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(71) Applicant: CATERPILLAR INC. [US/US]; 100 NE

Adams Street, Peoria, Illinois 61629-9510 (US).

(72) Inventors: KERESTES, Chad W.; 1016 N. 2150th Rd.,

Oglesby, Illinois 61348 (US). ULRICH IV, William J.;

104 Woodbrook Court, East Peoria, Illinois 61611 (US).

(74) Agent: GREENE, Jeff A. et al.; Caterpillar Inc., 100 NE

Adams Street - AH9510, Peoria, IL 61629-9510 (US).

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(54) Title: METHOD OF MANUFACTURING STRUCTURAL COMPONENT FOR JOINING WITH ANOTHER STRUCTURAL COMPONENT BY STRESS PROTECTED GROOVE WELD

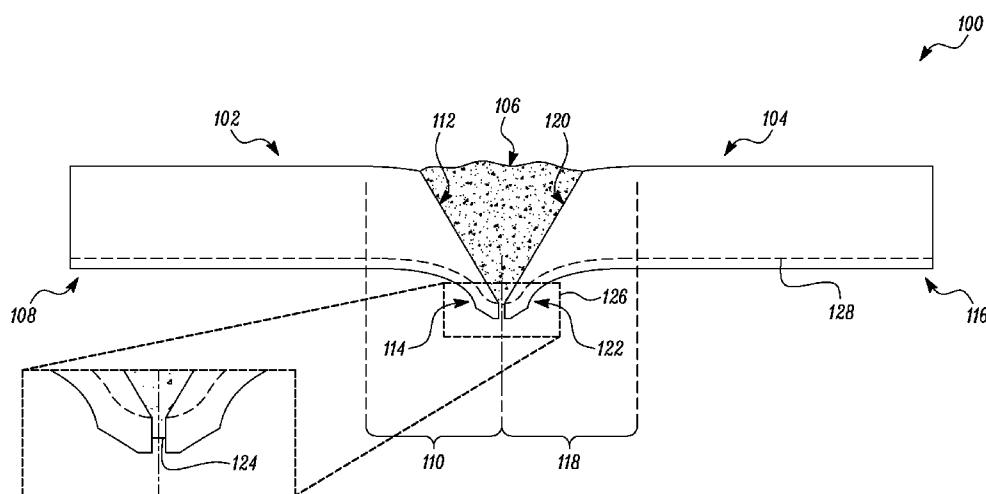


FIG. 1

(57) Abstract: Method (300) of manufacturing first structural component (102') for joining with second structural component (104) by groove weld (106) is provided. The first structural component (102') has first surface (108), second surface (110) and end portion (118). The component (102') is bent at end portion (118) to form bent portion (120) defining convex (122) and concave (126) faces. First portion (128) of bent portion (120) is removed at convex face (122) to form outer weld surface (112) having first face (124) extending from first surface (108), and second face (126) connected to first face (124). Second portion (124) of bent portion (120) is removed at concave face (126) to form inner edge surface (114) having arcuate profile (116). Inner edge surface (114) extends from second surface (110) and connects to second face (126) via transition portion (118). A portion of first face (124), second face (126), transition portion

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(240), and inner edge surface (236) define root protrusion (114), having a root protrusion height (RPH), for first structural component (102'). The root protrusion (114) defines stress protected weld root region (126) isolated beyond and away from root stress flow path.

Description

METHOD OF MANUFACTURING STRUCTURAL COMPONENT FOR
JOINING WITH ANOTHER STRUCTURAL COMPONENT BY STRESS
PROTECTED GROOVE WELD

5 Technical Field

The present disclosure generally relates to stress protected groove welds, and more particularly, relates to a method of manufacturing a structural component to be joined with another structural component by stress protected groove welds.

10 Background

Groove welds are known to be used to join structural components to form one or more weldments of a wide variety of numerous different types of structures. In particular, a groove weld may be a means by which two structural components or other metal components are joined together by the affixation of adjacent and/or mating edges or surfaces as a result of a mutual thermal bonding transformation therebetween which may be provided, at least in part, by heated filler material. At least a part of the interior of the groove weld may be composed of the filler material which may engage and thermally bond with the adjacent surfaces and edges of the pre-existing parent material of the structural components or other metal components, including at a bottom, or “root” portion of the groove weld and the structural components.

While groove welds may be widely used as an effective means by which structural components are joined to form a wide variety of numerous different types of structures, typical, conventional groove welds may be subsequently susceptible to fatigue or failure. For example, the welded structure may be subject to cyclic loading, forces and/or stresses, which may include, in part, tensile or bending forces that produce stresses on the weld and structural components. When loading, forces, and/or stresses are applied to the structure and the groove weld, portions of the groove weld, may be incapable of absorbing

and withstanding loading, forces, and/or stresses applied thereto, and thus may be particularly susceptible to fatigue or failure.

U.S. Pat. No. 7,374,823 (hereinafter referred to as the '823 patent) provides a weld assembly including first and second members having inclined portions that are joined by a weld bead. However, the failure of groove weld joints continues to be problematic in the field because the weld root and/or the weld toe remains subject to high stresses.

