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A manufacturing method of a structure body and a manufacturing apparatus of a structure body

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(56) Related Art
WO 97/48517
WO 95/26254
DE 19745126

Abstract of Disclosure:

A friction stir joining apparatus 1a comprises members 20 and 30 to be subjected to a friction stir joining which is fixed on a table 5, a joining head 200 which moves relatively to an arrow mark A direction against the table 5. A rotary tool 10 performs the friction stir processing and a joining bead 50 is formed. A sensor 210 irradiates a light beam 212 and detects edge portions 24 and 34 of the members and the joining head 200 is moved and controlled to a center of the joining portion. A burr removing cutting means 12 of the rotary tool 10 cut off the burr and the chips 60 are formed. An air jet J injected from an air nozzle is discharged to an outside from a cover 230 and an enter of the chips 60 to the sensor 210 can be prevented. In a friction stir joining apparatus, it provides the friction stir joining apparatus in which the enter of chips to the sensor 210 for detecting a center position of the joining portion can be prevented.

AUSTRALIA

PATENTS ACT 1990

COMPLETE SPECIFICATION

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INVENTION TITLE:

A manufacturing method of a structure body and a manufacturing apparatus of a structure body

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

METHOD AND APPARATUS FOR MANUFACTURING A STRUCTURE

Field of the Invention:

The present invention relates to a method and apparatus for manufacturing a structure.

Background of the Invention:

Two members to be subjected to a friction stir joining having a raised portion at an end portion thereof are abutted and from a side of the raised portion a rotary tool is inserted and then a friction stir joining is carried out. In this friction stir joining when a gap exists between two members to be subjected to the friction stir joining a reduced thickness of two members to be the subjected to the friction stir joining is compensated.

After the friction stir joining, when the raised portion of two members to be the subjected to the friction stir joining is unnecessary the raised portion is cut off or deleted and is removed the raised portion which is cut off or deleted and an outer face of the member to be subjected to the friction stir joining is formed flatly. This technique is disclosed in Japanese application patent laid-open publication No. Hei 09-309164 (EP 0797043 A2).

Further, a cutter is provided to a radial direction of the rotary tool. The small diameter portion of the rotary tool is inserted into a joining portion and a boundary formed between the large diameter portion and the small diameter portion of the rotary tool is contacted to the members to be subjected to the friction stir joining.

The cutter is projected toward a side of the large diameter portion of the rotary tool from the above stated boundary. This cutter can cut off or delete burr which is generated according to the friction stir joining. This technique is disclosed in Japanese application patent laid-open publication No. Hei 10-71477 (US Patent No. 5794835, EP 0810055 A1).

Further, the rotary tool and the cutter are provided separately, and as the cutter an end milling is used. This technique is disclosed in Japanese application patent laid-open publication No. Hei 10-175089.

When the members to be subjected to the joining having the raised portion at the end portion thereof are carried out to the friction stir joining to the joining portion the burr is generated. Further, the raised portion of the member to be subjected to the friction stir joining is left. In a case where the raised portion side is formed to an outer face of a structure body, it is necessary to remove the raised portion according to the cut-out.

Herein, to the rotary tool the cutter is attached, by the joining it is necessary to cut off an excessive raised

portion and the burr.

According to the cut-out, chips generate. According to the existence of the chips it is difficult to carry out a good friction stir joining.

The above stated reasons will be explained. To a front portion of an advancing direction of the rotary tool an optical sensor for detecting optically the raised portion of the member to be subjected to the friction stir joining is provided. This optical sensor can detect a width of the two raised portions of the member to be subjected to the friction stir joining and the rotary tool is positioned at a center thereof. Further, the optical sensor can detect a height of the raised portion of the member to be subjected to the friction stir joining and an insertion amount of the rotary tool to the members to be subjected to the friction stir joining can be determined suitably.

To a detection range of the optical sensor when the chips enter and then it is impossible to carry out a precise detection.

Further, at a front portion and at a rear portion of the rotary tool rollers are installed, such rollers presses the raised portion of the member to be subjected to the friction stir joining or the member to be subjected to the friction stir joining at a vicinity of the raised portion to a bed. Since at the rear portion of the rotary tool the chips are mounted mainly, the rear portion roller presses the chips. For this reason, the member to be subjected to the friction stir joining is injured according to the chips.

It is an object of the present invention to obviate the above-mentioned problems with the prior art, or at least provide a useful alternative.

Summary of the Invention:

In accordance with the present invention there is provided a method for manufacturing a structure, the structure including an abutment region defined by substantially abutting first and second members, including the steps of:

sensing the abutment region using a sensing means;

friction stir welding the first and second members along a first side of the abutment region with a friction stir welding rotary tool;

at least partially cutting the first side of the abutment region using a cutting means;

moving the sensing means and the cutting means along the first side of the abutment region in a moving direction transversely of the structure;

controlling said moving in accordance with said sensing; and

causing air to flow between the sensing means and the first side of the abutment region.

In accordance with the present invention there is also provided a method for manufacturing a structure, including an abutment region defined by substantially abutting first and second members of the structure along respective opposed sides, including the steps of:

substantially immobilising the first and second members by mounting a rolling means on a first side of the abutment region;

sensing the abutment region using a sensing means;

friction stir welding the first and second members

along the first side of the abutment region with a friction stir welding rotary tool;

at least partially cutting the first side of the abutment region using the cutting means;

moving a cutting means and the sensing means, along the first side of the abutment region in a moving direction

transversely of the structure, in accordance with said sensing;

forcing air between the sensing means and the first side of the abutment region either from in front of the sensing means with respect to the moving direction or from a lateral portion of the sensing means; and

causing air to flow between the sensing means and the first side of the abutment region from in front of the sensing means with respect to the moving direction and/or from a lateral position with respect to the sensing means, wherein the rolling means leads the sensing means and the sensing means leads the cutting means and wherein said air passing between the sensing means and the first side of the abutment region is deflected in a lateral direction with respect to the moving direction from between the sensing means and the cutting means.

