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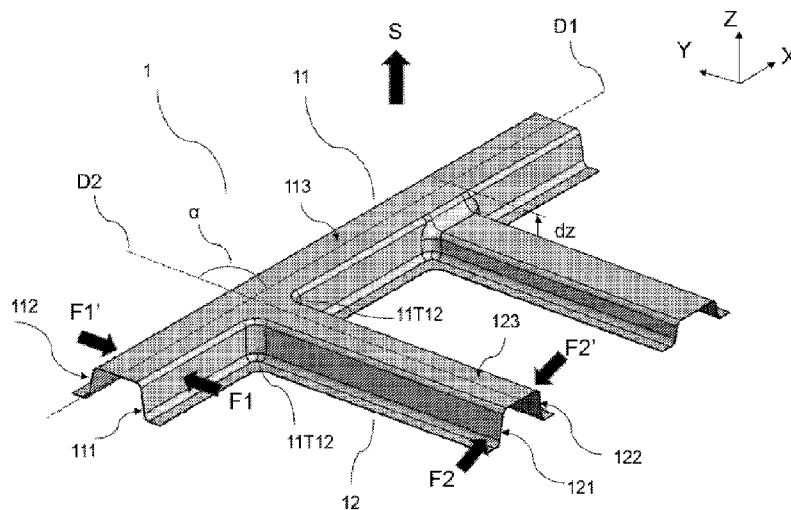


Fig. 1

(57) Abstract: Stamping method to form a metallic part (1) and associated metallic part, wherein the geometry of said metallic part is such that some areas need to deform in antagonistic directions during stamping. The stamping method comprises the step of providing a blank stack-up (10) comprising at least two sub-blanks (101, 102) corresponding to sub-parts (11, 12) of the metallic part, said blank stack-up further comprising an overlapping area (100) in which the blanks are overlapped onto one another, said overlapping area (100) corresponding to the critical transition area 11T12 between the two sub-parts.

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Manufacturing method for a metallic part and associated metallic part

The present invention relates to a process to manufacture a metallic part and the associated metallic part. In particular, it relates to the manufacturing of complex metallic parts in which the forming is performed by stamping.

5 There is a growing demand in the metallic part manufacturing industry, in particular in the automotive part manufacturing industry, to produce parts having ever more complex shapes. This allows for instance to integrate several separate individual parts into one single part. This streamlines the production process: only one forming operation replaces the combination of several separate forming
10 operations to produce the individual sub-parts and the corresponding joining process to assemble said individual sub parts. This also allows to improve part performance because the assembly points between individual sub parts are often weak points that can fail under load, for example when a crash occurs in the case of automotive parts. Furthermore, the simplification of the production process entails
15 further positive effects such as the reduction of green-house gas emissions during forming and cost reductions.

Stamping is a well-known sheet metal forming technique which consists of pressing a flat metallic sheet between an upper and a lower die generally having the shape of the formed metallic part. Said dies move relative to one another in a
20 direction termed the stamping direction.

During stamping, the pressed metal flows under the joint forces exerted by the upper and lower dies. It is generally not possible to stamp a part if there are abrupt transitions of the direction in which the metal flows. Indeed, in the areas where these abrupt transitions occur, the metal sheet needs to flow in two distinct
25 directions, which leads to very high deformation rates, excessive thinning and eventually the occurrence of cracks. In some instances this also leads to wrinkling of the part.

It is an object of the current invention to provide a metallic part forming process allowing to stamp complex shapes in which the sheet metal needs to flow
30 in several distinct directions without the occurrence of excessive thinning, cracking or folding. A further object of the present invention is to provide a part made

according to the inventive process and having a complex shape, not reachable using current state of the art stamping technology.

5 The object of the present invention is achieved by applying a part manufacturing process according to claim 1, optionally comprising the features of claims 2 to 14 taken individually or according to any possible combination. The present invention further concerns a metallic part according to claim 15, optionally comprising the features of claims 16 or 17, taken individually or according to any possible combination. The present invention further concerns an automotive vehicle according to claim 18.

