FIG. 6	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
7	A	LINEAR FORM	12	METHOD ILLUSTRATED IN FIG. 7	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
8	A	LINEAR FORM	5	METHOD -ILLUSTRATED IN FIG. 8	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
9	B	LINEAR FORM	10	METHOD ILLUSTRATED IN FIG. 5	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
10	B	LINEAR FORM	8	METHOD ILLUSTRATED IN FIG. 6	GOOD NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION

(continued)

No.	MATERIAL SYMBOL	V GROOVE	V GROOVE: DEPTH (%)	FORMING METHOD	RESULT OF FORMING		DIMENSIONAL PRECISION	REMARKS
11	B	DOTTED-LINE FORM	4	METHOD ILLUSTRATED IN FIG. 1	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
12	B	DOTTED-LINE FORM	15	METHOD ILLUSTRATED IN FIG. 2	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
13	B	BROKEN-LINE FORM	6	METHOD ILLUSTRATED IN FIG. 3	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
14	B	BROKEN-LINE FORM	13	METHOD ILLUSTRATED IN FIG. 4	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
15	B	DOTTED-LINE FORM	16	METHOD ILLUSTRATED IN FIG. 7	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
16	B	DOTTED-LINE FORM	6	METHOD ILLUSTRATED IN FIG. 8	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
17	C	BROKEN-LINE FORM	8	METHOD ILLUSTRATED IN FIG. 3	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
18	C	BROKEN-LINE FORM	12	METHOD ILLUSTRATED IN FIG. 4	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
19	C	DOTTED-LINE FORM	4	METHOD ILLUSTRATED IN FIG. 5	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
20	C	DOTTED-LINE FORM	9	METHOD ILLUSTRATED IN FIG. 6	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION

(continued)

No.	MATERIAL SYMBOL	V GROOVE	V GROOVE: DEPTH (%)	FORMING METHOD	RESULT OF FORMING		DIMENSIONAL PRECISION	REMARKS
21	C	LINEAR FORM	3	METHOD ILLUSTRATED IN FIG. 1	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
22	C	LINEAR FORM	5	METHOD ILLUSTRATED IN FIG. 2	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
23	C	BROKEN-LINE FORM	5	METHOD ILLUSTRATED IN FIG. 7	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION
24	C	BROKEN-LINE FORM	10	METHOD ILLUSTRATED IN FIG. 8	GOOD	NOCRACKS/WRINKLES PRODUCED	GOOD	EXAMPLE OF PRESENT INVENTION

Reference Signs List

[0021]

- 5 1, 2 Blanks
- 1F, 2F Flanges, Portions corresponding to flanges
- 10 10, 20 Portions constituting curved parts according to present invention
- 30 Curved part according to present invention (target to be formed)
- 50 Curved part formed by conventional press forming (50A and 50B denote portions constituting curved part 50)

Claims

1. A curved-part forming method for obtaining a curved part (30) by performing forming on a blank (1,2) formed of a single metal plate, the method comprising:

a bending process in which the blank (1, 2) having a curved outline corresponding to a curve of the curved part (30) in a longitudinal direction is bent into a sectional shape corresponding to a division portion (10, 20) of a sectional shape of the curved part (30); and

a joining process in which two or more of said division portions (10, 20) obtained by the bending process are joined together, **characterized in that:**

prior to the bending process, a folding line is formed in the blank (1, 2);
the folding line is formed by V groove and a depth of the V groove is 20% or less of the thickness of the single metal plate;

and the single metal plate is a steel sheet having a tensile strength of 590 MPa or more.

2. The curved-part forming method according to claim 1, wherein the folding line formed by V groove has a linear form, a broken-line form, or a dotted-line form.

Patentansprüche

1. Herstellungsverfahren für ein gebogenes Teil zum Erhalten eines gebogenen Teils (30) durch Durchführen von Umformen an einem Rohling (1, 2), der aus einer einzelnen Metallplatte besteht, wobei das Verfahren umfasst:

einen Biegeprozess, in dem der Rohling (1, 2), der eine gebogene Kontur entsprechend einer Biegung des gebogenen Teils (30) in einer Längsrichtung aufweist, zu einer Querschnittsform entsprechend einem Teilungsabschnitt (10, 20) einer Querschnittsform des gebogenen Teils (30) gebogen wird; und

einen Verbindungsprozess, in dem zwei oder mehr der Teilungsabschnitte (10, 20), die in dem Biegeprozess erhalten werden, miteinander verbunden werden,

dadurch gekennzeichnet, dass

vor dem Biegeprozess eine Falzlinie in dem Rohling (1, 2) ausgebildet wird;

die Falzlinie von einer V-Nut gebildet wird und eine Tiefe der V-Nut 20 % oder weniger der Dicke der einzelnen Metallplatte aufweist;

die einzelne Metallplatte ein Stahlblech mit einer Zugfestigkeit von 590 MPa oder mehr ist.