In accordance with the present invention there is also provided apparatus for friction stir welding a structure including:

means for supporting two adjacent members abutted along opposed respective sides, where the abutted opposed respective sides thereby form a joining portion;

means for friction stir welding a first side of the joining portion;

means for at least partially cutting the first side of the joining portion

means for sensing the joining portion;

means for housing the sensing means,

means for causing air to flow between the means for sensing and the first side of the abutment region; and

means for moving the means for friction stir welding, the means for at least partially cutting the joining portion, the means for sensing the joining portion, the

means for housing the sensing means and the means for causing air to flow along the first side of the joining portion in a moving direction transversely of the structure in accordance with said sensing means;

wherein the means for friction stir welding is a friction stir welding rotary tool and the cutting means is coupled to and projects radially from the friction stir welding rotary tool to thereby effect said welding and said cutting substantially concurrently; wherein the sensing means leads the cutting means and the friction stir welding means; wherein the means for housing includes a first wall, coupled to a first side of the means for sensing, extending parallel to the moving direction and a second wall, being disposed between the means for sensing and the means for cutting, coupled to and extending from the first wall at an obtuse angle to the moving direction; and wherein said air flows from in front of the sensing means with respect to the moving direction.

In accordance with the present invention there is provided a method for manufacturing a structure, the structure including an abutment region defined by substantially abutting raised portions of first and second members of the structure along respective opposed sides of the first and second members, including the step of:

friction stir welding the first and second members along the abutment region using a friction stir welding rotary tool,

wherein the friction stir welding rotary tool has a first portion, with a first diameter located at a distal end of the friction stir welding rotary tool, for engaging the abutment region and a second portion, with a second diameter smaller than that of the first portion, extending from the first portion; wherein the friction stir welding rotary tool

is disposed at an oblique angle to the abutment region; and wherein a cutting means is coupled to and extends radially from said first portion and the rotational radius of the cutting means is greater than a half width of the abutment region.

Brief Description of the Drawings:

Figure 1 shows a side view of apparatus for manufacturing a structure in accordance with the present invention;

Figure 2 shows a side view of part of the apparatus shown in Figure 1.

Figure 3 is a plan view of the apparatus shown in Figure 2.

Figure 4 shows a part of the apparatus shown in Figure 1;

Figure 5 shows the part illustrated in Figure 4 in use;

Figure 6(A) shows an alternative part for the part of the apparatus shown in Figure 4;

Figure 6(B) shows a further alternative for the part of the apparatus shown in Figure 6(A);

Figures 7(A) to 7(D) show the method steps for manufacturing a structure in accordance with the invention;

Figure 8 shows a side view of apparatus for manufacturing a structure in accordance with the invention;

Figure 9 shows a side view of apparatus for manufacturing a structure in accordance with the invention;

Figure 10 shows a side view of apparatus for manufacturing a structure in accordance with the invention;

Description of the Invention:

Figure 1 is a side face view showing a manufacturing method of a structure body and a manufacturing apparatus of a structure body, and a friction stir joining method for a

structure body and a friction stir joining apparatus for a structure body according to the present invention.

A friction stir joining apparatus for a structure body indicated with a reference numeral 1a in total comprises a table 5 on which two members 20 and 30 to be subjected to a friction stir joining are mounted, and a joining head 200 moves relatively at an arrow mark A direction against the table 5 with a first pressing roller unit 110 which is provided at a front portion of the joining head 200 and also a second pressing roller unit 120 which is provided at a rear portion of the joining head 200.

The first pressing roller unit 110 is arranged at a front portion of an advancing direction against the joining head 200 and a rotation roller 112 presses down upper faces of non-joining raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining.

The first pressing roller unit 110 has an air nozzle 114 and this air nozzle 114 can remove foreign matters of the friction stir joining portion. Further, the first pressing roller 110 can remove foreign matters from a rolling face of the roller 112. An injection direction of an air jet of the air nozzle 114 is a front direction of a moving direction A. Further, the injection direction of an air jet of the air nozzle 114 is a side portion against to the moving direction.

The second pressing roller unit 120 is arranged at a rear portion of the advancing direction of the joining head 200 and a rotation roller 122 presses down an upper face of a joining bead 50. The second pressing roller unit 120 has also an air nozzle 124 and this air nozzle 124 can remove chips etc. which are generated during a friction stir joining time. Further, the second pressing roller 120 can remove foreign matters from a rolling face of the roller 122. An injection direction of an air jet of the air nozzle

114 is a front direction of a moving direction A. Further, the injection direction of an air jet of the air nozzle 114 is a side portion against to the moving direction.

Fig. 2 is a side face view showing the joining head of the friction stir joining apparatus for the structure body and Fig. 3 is a plan view showing the joining head of the friction stir joining apparatus for the structure body.

The joining head 200 of the friction stir joining apparatus indicated with a reference numeral 1a in total moves relatively to the arrow mark A direction against the table 5 and also is move-controlled against a direction B orthogonal to the advancing direction and a height direction C.

On the table 5, the first member 20 to be subjected to the friction stir joining and the second member 30 to be subjected to the friction stir joining are installed by contacting or approaching joining end faces thereof. The first member 20 to be subjected to the friction stir joining has the joining use raised portion 22 and further the second member 30 to be subjected to the friction stir joining has the joining use raised portion 32.