Summary of the Invention

In an aspect of the present disclosure, a method of manufacturing first structural component for joining with second structural component by groove weld is provided. The first structural component includes a body having a first surface, a second surface and an end portion. The method includes bending the first structural component at the end portion to form a bent portion defining a convex and a concave face. The first portion of the bent portion is removed at the convex face to form an outer weld surface having a first face extending from the first surface, and a second face connected to the first face. Further, the second portion of bent portion is removed at the concave face to form an inner edge surface having an arcuate profile. The inner edge surface extends from the second surface and connects to the second face via a transition portion. A portion of the first face, the second face, the transition portion, and the inner edge surface define a root protrusion, having a root protrusion height, for the first structural component. The root protrusion defines a stress protected weld root region isolated beyond and away from root stress flow path that propagates through the first structural component.

Brief Description of the Drawings

FIG. 1 illustrates an exemplary structure including a first structural component and a second structural component joined together by a groove weld, in accordance with an embodiment of the present disclosure;

FIGS. 2 to 7 illustrate an exemplary method of manufacturing the first structural component for joining with the second structural component by the groove weld, in accordance with the embodiment of the present disclosure; and

FIG. 8 illustrates a perspective view of the first structural component manufactured by the method illustrated in FIGS. 2 to 7, in accordance with the embodiment of the present disclosure.

Detailed Description

Reference will now be made in detail to specific embodiments or features, examples of which are illustrated in the accompanying drawings. Generally, corresponding reference numbers will be used throughout the drawings to refer to the same or corresponding parts.

The present disclosure relates to a structure having two or more structural components joined by groove welds according to the embodiments of the present disclosure. FIG. 1 illustrates an exemplary structure 100 including a first structural component 102 and a second structural component 104 joined by a groove weld 106 to form a weldment and the resultant structure 100. Although the illustrated embodiments show two structural components, it may be contemplated that the structure 100 may include any number of structural components which may be joined by numerous groove welds, without deviating from the scope of the claimed subject matter.

Each of the first structural component 102 and the second structural component 104 may be composed of a metal, including but not limited to iron, steel, aluminum, or any other metal, or any alloys thereof, capable of being joined via a groove weld, such as the groove weld 106 of the present disclosure. For the purposes of the present disclosure, the term “welding” (or “weld”), includes any process or result thereof wherein two structural components or metal components are joined together by affixation of adjacent and/or mating edges or surfaces as a result of a mutual thermal, frictional, or any other type of bonding transformation therebetween.

The groove weld 106 may include, but not limited to, shielded metal arc welding, gas tungsten arc welding, or tungsten inert gas welding, gas metal arc welding or metal inert gas welding, flux-cored arc welding, submerged arc welding, electroslog welding, and the like. The groove weld 106 may also
5 include cladding, brazing, soldering, friction stir welding, laser welding, and hybrid laser arc welding.

Further, each of the first structural component 102 and the second structural component 104 may be formed to embody any of variety of shapes, contours, profiles, bodies, structures or any combination or combinations thereof,
10 as necessary to form a suitable or desired structure, such as the structure 100 of the present disclosure. In the illustrated embodiment, the first structural component 102 and the second structural component 104 may be planar to define a plate. Alternatively, the first structural component 102 and the second structural component 104 may include one or more of planar, arcuate, cylindrical,
15 concave, convex, and/or incurvate shape, to form a contoured structure of the structural components 102, 104. In a yet another non-limiting example, the structural components 102, 104 may be tubular or cylindrical or curved to form a cylindrical tube or a non-cylindrical tube.

In an embodiment of the present disclosure, the first structural
20 component 102 includes a first end 108, and a weld end 110 having a first outer weld surface 112 and a first root protrusion 114. Similarly, the second structural component 104 includes a respective first end 116 and a weld end 118 having a second outer weld surface 120 and a second root protrusion 122. The weld ends 110, 118, the outer weld surfaces 112, 120 and the root protrusions 114, 122 are
25 included at each of any one or more outer edges, sides, extensions, or boundaries of the first structural component 102 and the second structural component 104, which are configured to be joined via the groove weld 106 to an adjacent, corresponding, opposing weld ends 110, 118, the outer weld surfaces 112, 120 and the root protrusions 114, 122 of an opposing, second structural component
30 104 and first structural component 102 (or any other structural component,

including, in part, any root protrusion according to the present disclosure) to form the structure 100.

In an embodiment of the present disclosure, the root protrusions 114, 122 are configured to locate a weld root 124 of the groove weld 106 within a stress protected weld root region 126. The stress protected weld root region 126 corresponds to a negligible stress concentration zone isolated beyond and away from a root stress flow path 128 propagated through the structural components 102, 104 of the structure 100, such that fatigue failure does not occur in the weld root 124 and the stress protected weld root region 126.

In an embodiment of the present disclosure, each of the first structural component 102 and the second structural component 104 are identical to each other. However, it may be contemplated that in various alternative embodiments, the structural components 102, 104 may have different profiles, shapes and dimensions than one another, without deviating from the scope of the claimed subject matter.

Referring to FIGS. 2 to 7, an exemplary first structural component 102' is provided along with a method 300 for manufacturing the first structural component 102 having the profile as shown in FIG. 1.