2. Herstellungsverfahren für ein gebogenes Teil nach Anspruch 1, wobei die Falzlinie, die von der V-Nut gebildet wird, die Form einer Linie, die Form einer unterbrochenen Linie oder die Form einer gepunkteten Linie aufweist.

Revendications

1. Procédé de formation d'une partie incurvée pour obtenir une partie incurvée (30) en mettant en oeuvre la formation

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d'une ébauche (1, 2) formée dans une plaque métallique unique, le procédé comprenant :

un processus de cintrage dans lequel l'ébauche (1, 2) ayant un contour incurvé correspondant à une courbure de la partie incurvée (30) en direction longitudinale est incurvée en une forme en section correspondant à une portion de division (10, 20) d'une forme en section de la partie incurvée (30) ; et
un processus d'assemblage dans lequel deux ou plusieurs desdites portions de division (10, 20) obtenues par le processus de cintrage sont assemblées, caractérisé en ce qui :

avant le processus de cintrage, une ligne de pliage est formée dans l'ébauche (1, 2) ;
la ligne de pliage est formée par une rainure en V et une profondeur de la rainure en V est inférieure ou égale à 20 % de l'épaisseur de la plaque métallique unique ; et
la plaque métallique unique est une tôle d'acier présentant une résistance à la traction supérieure ou égale à 590 MPa.

- 2.** Procédé de formation de partie incurvée selon la revendication 1, dans lequel la ligne de pliage formée par une rainure en V présente une forme linéaire, une forme de ligne brisée, ou une forme de ligne pointillée.