The joining head 200 comprises the rotary tool 10 and the optical sensor 210. The rotary tool 10 moves toward the arrow mark A direction by rotating toward an arrow mark R direction and carries out the friction stir joining to the joining portion of the members 20 and 30 to be subjected to the

friction stir joining and then the joining bead 50 is formed.

The rotary tool 10 has the burr removing cutter 12 and this cutter 12 cut off the burr etc. which generate during the friction stir joining time and removes them on the joining bead 50 as the chips 60.

The optical sensor 210 provided on the joining head 200 has a box shape housing and is covered by a cover 230. The cover 230 covers one of side faces of the optical sensor 210 and a front face which opposites to the rotary tool 10.

To a position which is an opposite side to the rotary tool 10 of the housing of the joining head 200, an air nozzle 240 is installed.

The optical sensor 210 projects a light beam 212 to the upper faces of the members 20 and 30 to be subjected to the friction stir joining and detects optically the positions of edge portions 24 and 34 of the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining.

In accordance with the information of this optical sensor 210, the joining head 200 is moved and controlled toward the arrow mark B direction and a center of the rotary tool 10 is guided along to the center of the both edge portions 24 and 34 of the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining.

Further, the optical sensor 210 detects the height positions of apexes of the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining. According to this detection, the joining head or a processing

head 200 is moved and controlled toward the arrow mark C direction and the insertion amount of the rotary tool 10 is determined at a predetermined value.

The rotary tool 10 has the burr removing cutter 12 and the cutter 12 cut off the burr which generate during the friction stir joining time and changes them to the chips 60. Further, the apex sides of the raised portions 22 and 32 are cut off and the cut-off matters are changed to the chips 60. According to a centrifugal force of the rotary tool 10, the chips 60 are dispersed toward a surrounding portion of the table 5.

A front face plate 232 of the cover 230 is folded with a fold angle of an obtuse angle α against a side face plate 231 which is in parallel with the advancing direction of the joining head 200 and covers a front side of the housing of the optical sensor 210. The front face plate 232 is inclined to against to the moving direction.

An air jet J is injected from the air nozzle to directing for the side face plate 231 which is provided at a vicinity of the front face plate 232. A height position of an injection port of the air nozzle is near to the raised portion 32.

The air jet J which has been run to the side face 231 of the cover 230 is deflected to an arrow mark F direction along to the side face plate 232 and then the chips 60 are scattered to an opened side portion of the cover 230. Accordingly, the chips 60 which have been entered in the cover 230 can be discharged. At a side portion of the moving direction since there is no side face plate, the chips 60 which have been entered

in the cover 230 can be discharged easily.

The air jet J is injected from the air nozzle 240 which is provided at the rear portion of the housing of the optical sensor 210 and injects from a gap G which is formed at a lower face of the front face plate 232 of the cover 230 and removes the chips 60 which will enter to the cover 230. The air nozzle for injecting the air jet J may be provided a lateral direction of the optical sensor 210.

Further, the air jet J which has collided with a rear side of the front face plate of the cover 230 is deflected toward an arrow mark F direction along to the front face plate 232 and blows off the chips 60 toward a side portion in which the cover 230 is opened and closed.

Fig. 4 shows a relationship between a rotation center axis C1 of the rotary tool 10 and the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining.

At a tip end portion of the rotary tool 10 the small diameter portion 14 is provided, and an outer periphery portion thereof the burr removing cutter 12 is formed.

Fig. 4 shows a condition in which the rotation center axis C1 of the rotary tool 10 is arranged in 90 degrees with the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining.

In a case of an actual friction stir joining time, as shown in Fig. 5, against the perpendicular line C1 with the surface of the member a rotation center axis C2 of the rotary

tool 10 is joined by inclining with an angle of β. This angle β differs from the friction stir joining conditions and is selected with about 3 degree.

Each of Fig. 6(A) and Fig. 6(B) shows a position relationship between the tip end of the large diameter portion of the rotary tool 10 and the burr removing cutter 12. Fig. 6(A) shows a condition in which the lower end of the cutter 12 is provided with a stepwise difference from the tip end of the large diameter portion of the rotary tool 10 with a height dimension H1 against the tip end of the large diameter portion of the rotary tool 10. Fig. 6(B) shows a condition in which the lower end of the cutter 12 is arranged by projecting a height dimension H2 from the tip end of the large diameter portion of the rotary tool 10.

The arrangement position of the burr removing cutter 12 can be set, for example, the lower end of the burr removing cutter 12 may set to the height to the same against the tip end of the large diameter portion.

Each of Fig. 7(A), Fig. 7(B), Fig. 7(C) and Fig. 7(D) shows a condition of the joining bead portion.

As shown in Fig. 7(A), an outer diameter D1 of the large diameter portion of the rotary tool 10 is smaller than a width dimension L1 of the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining. And a rotation diameter D2 of the burr removing cutter 12 is set to be larger than the width dimension L1 of the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction

stir joining.

As shown in Fig. 7(B), when the joining bead 50 is formed according to the friction stir joining apparatus, the burr 52 generates. With this condition as it is, a surface 50a of the joining bead 50 is positioned at a height position dimension T1 from the surface of the members 20 and 30 to be subjected to the friction stir joining.

Fig. 7(C) shows in which according to the cutter 12 the surface including the burr is cut off and a flat face 50b is formed at position of a height dimension T2.

Further, as shown in Fig. 7(D), the above stated surface is removed using a manual tool etc. and a flat face 50c same to the members 20 and 30 to be subjected to the friction stir joining can be obtained.

Fig. 8 shows another embodiment of a friction stir joining apparatus for a structure body according to the present invention. A joining head 300 of a friction stir joining apparatus 1b of this embodiment according to the present invention has the rotary tool 10 but this rotary tool 10 has no burr removing cutter.