FIGS. 2 and 3 illustrate an exemplary first structural component 102', hereinafter interchangeably referred to as the component 102', in the form of a plate 202. The component 102' includes a body 204 defining the first end 108' and a second end 206. The body 204 further includes a first surface 208, a second surface 210, a first side surface 212, and a second side surface 214. The component 102' further includes a first end portion 216 defined proximal to the first end 108' and a second end portion 218 defined proximal to the second end 206 (as shown in FIG. 3). The first surface 208 and the second surface 210 define a thickness T of the component 102', whereas the first side surface 212 and the second side surface 214 define a width W of the component 102'. The first surface 208 may define an outer or upper surface of the component 102', whereas the second surface 210 may define an inner or lower surface of the component 102'. Alternatively, the first surface 208 may define the inner or

lower surface of the component 102', and the second surface 210 may define the outer or upper surface of the component 102' depending upon the type, use, application, constraints, or other considerations attendant to the structure 100, including but not limited to the formation thereof. As such, although the relative
5 terms "above", "outer", "upper", "raised", "below", "lower", "lowered", or "inner" may be used, such terms are used exclusively for the purposes of identifying and disclosing the various features of the disclosure herein with respect to and relative to the orientation of the illustrated Figures, but should not be construed as limiting the scope of the disclosure as excluding orientations
10 which may differ from the illustrated Figures, but in all other respects are equivalent.

In the illustrated embodiment of the present disclosure, the first surface 208 is parallel to the second surface 210, and the first side surface 212 is parallel to the second side surface 214, thereby defining a cuboidal structure of
15 the component 102'. It may further be contemplated that the shape and dimensions of the component 102' are merely exemplary and may be varied to achieve similar results without deviating from the scope of the claimed subject matter.

Referring to FIGS. 4 to 7, an exemplary method 300 of
20 manufacturing the first structural component 102, from the first structural component 102', for joining with the second structural component 104 to form the resultant structure 100, is disclosed. In an embodiment, as shown in FIG. 4, initially at step 302, the first structural component 102' is bent at the second end portion 218 with respect to the first end portion 216, to form a bent portion 220
25 therebetween. For example, the component 102' is bent in the component's rolling direction, as shown by the arrow 222. The component 102' may be bent using dies, fixtures, or any other conventionally known bending process. It may also be contemplated that the bending of the component 102' may be done manually or by using automated machines.

30 The bent portion 220 may define a bending radius R_B that is directly proportional to the thickness T of the component 102'. In an

embodiment of the present disclosure, the bending radius R_B lies within a range of 1.5 times to 3.5 times the thickness T of the component 102'. In one non-limiting example, the bent portion 220 includes a bending radius R_B of 1.5 times the thickness T of the component 102', when the thickness T lies within 10 millimeters to 30 millimeters. In another non-limiting example, the bent portion 220 includes a bending radius R_B of 3 times the thickness T of the component 102', when the thickness T lies within 30 millimeters to 50 millimeters. In a yet another non-limiting example, the bent portion 220 includes a bending radius R_B of 3.5 times the thickness T of the component 102', when the thickness T is greater than 50 millimeters. Further, as shown in FIG. 4, the component 102' is bent at a bend angle A_B , that is formed between the first end portion 216 and the second end portion 218. The bend angle A_B may be directly proportional to the thickness T of the component 102'. In an embodiment of the present disclosure, the bend angle A_B lies within a range of 110 degrees to 135 degrees. In one example, the bend angle A_B is 135 degrees.

The bent portion 220 defines a convex face 224 and a concave face 226. As illustrated, the convex face 224 extends between a portion 208' of the first surface 208 associated with the first end portion 216 and a portion 208'' of the first surface 208 associated with the second end portion 218. Similarly, the concave face 226 extends between a portion 210' of the second surface 210 associated with the first end portion 216 and a portion 210'' of the second surface 210 associated with the second end portion 218.

Subsequent to bending of the component 102' at step 302, the method 300 proceeds to step 304 shown in FIGS. 5 & 6. In an embodiment of the present disclosure, at step 304, a first portion 228 of the bent portion 220 along with the second end portion 218 of the component 102', is removed from the component 102', to form the first outer weld surface 112 (as shown in FIG. 6). In various examples, removal of the first portion 228 and the second end portion 218 may be done using conventionally known machining methods, such as milling, laser cutting, etc. To this end, material of the component 102' may be removed across the width W , such that the first outer weld surface 112 extends

across the width W of the component 102'. However, it may be contemplated that the material may be removed partially between the side surfaces 212, 214 so as to form partial outer weld surface(s) in certain applications. Although the first portion 228 and the second end portion 218 may be removed simultaneously, it
5 may be noted that, in some embodiments, the second end portion 218 may be removed prior to the removal of the first portion 228.

In an embodiment, as shown in FIG. 6, the first outer weld surface 112 of the component 102' includes a first face 230 and a second face 232 connected to the first face 230 to define an excluded angle D therebetween. The
10 magnitude of the excluded angle D may lie within a range of 190 degrees to 215 degrees. In one example, the magnitude of the excluded angle D is 210 degrees. Further, the first face 230 defines an angle B with the portion 208' of the first surface 208 associated with the first end portion 216 of the component 102'. In an example, a magnitude of the angle B may lie within a range of 110 degrees to
15 120 degrees. Furthermore, the first face 230 defines an angle C (e.g., an acute angle C) with the portion 210' of the second surface 210 associated with the first end portion 216 of the component 102'. In one example, a magnitude of the angle C lies within a range of 60 degrees to 70 degrees.

The second face 232 defines an angle E with the portion 210' of
20 the second surface 210 associated with the first end portion 216 of the component 102'. For example, a magnitude of the angle E lies within a range of 85 degrees to 95 degrees. In one example, the magnitude of the angle E is 90 degrees, i.e., the second face 232 is perpendicular to the portion 210' of the second surface 210 associated with the first end portion 216 of the component 102.