FIG. 1

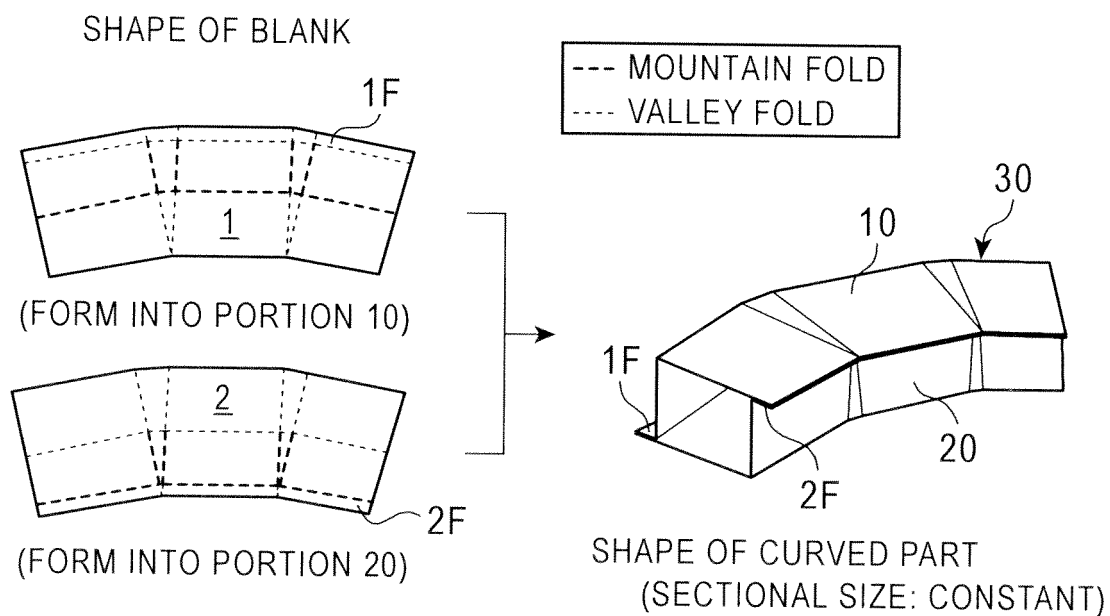


FIG. 2

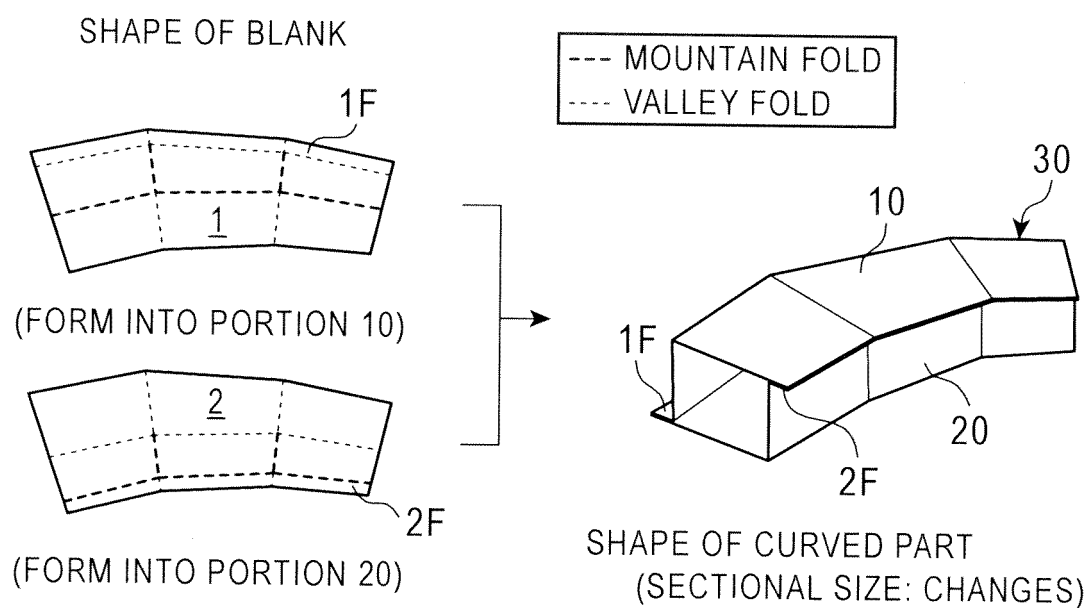


FIG. 3