At a rear portion of the advancing direction of the rotary tool 10, a cutting tool 310 such as an end milling and this cutting tool 310 removes the burr which have generated to the joining bead.

Other constructions of the friction stir joining apparatus for a structure body of this embodiment according to the present invention are similarly to those of the former

embodiment of the friction stir joining apparatus for a structure body according to the present invention shown in Fig. 1.

Fig. 9 shows a further embodiment of a friction stir joining apparatus for a structure body according to the present invention. A joining head 400 of a friction stir joining apparatus indicated by a reference numeral 1c of this embodiment has a welding torch 410 and a welding bead W1 is formed. According to a cutting tool 420 which is arranged at a rear portion of the welding torch 410 a surface of the welding bead W1 is cut off to form a flat face.

Other constructions of the friction stir joining apparatus for the structure body of this embodiment according to the present invention are similarly to those of the former embodiment of the friction stir joining apparatus for the structure body according to the present invention shown in Fig. 1.

Fig. 10 shows a further embodiment of a friction stir joining apparatus for a structure body according to the present invention. A head 400 of a friction stir joining apparatus indicated by a reference numeral 1d for the structure body of this embodiment according to the present invention has a cut-off tool 510 and to the raised portions 22 and 32 of the members 20 and 30 to be subjected to the friction stir joining and an upper face of the joining bead a necessary processing is performed.

Other constructions of the friction stir joining

apparatus for the structure body of this embodiment according to the present invention are similarly to those of the former embodiment of the friction stir joining apparatus for the structure body according to the present invention shown in Fig. 1.

A technical range of the present invention is not limited to the wordings stated on each claim of claims or the wordings stated on the item of the means for solving the problem and further it refers to the range in which the man belonged to this technical field can replace easily.

As stated in above, according to the present invention, the friction stir joining apparatus for the structure body has a function in which the center of the joining portion is detected according to the optical sensor and to b e consistent the center of the rotary tool with the center of the joining portion the position control of a whole joining head is carried out.

Further, the optical sensor is arranged at the front portion of the rotary tool and the light beam is irradiated to the friction stir joining portion and detects optically the position of the joining portion. In this friction stir joining apparatus for the structure body, the optical sensor is covered according to the cover and the enter of the generated chips can be prevented.

The cover has the plate shape and the cover is constituted by the side face plate which covers one side portion which is in parallel to the advancing direction of the joining head of the box shape optical sensor housing and the front face plate

which is folded to the obtuse angle against the side face plate and covers the face of the rotary tool side of the optical sensor housing.

Further, at the rear face portion of the optical sensor housing the air nozzle is provided and the air jet is injected toward the outside from the inner side of the cover. This air jet is injected to the outer side from the lower portion of the front face plate of the cover and the enter of the generated chips to the optical sensor side can be prevented.

Further, the air jet which has collided with the inner face of the cover is deflected by the front face plate of the cover and further is blown off to the side portion in which the optical sensor housing is opened.

Accordingly, the enter of the generated chips to the beam portion of the optical sensor and an accuracy degree can be improved.

Further, the pressing roller unit which is provided at the front and the rear portions of the joining head has the air nozzle and the chips on the members to be subjected to the friction stir joining can be removed and it does not occur the injure of the surface of the member to be subjected to the friction stir joining according to the steps of the generated chips by the pressing roller.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A method for manufacturing a structure, the structure including an abutment region defined by substantially abutting first and second members, including the steps of:

sensing the abutment region using a sensing means;

friction stir welding the first and second members along a first side of the abutment region with a friction stir welding rotary tool;

at least partially cutting the first side of the abutment region using a cutting means;

moving the sensing means and the cutting means along the first side of the abutment region in a moving direction transversely of the structure;

controlling said moving in accordance with said sensing; and

causing air to flow between the sensing means and the first side of the abutment region.

2. The method claimed in claim 1, where said cutting means trails the sensing means.

3. The method claimed in claim 1 or claim 2, where said step of causing air to flow between the sensing means and the first side of the abutment region is effected from either in front of the sensing means with respect to the moving direction or from a lateral position with respect to the sensing means.

4. The method claimed in claim 3, where said air is caused to flow between the sensing means and the first side of the abutment region and is thence deflected at an obtuse angle

to the moving direction by a partitioning member positioned between the sensing means and the cutting means.

5. The method claimed in any one of the preceding claims, where said cutting means is coupled to and projects radially from the friction stir welding rotary tool and where the step of cutting is effected substantially simultaneously with the step of welding.

6. The method claimed in any one of claims 2 to 5, including the step of substantially immobilising the first and second adjacent members using a first rolling means that engages the abutment region and is adapted to move along the abutment region in the moving direction, wherein the first rolling means is disposed in front of the sensing means with respect to the moving direction and wherein the first rolling means is adapted to cause air to flow from the first rolling means towards the abutment region in the moving direction.

7. The method claimed in any one of claims 2 to 6, including the step of substantially immobilising the first and second adjacent members using a second rolling means that engages the abutment region and is adapted to move along the abutment region in the moving direction, wherein the second rolling means is disposed behind the cutting means with respect to the moving direction and wherein the second rolling means is adapted to cause air to flow from the second rolling means towards the abutment region in the moving direction.

8. The method claimed in any one of the preceding claims, wherein the step of controlling includes guiding the cutting means in orthogonal directions with respect to the moving direction in accordance with the step of sensing.

9. The method claimed in any one of the preceding claims, wherein the sensing means includes an optical sensor that detects edge positions of the abutment region as defined by the first and second adjacent members.