25 Subsequent to the removal of the first portion 228 and the second end portion 218 at step 304, the method 300 proceeds to step 306 as shown in FIG. 7. At step 306, a second portion 234 (as shown in FIG. 5) of the bent portion 220 at the concave face 226 is removed to form an inner edge surface 236 and accordingly obtain the profile of the first structural component 102 of FIG. 1.
30 In various examples, similar to the removal of first portion 228 at step 304, the removal of the second portion 234 may also be done using conventionally known

machining methods, such as milling, laser cutting, etc. Further, the material may be removed across the width W of the component 102', such that the inner edge surface 236 extends across the width W . However, it may be contemplated that the material may be removed partially between the side surfaces 212, 214 so as to
5 form a partial inner edge surface(s) in certain applications. In some applications, step 304 and step 306 may be performed simultaneously.

As illustrated, the inner edge surface 236 includes an arcuate profile 238, and extends from the second surface 210 (or a portion 210' of the second surface 210) associated with the first end portion 216 and connects to the
10 second face 232 of the first outer weld surface 112. In an embodiment of the present disclosure, the arcuate profile 238 is an elliptical profile having a major radius R_{MJ} and a minor radius R_{MN} , such that the major radius R_{MJ} is greater than the minor radius R_{MN} . In one example, the major radius R_{MJ} is 2.5 times the
15 minor radius R_{MN} . For example, the minor radius R_{MN} is 8 millimeters, and the major radius R_{MJ} is 2.5 times the minor radius R_{MN} , i.e., 20 millimeters. It may be contemplated that the magnitude and proportion of the major radius R_{MJ} and the minor radius R_{MN} with respect to each other are merely exemplary and may be varied to achieve similar results without deviating from the scope of the
20 claimed subject matter. In an alternative embodiment of the present disclosure, the arcuate profile 238 may be a circular profile, where the major radius R_{MJ} and the minor radius R_{MN} are equal.

Furthermore, the inner edge surface 236 is connected to the second face 232 via a transition portion 240 including a first transition face 242 and a second transition face 244. In an embodiment, and although not limited, the first
25 transition face 242 may be machined and removed during the removal of the first portion 228 at step 304 from the body 204 of the component 102' (i.e., the first transition face 242 may be formed along with the formation of the first face 230 and the second face 232). The first transition face 242 may be a planar face that may be largely perpendicular to the second face 232, although angular variations
30 between the second face 232 and the first transition face 242 may be contemplated. According to an embodiment, the first transition face 242 may be

disposed at an angle that lies within a range of 85 degrees to 95 degrees with respect to the second face 232. Further, the second transition face 244 may be formed if the arcuate profile 238 of the inner edge surface 236, extending from the portion 210' of the second surface 210, defines a curvature that stops short of the second face 232 and the first transition face 242. In other words, the second transition face 244 may be a portion 210''' of the second surface 210 itself (associated with the bent portion 220) that does not encounter any machining and/or removal owing to the curvature defined by the arcuate profile 238 of the inner edge surface 236 stopping short of the second face 232 and the first transition face 242.

In an embodiment of the present disclosure, a portion 230' of the first face 230, the second face 232, the transition portion 240, and the inner edge surface 236 (having the arcuate profile 238), define the first root protrusion 114 of the first structural component 102, as shown in Fig. 1. The first root protrusion 114 extends radially outward from the portion 210' of the second surface 210 associated with the first end portion 216 of the first structural component 102 to an outer end 246 of the first root protrusion 114, thereby defining a root protrusion height RP_H extending from the second surface 210 of the component 102 to the outer end 246 of the first root protrusion 114. As illustrated, in various embodiments, the outer end 246 of the first root protrusion 114 may correspond to the first transition face 242. Further, according to the disclosed embodiment, it may be contemplated that the minor radius R_{MN} may be defined so as to be aligned to and be equal to the height RP_H of the first root protrusion 114, although in certain other embodiments the radius R_{MN} may be unequal to (e.g., higher than) the height RP_H – for example, when the arcuate profile 238 defines a curvature that extends at least in part or fully beyond the second face 232.

In an embodiment of the present disclosure, the first root protrusion 114, the arcuate profile 238, the inner edge surface 236, the root protrusion height RP_H , and the portion 230' of the first face 230 of the first outer weld surface 112, define the stress protected weld root region 126 (as shown in

FIG. 1) isolated beyond and away from the root stress flow path 128 propagated through the body 204 of the first structural component 102.

Referring to FIG. 8, the resultant first structural component 102 having the first root protrusion 114 manufactured from the first structural component 102' by method 300, is illustrated. Similar to the first structural component 102, the second structural component 104 is also manufactured by the same method 300 and includes the respective second root protrusion 122 (see FIG. 1). The first structural component 102 and the second structural component 104 are joined by the groove weld 106 (which is a stress protected groove weld 106) to form the structure 100, as shown in FIG. 1. For example, the first outer weld surface 112 and the first root protrusion 114 of the first structural component 102 are aligned with the second outer weld surface 120 and the second root protrusion 122 of the second structural component 104, thus defining a V-shaped receiving portion therebetween into which a weld material may be received to form the groove weld 106, as illustrated in FIG. 1, and in turn joining the first structural component 102 with the second structural component 104.

Industrial Applicability

The present disclosure may be applicable to any structure 100 composed of at least two structural components, i.e., the first structural component 102 and the second structural component 104 joined by at least one groove weld 106. The present disclosure may be applicable to any type of structural member, component, part, structure, and/or body which is capable of being joined to any other structural member, component, part, structure, and/or body via a groove weld, to form a weldment and resultant structure including the joined structural components.