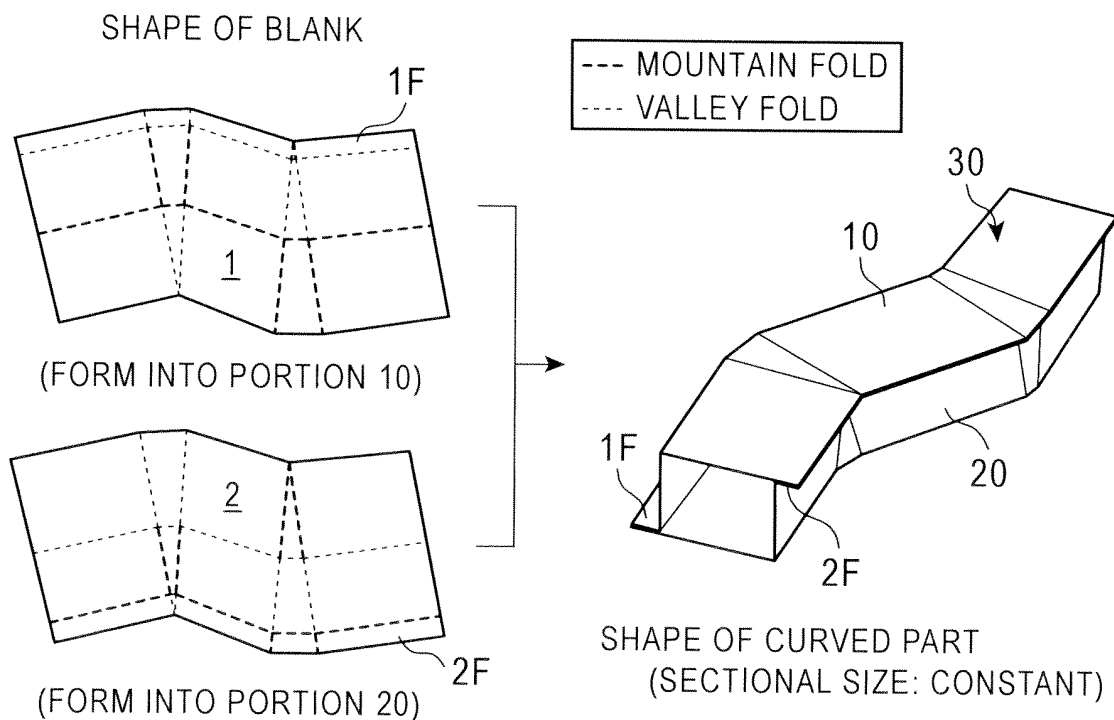


FIG. 4

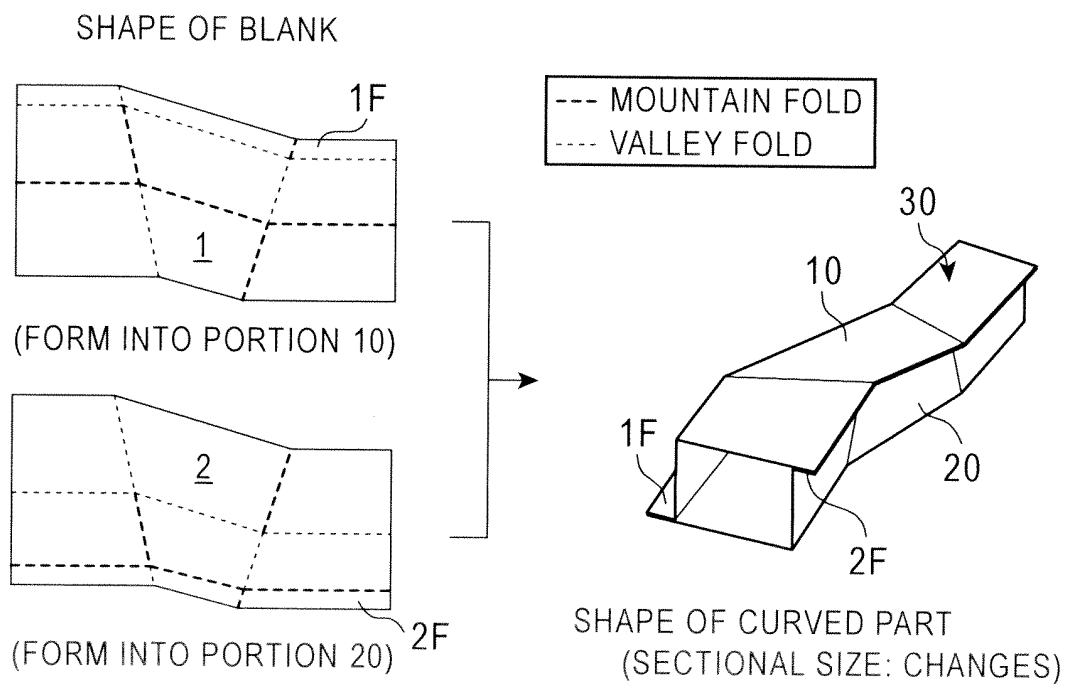


FIG. 5