10. A method for manufacturing a structure, the structure including an abutment region defined by substantially abutting first and second members of the structure along respective opposed sides, including the steps of:

substantially immobilising the first and second members using a rolling means mounted on a first side of the abutment region;

sensing the abutment region using a sensing means;

friction stir welding the first and second members along a first side of the abutment region with a friction stir welding rotary tool;

at least partially cutting the first side of the abutment region using the cutting means;

moving a cutting means and the sensing means, along the first side of the abutment region in a moving direction transversely of the structure, in accordance with said sensing;

forcing air between the sensing means and the first side of the abutment region either from in front of the sensing means with respect to the moving direction or from a lateral portion of the sensing means; and

causing air to flow between the sensing means and the first side of the abutment region from in front of the sensing means with respect to the moving direction and/or from a lateral position with respect to the sensing means,

wherein the rolling means leads the sensing means and the

sensing means leads the cutting means and wherein said air passing between the sensing means and the first side of the abutment region is deflected in a lateral direction with respect to the moving direction from between the sensing means and the cutting means.

11. The method claimed in claim 10, wherein the step of substantially immobilising the first and second members includes a further rolling means mounted on the first side of the abutment region and wherein the further rolling means leads the sensing means and causes air to flow towards the abutment region in the moving direction.

12. Apparatus for friction stir welding a structure including:

means for supporting two adjacent members abutted along opposed respective sides, where the abutted opposed respective sides thereby form a joining portion;

means for friction stir welding a first side of the joining portion;

means for at least partially cutting the first side of the joining portion;

means for sensing the joining portion;

means for housing the sensing means;

means for causing air to flow between the means for sensing and the first side of the abutment region; and

means for moving the means for friction stir welding, the means for at least partially cutting the joining portion, the means for sensing the joining portion, the means for housing the sensing means and the means for causing air to flow along the first side of the joining portion in a moving direction transversely of the structure

in accordance with said sensing means;

wherein the means for friction stir welding is a friction stir welding rotary tool and the cutting means is coupled to and projects radially from the friction stir welding rotary tool to thereby effect said welding and said cutting substantially concurrently; wherein the sensing means leads the cutting means and the friction stir welding means; wherein the means for housing includes a first wall, coupled to a first side of the means for sensing, extending parallel to the moving direction and a second wall, being disposed between the means for sensing and the means for cutting, coupled to and extending from the first wall at an obtuse angle to the moving direction; and wherein said air flows from in front of the sensing means with respect to the moving direction.

13. A method for manufacturing a structure, the structure including an abutment region defined by substantially abutting raised portions of first and second members of the structure along respective opposed sides of the first and second members, including the step of:

friction stir welding the first and second members along the abutment region using a friction stir welding rotary tool,

wherein the friction stir welding rotary tool has a first portion, with a first diameter, located at a distal end of the friction stir welding rotary tool, for engaging the abutment region and a second portion, with a second diameter smaller than that of the first portion, extending from the first portion; wherein the friction stir welding rotary tool is disposed at an oblique angle to the abutment region; and wherein a cutting means is coupled to and extends radially

from said first portion and the rotational radius of the cutting means is greater than a half width of the abutment region.

14. A method for manufacturing a structure substantially as hereinbefore described with reference to the accompanying drawings.

15. Apparatus for friction stir welding a structure substantially as hereinbefore described with reference to the accompanying drawings.

16. A method for friction stir joining a structure substantially as hereinbefore described with reference to the accompanying drawings.

DATED this 19th day of JULY, 2001

HITACHI, LTD.