Aspects of the disclosed method 300 of manufacturing the structural components 102, 104 to be joined by the stress protected groove weld 106 may reduce manufacturing costs and at the same time, significantly reduce or eliminate damage, fatigue, or failure within the groove weld 106 (including, in part, the adjacent and/or mating edges or surfaces of the structural components

102, 104 which are engaged and in thermal proximity with the groove weld 106, and the filler material thereof, which are mutually thermally bonded and transformed via the energy of the groove weld 106) which may be caused by cyclic loading, forces and/or stresses, which may include, in part, tensile or
5 bending forces that produce stresses on the weld.

It will be apparent to those skilled in the art that various modifications and variations can be made to the system of the present disclosure without departing from the scope of the disclosure. Other embodiments will be apparent to those skilled in the art from consideration of the specification and
10 practice of the system disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalent.

Claims

1. A method (300) of manufacturing a first structural component (102') for joining with at least one second structural component (104) by a groove weld (106), the first structural component (102') including a body (204) having a first surface (208), a second surface (210), and an end portion (218), the method (300) comprising:
- 5 bending the first structural component (102') at the end portion (218) to form a bent portion (220), the bent portion (220) defining a convex face (224) and a concave face (226);
- 10 removing a first portion (228) of the bent portion at the convex face (224) to form an outer weld surface (112), the outer weld surface (112) including a first face (230) extending from the first surface (208), and a second face (232) connected to the first face (230); and
- 15 removing a second portion (234) of the bent portion (220) at the concave face (226) to form an inner edge surface (236) having an arcuate profile (238), the inner edge surface (236) extending from the second surface (210) and connecting to the second face (232) via a transition portion (240), wherein a portion of the first face (230), the second face (232), the transition portion (240), and the inner edge surface (236) define a root protrusion (114) for the first
- 20 structural component (102'),
- wherein the root protrusion (114) extends radially outward from the second surface (210) to an outer end (246) to define a root protrusion height (RP_H) extending from the second surface (210) of the first structural component (102') to the outer end (246); and
- 25 wherein the root protrusion (114), the root protrusion height (RP_H) and the inner edge surface (236) of the root protrusion (114) define a stress protected weld root region (126) isolated beyond and away from a root stress flow path propagated through the body (204) of the first structural component (102').

2. The method (300) of claim 1, wherein the first structural component (102') includes a thickness (T) within a range of 10 millimeters to 30 millimeters, and wherein the bent portion (220) includes a bending radius of 2.5 times the predefined thickness (T).

5

3. The method (300) of claim 1, wherein the first structural component (102') includes a thickness (T) within a range of 30 millimeters to 50 millimeters, and wherein the bent portion (220) includes a bending radius of 3 times the predefined thickness (T).

10

4. The method (300) of claim 1, wherein the first structural component (102') includes a thickness (T) greater than 50 millimeters, and wherein the bent portion (220) includes a bending radius of 3.5 times the predefined thickness (T).

15

5. The method (300) of claim 1, wherein the first structural component (102') includes a first end portion (216) and a second end portion (218) and wherein the first structural component (102') is bent at the second end portion (218) with respect to the first end portion (216) to form a bend angle (A_B), the bend angle (A_B) being within a range of 110 degrees to 135 degrees.

20

6. The method (300) of claim 1, wherein the arcuate profile (238) of the inner edge surface (236) is a circular profile.

25

7. The method (300) of claim 1, wherein the arcuate profile (238) of the inner edge surface (236) is an elliptical profile having a major radius (R_{MJ}) and a minor radius (R_{MN}), the major radius (R_{MJ}) being greater than the minor radius (R_{MN}).

30

8. The method (300) of claim 7, wherein the major radius (R_{MJ}) is 2.5 times the minor radius (R_{MN}).

9. The method (300) of claim 1, wherein the second face (232) of the outer weld surface (112) defines an excluded angle between 190 degrees and 215 degrees with the first face (230).
- 5 10. A method of manufacturing a structure (100) including the first structural component (102, 102') and the second structural component (104) joined by the groove weld (106), the method (300) comprising:
- manufacturing each of the first structural component (102, 102') and the second structural component (104) according to the method (300) of
- 10 claim 1; and
- aligning the outer weld surface (112) and the root protrusion (114) of the first structural component (102, 102') with the outer weld surface (120) and the root protrusion (122) of the second structural component (104) to receive a weld material therebetween.