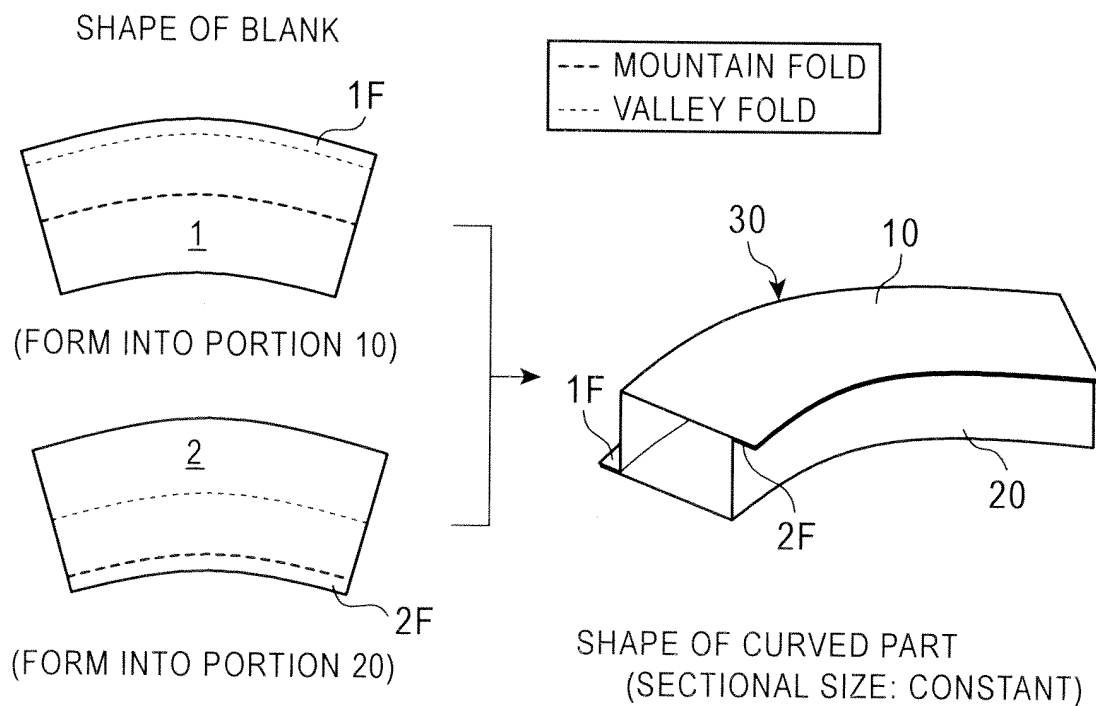


FIG. 6

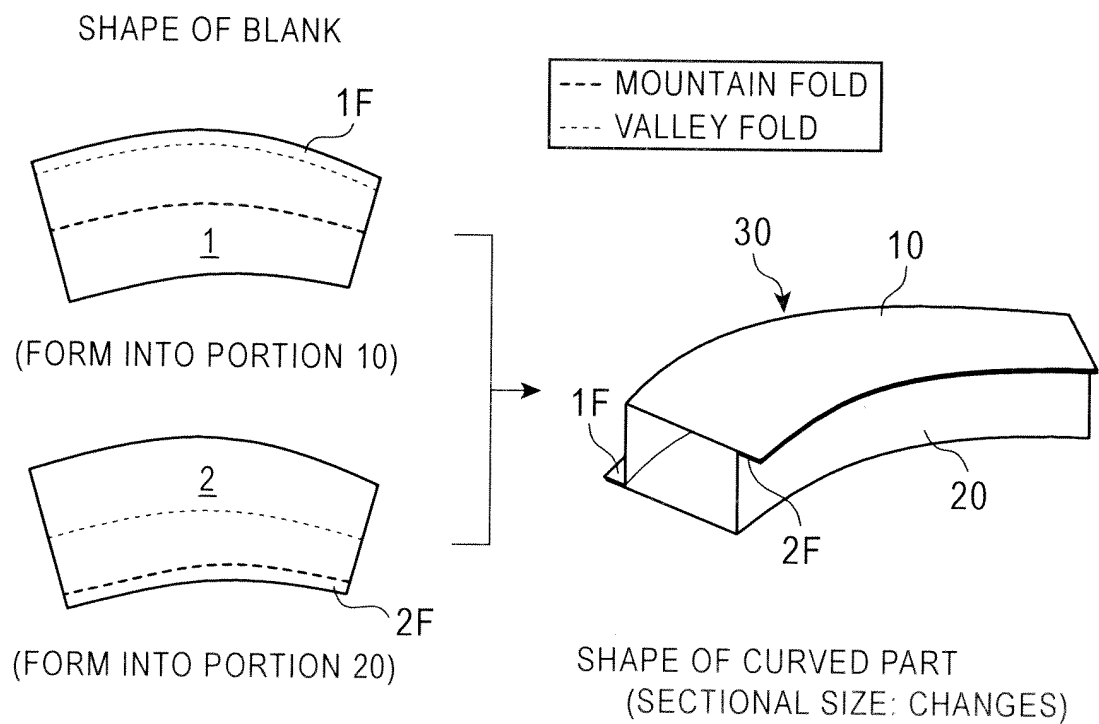


FIG. 7