By its patent attorneys
DAVIES COLLISON CAVE

FIG. 1

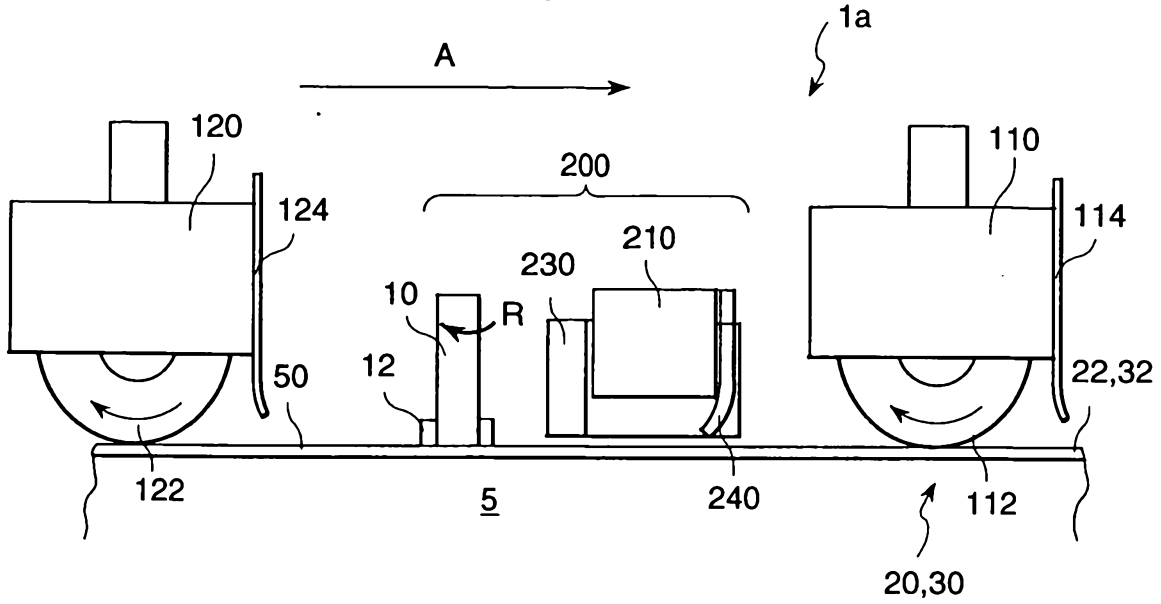

1a
A
120
124
200
210
230
10
R
12
50
110
114
22,32
122
5
240
112
20,30

FIG. 2

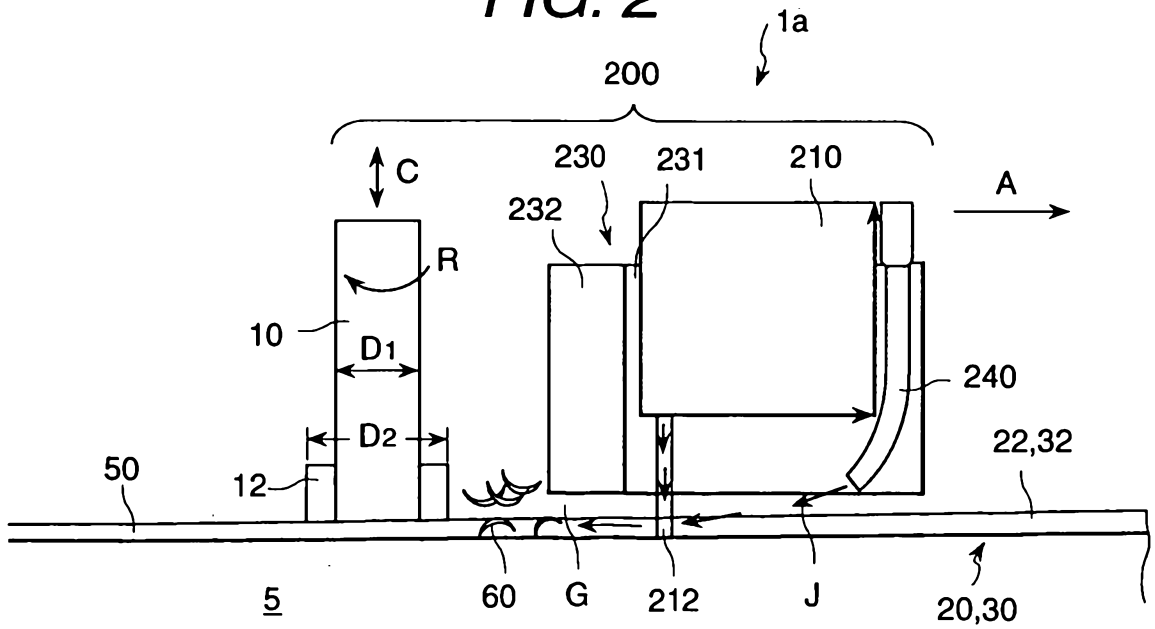

1a
200
C
230
231
210
A
232
R
10
D1
D2
240
22,32
50
12
5
60
G
212
J
20,30

FIG. 3

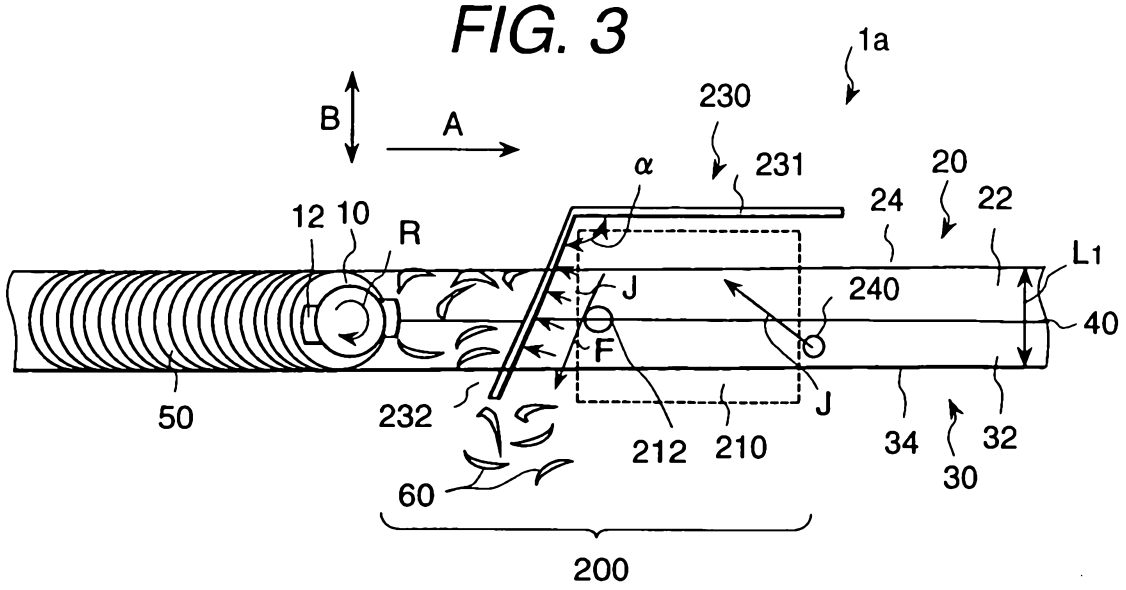


FIG. 4