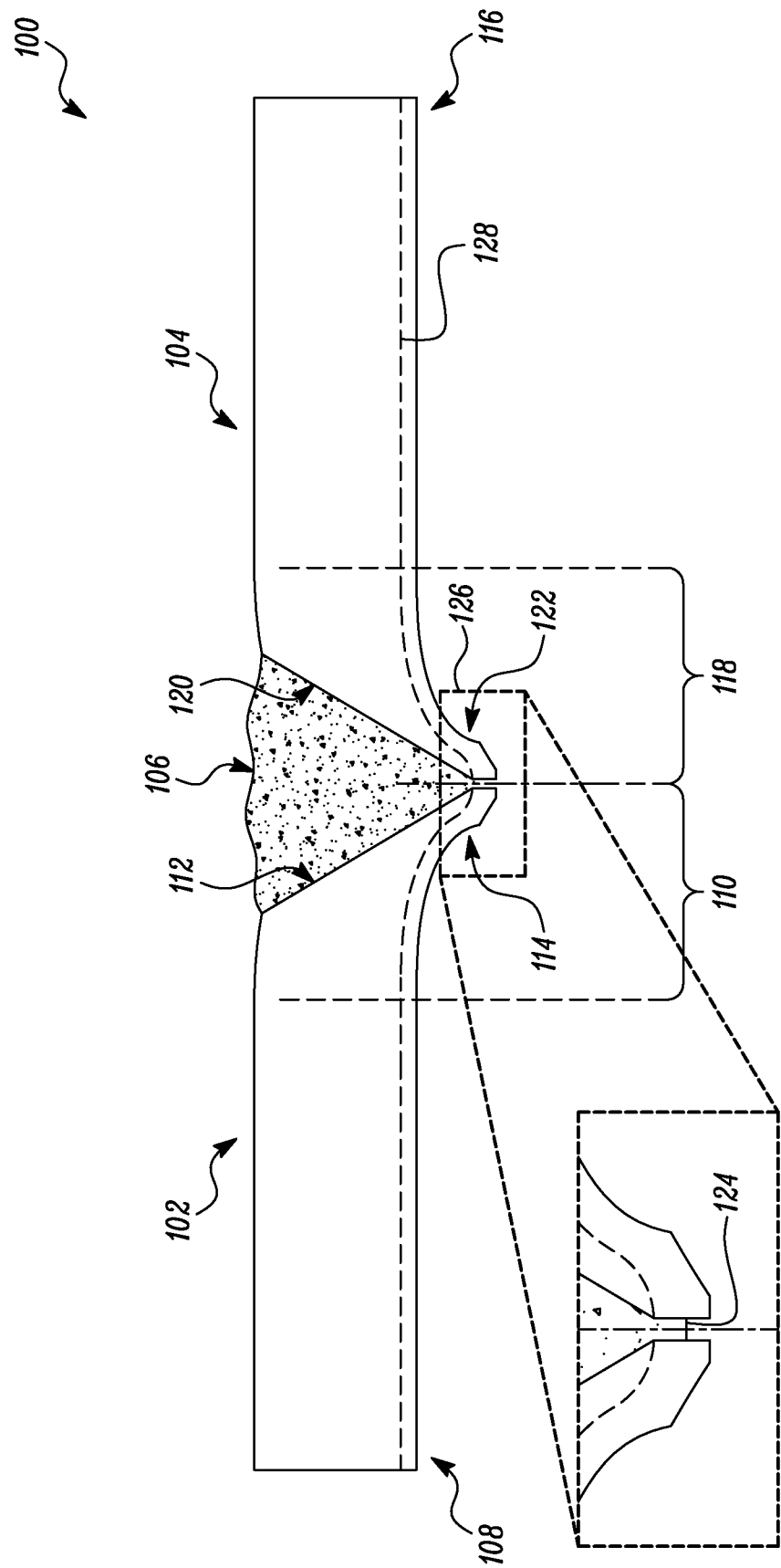


FIG. 1

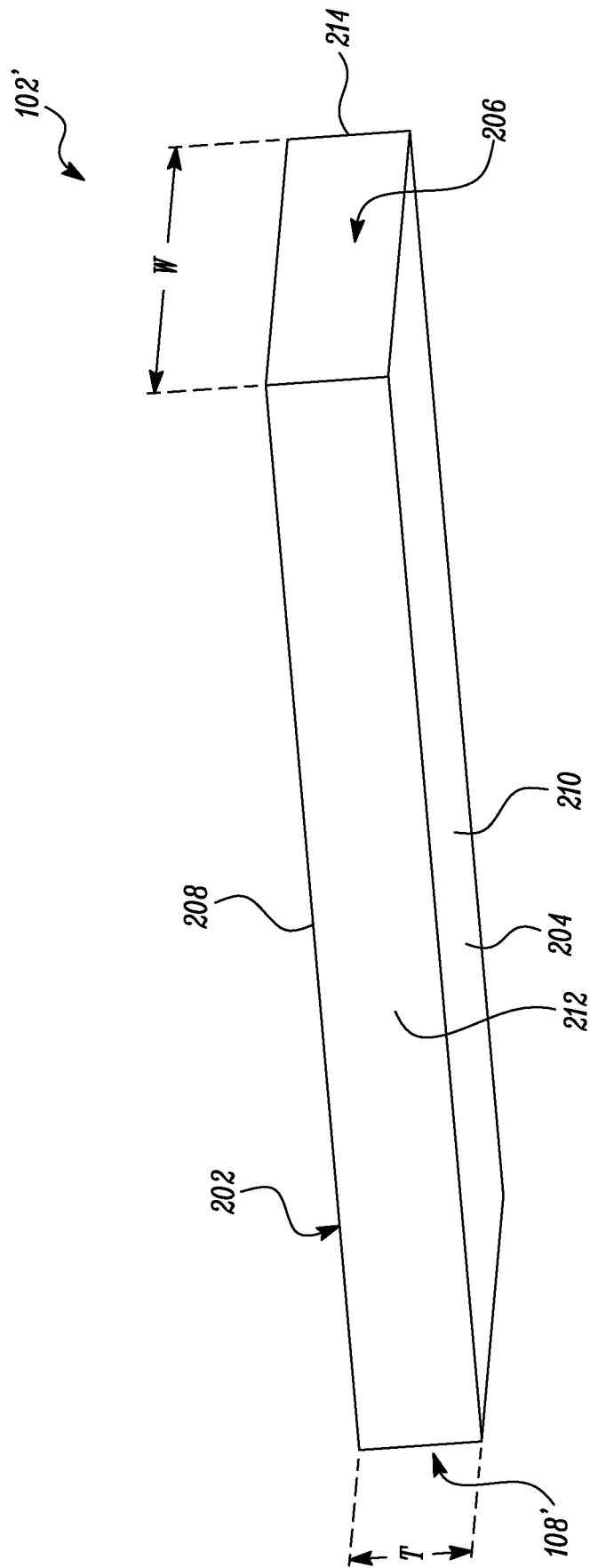


FIG. 2

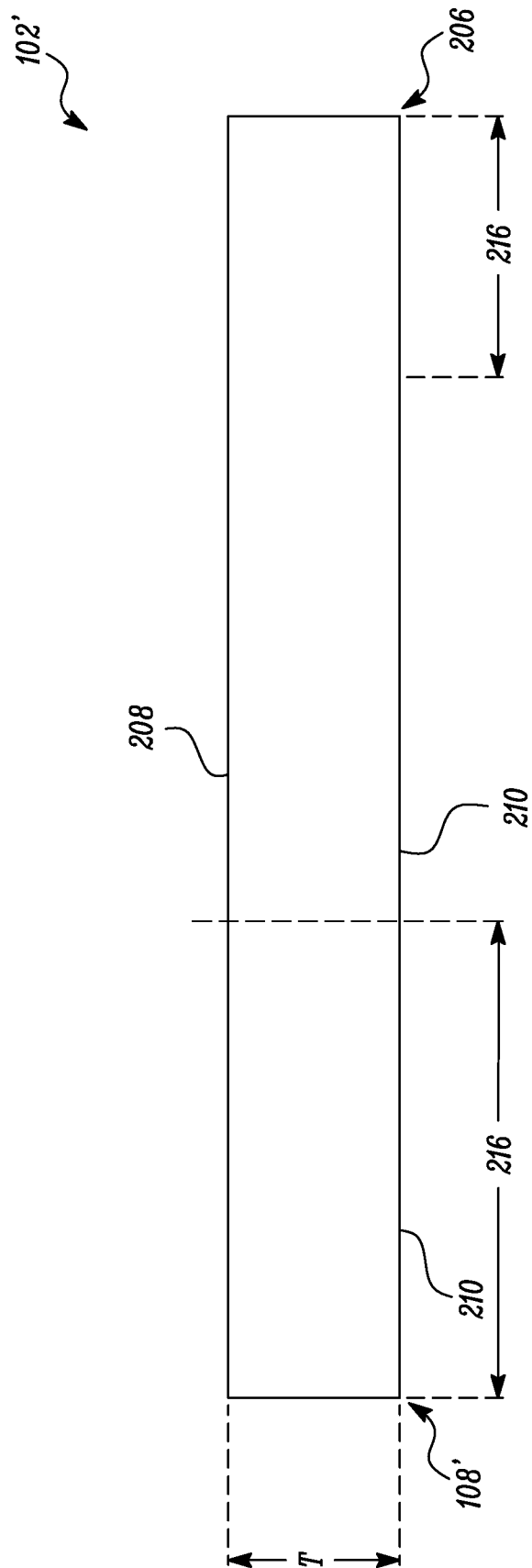


FIG. 3



FIG. 5



FIG. 6

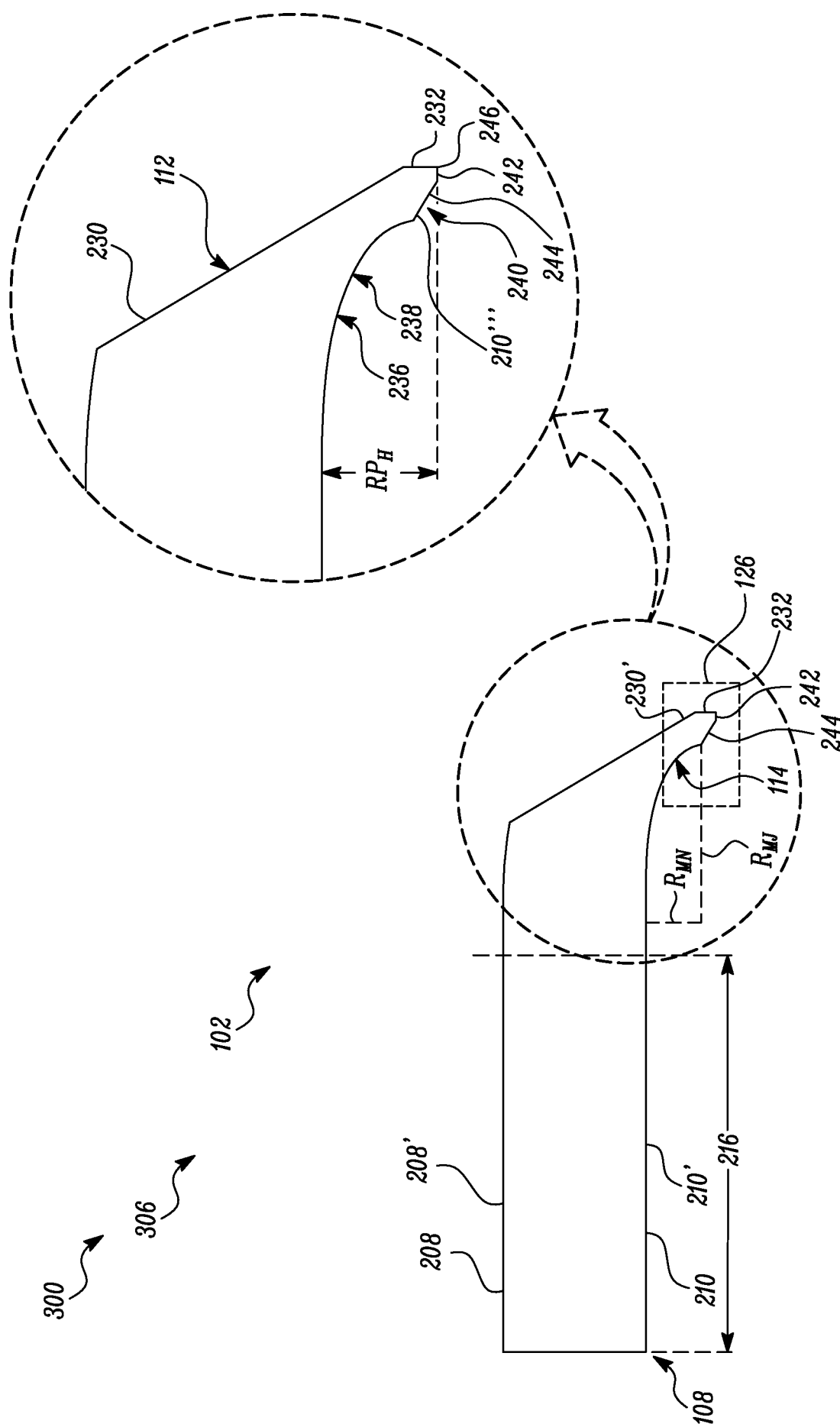


FIG. 7

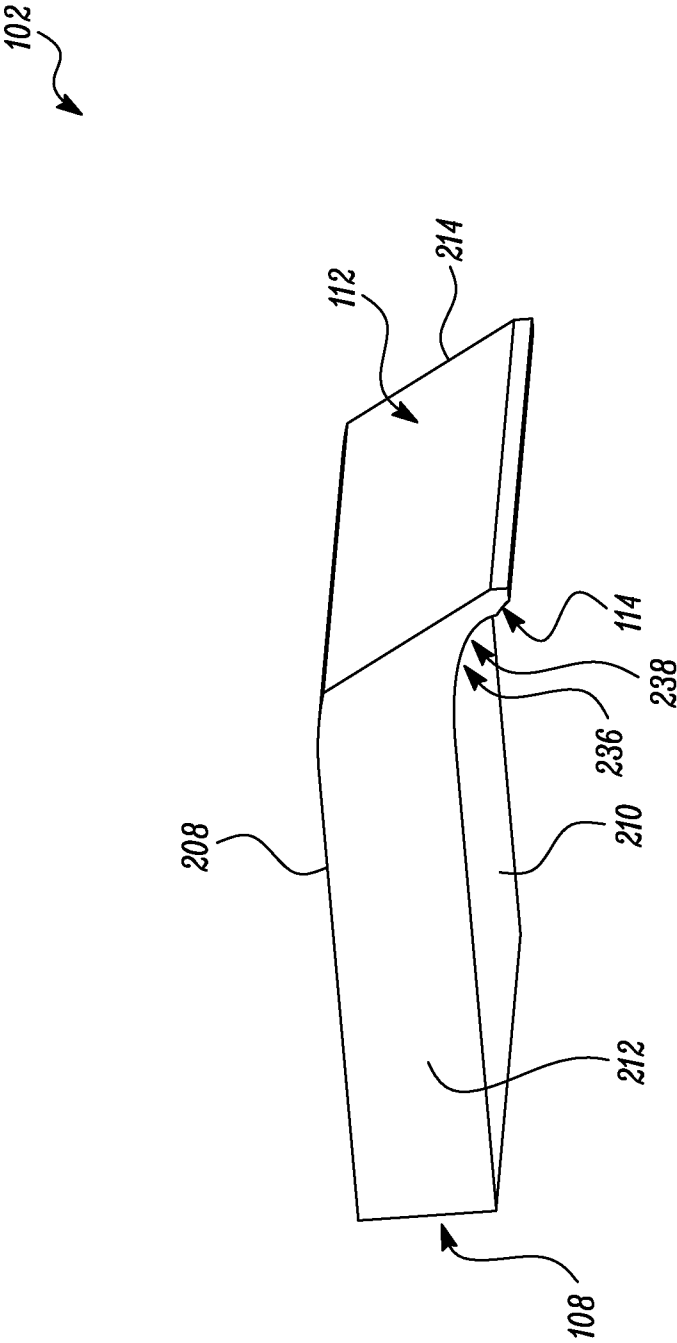


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/016915

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K33/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018/304413 A1 (GRIFFITH DAVID R [US] ET AL) 25 October 2018 (2018-10-25) the whole document	1-10
A	US 2018/161941 A1 (GRIFFITH DAVID R [US] ET AL) 14 June 2018 (2018-06-14) paragraphs [0001] - [0056]; figures 1-12	1-10
A	US 7 374 823 B2 (PRESS KOGYO KK [JP]) 20 May 2008 (2008-05-20) cited in the application the whole document	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Altamura, Alessandra

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/016915

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2018304413	A1	25-10-2018	NONE

US 2018161941	A1	14-06-2018	CN 110198806 A 03-09-2019
		DE 112017005789 T5	14-08-2019
		GB 2572299 A	25-09-2019
		JP 2020513324 A	14-05-2020
		KR 20190087625 A	24-07-2019
		SE 1950713 A1	13-06-2019
		US 2018161941 A1	14-06-2018
		WO 2018111654 A1	21-06-2018

US 7374823	B2	20-05-2008	NONE