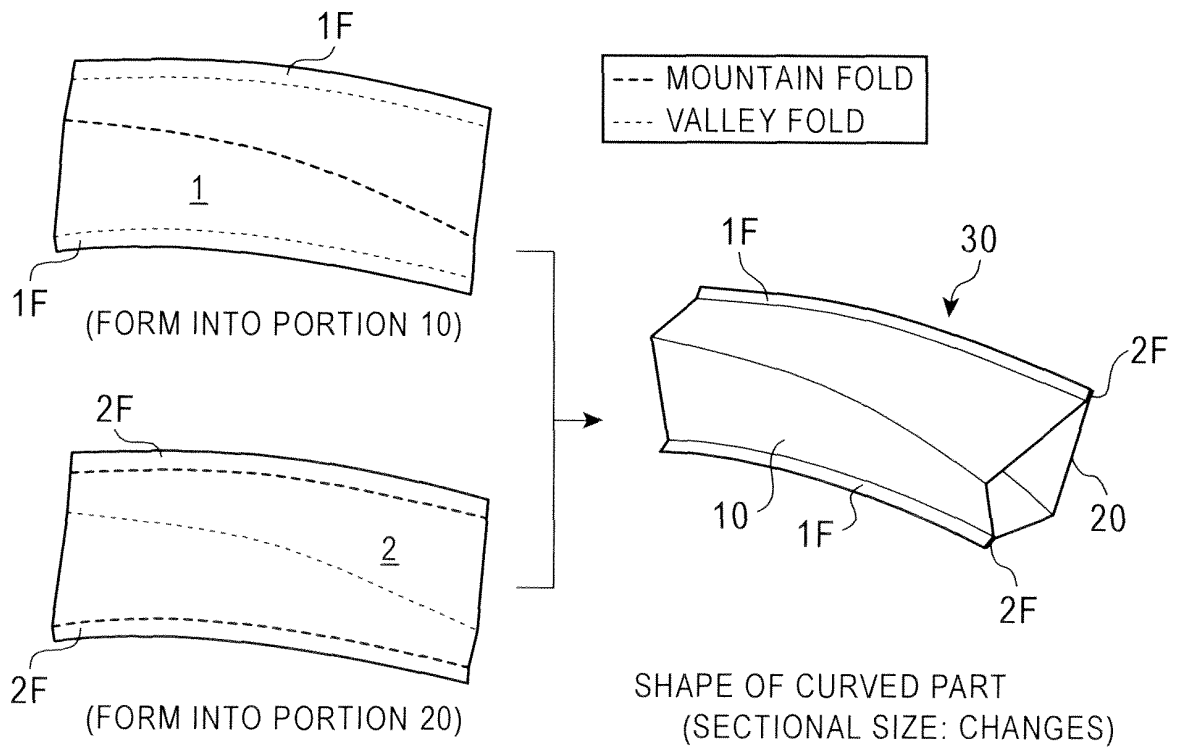


FIG. 8

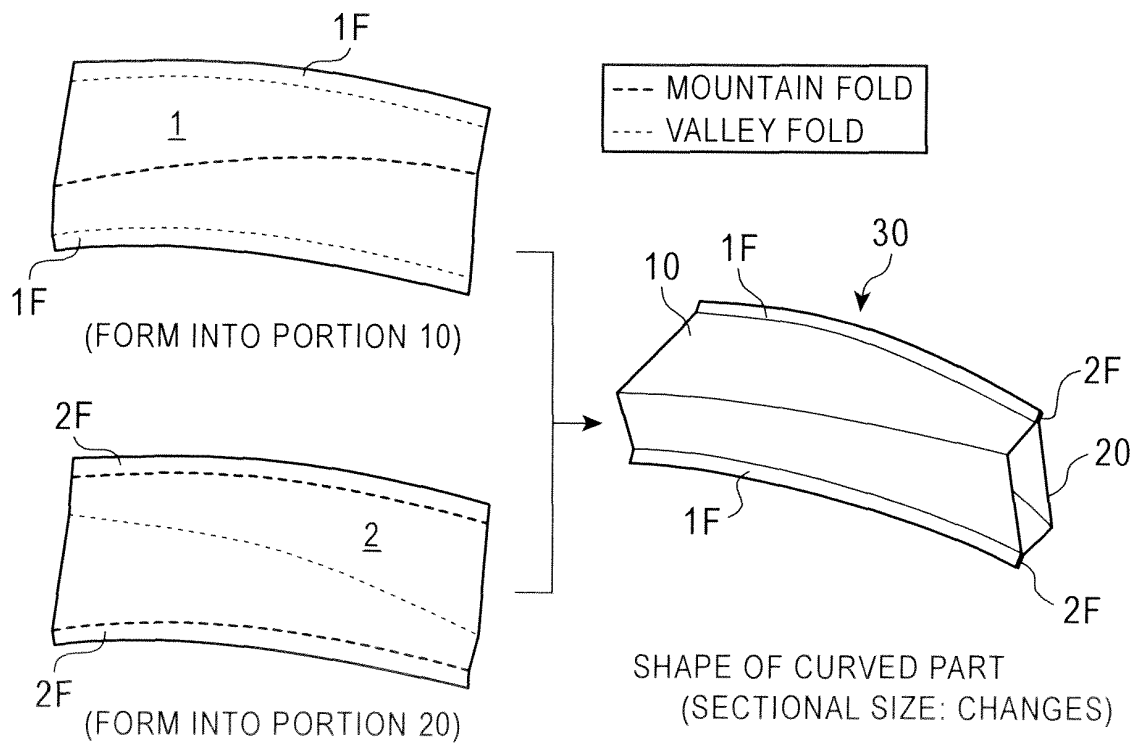


FIG. 9