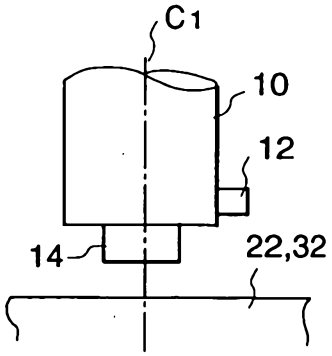


FIG. 5

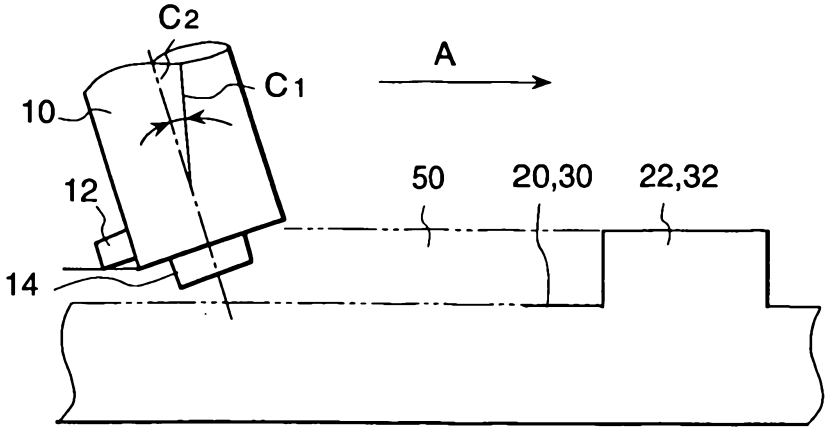


FIG. 6(A)

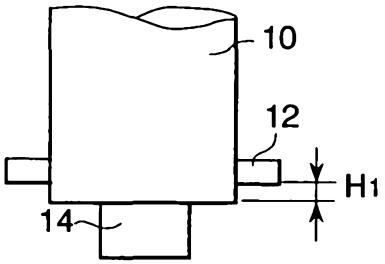


FIG. 6(B)

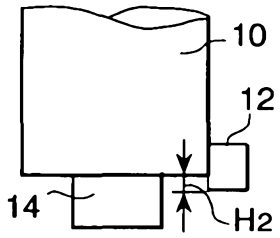


FIG. 10

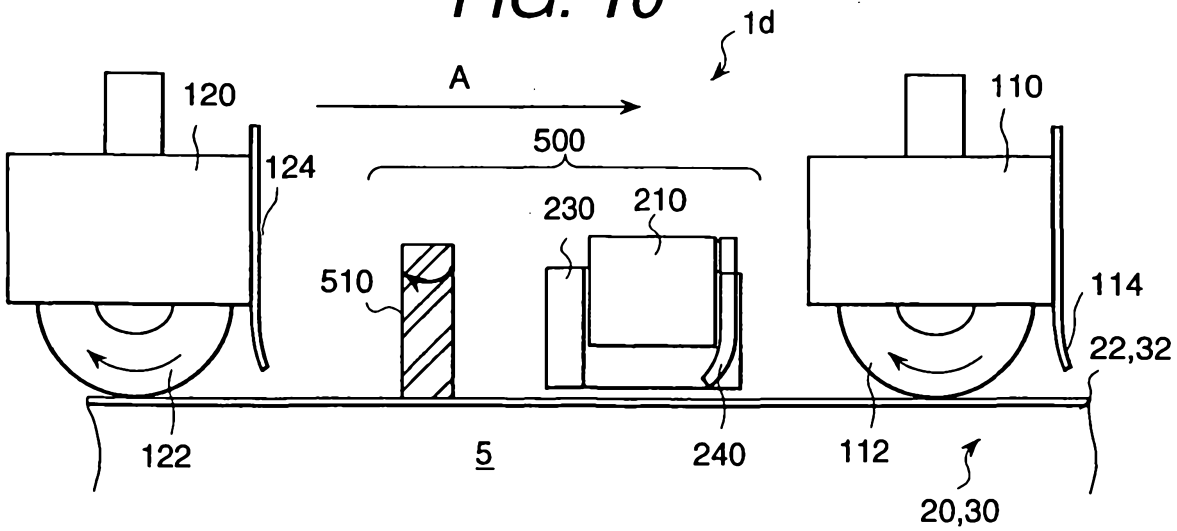


FIG. 7(A)

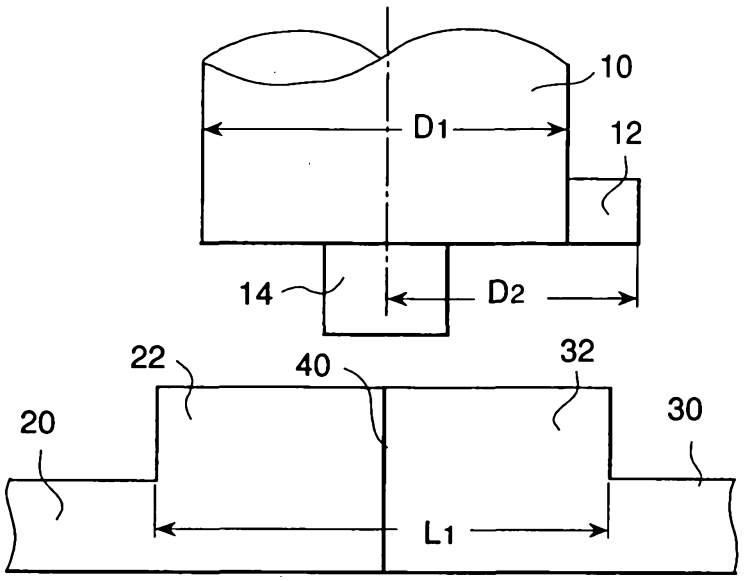


FIG. 7(B)

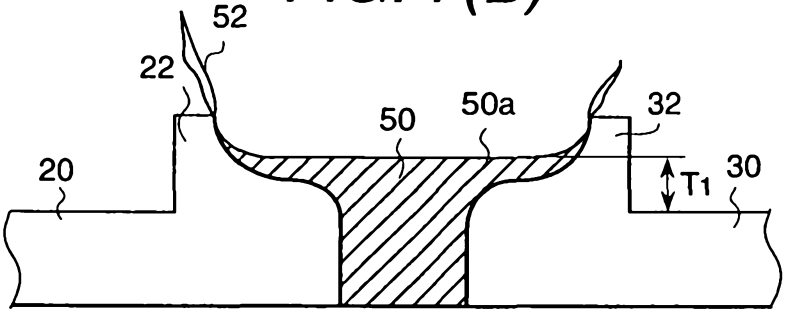


FIG. 7(C)

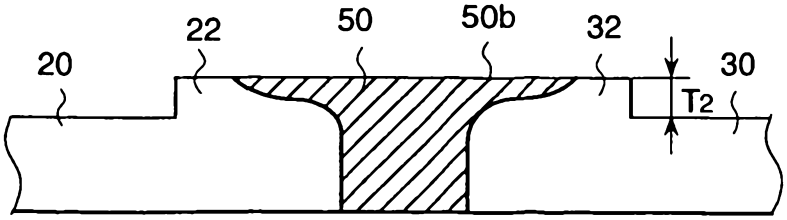


FIG. 7(D)

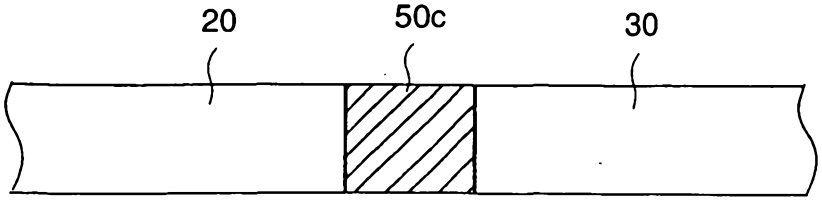
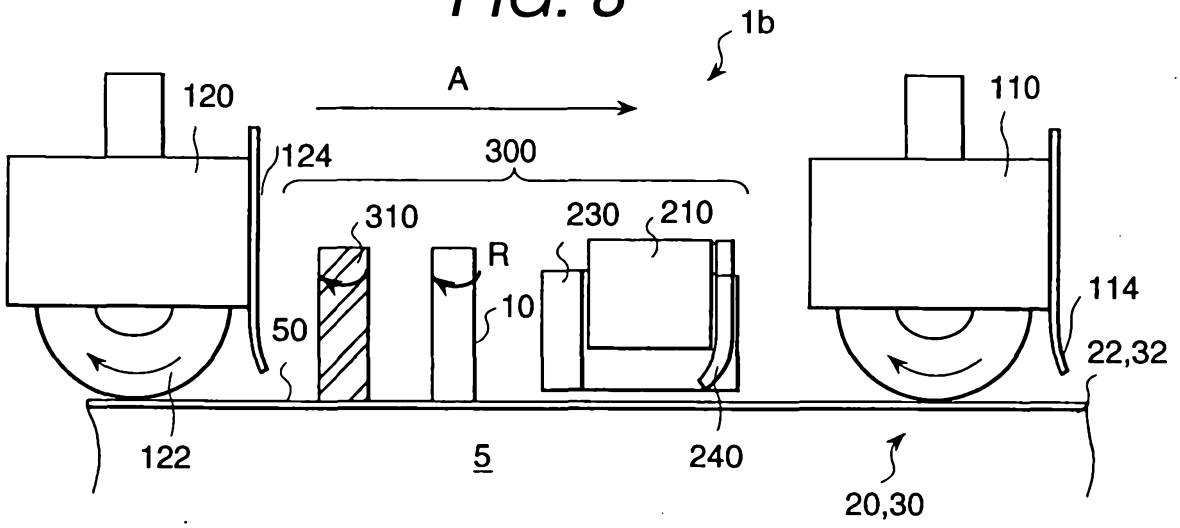


FIG. 8


1b
A
120
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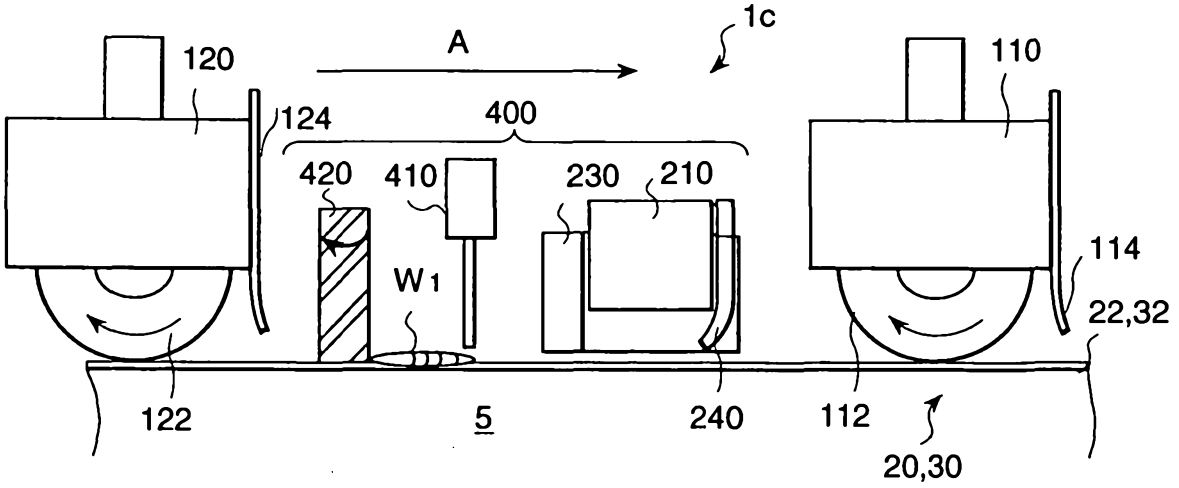
310
230
210
R
10
50
110
114
22,32
122
5
240
20,30

FIG. 9


1c
A
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124
400
420
410
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W1
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114
22,32
122
5
240
112
20,30