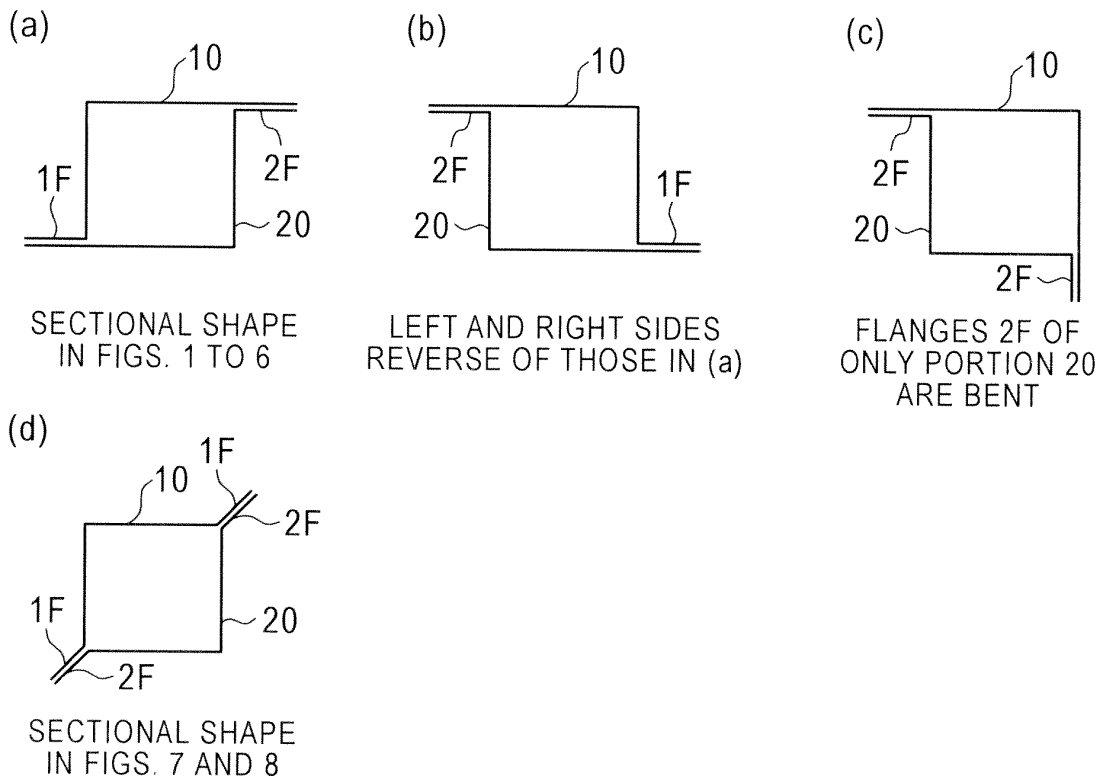


FIG. 10

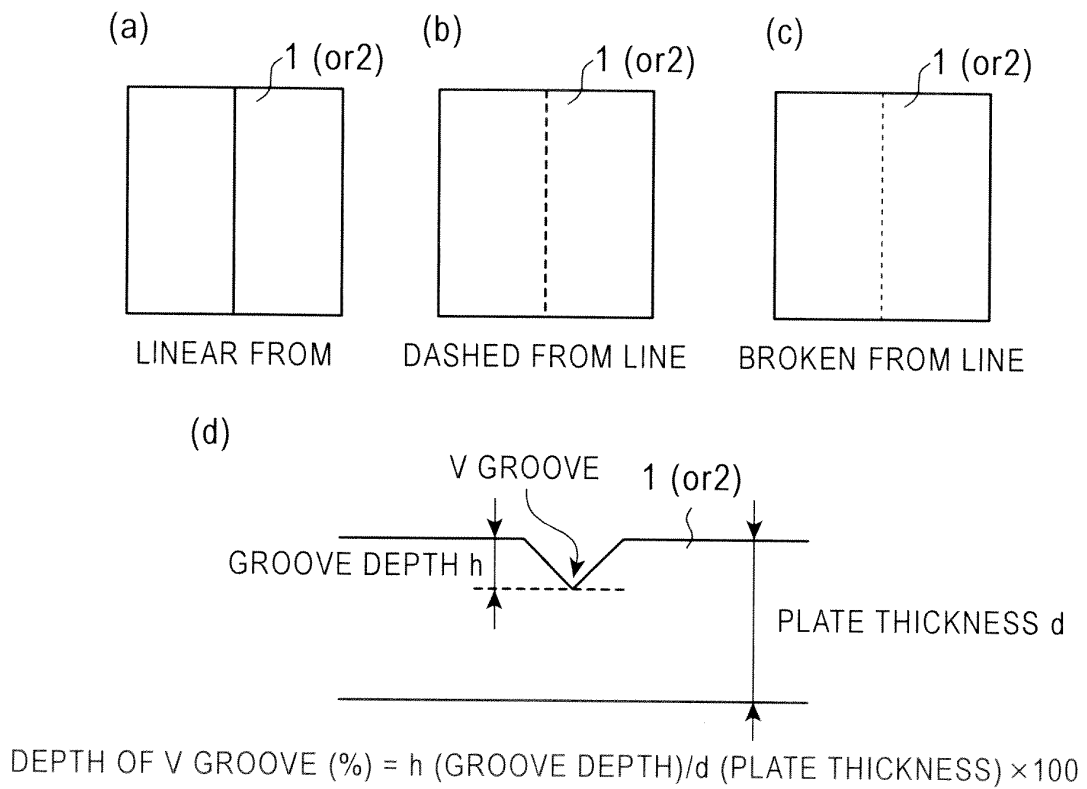
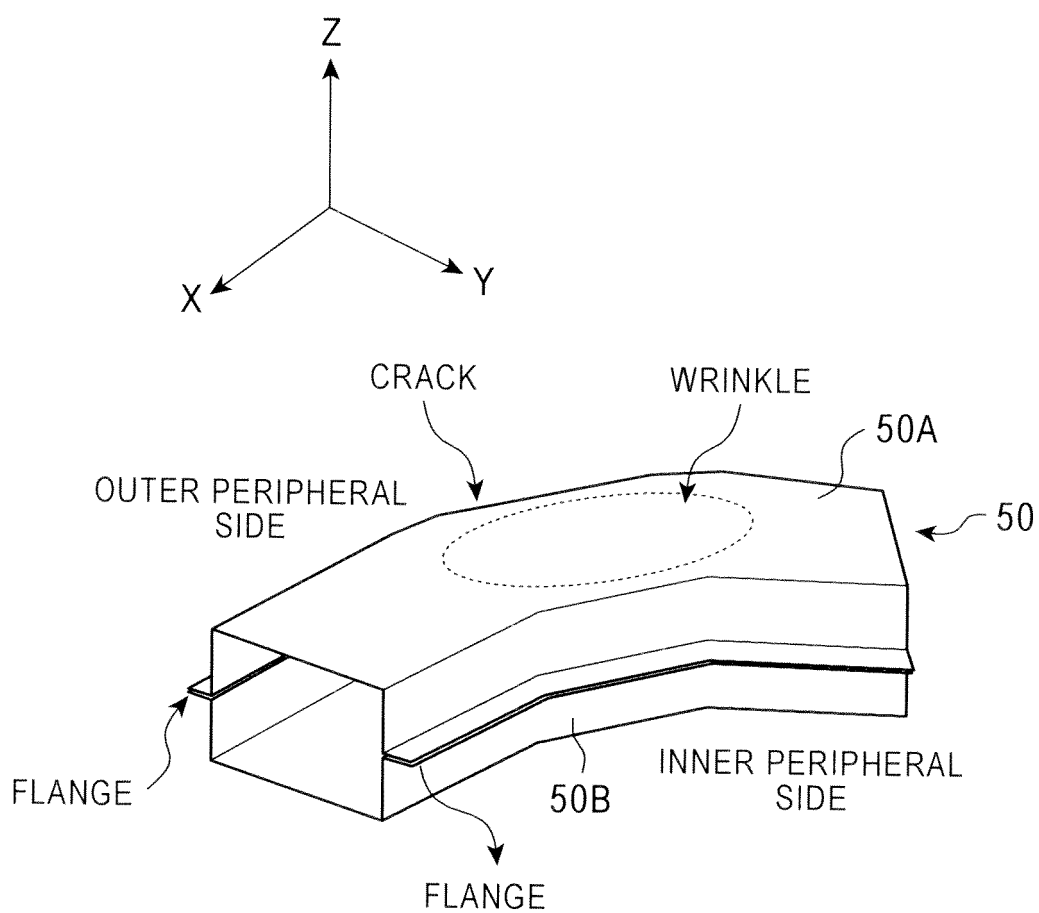


FIG. 11



REFERENCES CITED IN THE DESCRIPTION

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