10 Other aspects and advantages of the invention will appear upon reading the following description, given by way of example, and made in reference to the appended drawings, which are in no way limitative, wherein:

-Figure 1 is a perspective view of a specific embodiment of a metallic part for which the present invention provides a manufacturing process,

15 -Figure 2 is a top view of sub- blanks according to the current invention,

-Figure 3A is a top view of a punch and binder of a stamping tool according to the prior art and figure 3B of a punch and binder of a stamping tool according to the invention,

20 -Figure 4 is a perspective view of the start of a stamping operation according to the current invention – for clarity's sake the upper die is not represented in this figure,

- Figure 5 is a perspective view of the same stamping operation as in figure 4, representing this time the end of the stamping operation,

25 -Figure 6A is a top view of a punch and binder of a stamping tool according to the invention and figure 6B of a conforming tool according to a particular embodiment of the current invention,

-Figure 7 is perspective view of a further embodiment of a metallic part for which the present invention provides a manufacturing process,

-Figure 8 is perspective view of a further embodiment of a metallic part for which the present invention provides a manufacturing process,

-Figures 9A and 9B are perspective views of metallic parts formed by prior art techniques and Figure 9C is a perspective view of a metallic part formed according to the current invention.

-Figure 10 is a perspective view of a specific embodiment of a metallic part for which the present invention provides a manufacturing process.

-Figures 11a, b, c and d are perspective views of a specific embodiment of the stamping process according to the invention in chronological order from just before the stamping operation actually starts to the end of stamping – these only depict the significant portion of the sub-blanks during the stamping operation for clarity's sake.

In the following figures and description, the orientations and spatial references are all made using an X, Y, Z coordinates associated to the following directions:

-X is a longitudinal direction in the horizontal plane, the X axis being oriented such that the X coordinates increase in the front to rear direction, i.e. a position located further back will have a higher X coordinate than a position located further in the front,

-Y is a transverse direction in the horizontal plane,

-Z is an elevation direction, the Z axis being oriented such that the Z coordinates increase from a lower position to an upper position, i.e. a first position located below a second position will have a lower Z coordinate value.

The referential is represented in each figure. When the figure is a 2D flat representation, the axis which is outside of the figure is represented by a dot in a circle when it is pointing towards the reader and by a cross in a circle when it is pointing away from the reader, following established conventions.

In particular, the terms “top”, “up”, “upper”, “above”, “bottom”, “low”, “lower”, “below” etc. are defined according to the elevation direction. The terms “front”, “back”, “rear”, “forward”, “backward” etc. are defined according to the longitudinal

direction. The terms “left”, “right”, “transverse”, etc. are defined according to the transverse direction. The term “horizontal” refers to the orientation of the plane comprising the longitudinal and the transverse directions. The term “vertical” refers to any orientation comprising the elevation direction.

5

By “substantially parallel” or “substantially perpendicular” it is meant a direction which can deviate from the parallel or perpendicular direction by no more than 15°.

10 A metallic sheet refers to a flat sheet of steel. It has a top and bottom face, which are also referred to as a top and bottom side or as a top and bottom surface. The distance between said faces is designated as the thickness of the sheet. The thickness can be measured for example using a micrometer, the spindle and anvil of which are placed on the top and bottom faces. In a similar way, the thickness can also be measured on a formed part.

15 By average thickness of a part, or of a portion of a part, it is meant the overall average thickness of the material making up the part after it has been formed into a 3-dimensional part from an initially flat sheet.

Tailor welded blanks are made by assembling together, for example by laser welding, several sheets or cut-out blanks of steel, known as sub-blanks, in order to
20 optimize the performance of the part in its different areas, to reduce overall part weight, to reduce overall part cost and to reduce material scrap. The sub-blanks forming the tailor welded blanks can be assembled with or without overlap, for example they can be laser butt-welded (no overlap), or they can be spot-welded to one another (with overlap).

25 A blank stack-up is a combination of several sub-blanks which includes overlapping regions allowing the sub-blanks to move in different directions during the forming operation.

By opposition to a tailor welded blank, a monolithic blank refers to a blank which consists of one single sub-blank, without several sub-blanks being combined
30 together.

A tailor rolled blank is a blank having multiple sheet thicknesses obtained by differential rolling during the steel sheet production process.

The ultimate tensile strength, the yield strength and the elongation are measured according to ISO standard ISO 6892-1, published in October 2009. The tensile test specimens are cut-out from flat areas. If necessary, small size tensile test samples are taken to accommodate for the total available flat area on the part.

- 5 The bending angle is measured according to the VDA-238 bending standard. For the same material, the bending angle depends on the thickness. For the sake of simplicity, the bending angle values of the current invention refer to a thickness of 1.5mm. If the thickness is different than 1.5mm, the bending angle value needs to be normalized to 1.5mm by the following calculation where $\alpha_{1.5}$ is the bending angle normalized at 1.5mm, t is the thickness, and α_t is the bending angle for thickness t :
- 10

$$\alpha_{1.5} = (\alpha_t \times \sqrt{t}) / \sqrt{1.5}$$

- Cold stamping is a forming technology for metals which involves shaping a metallic sheet into a formed part by pressing it between an upper and lower die, called the cold stamping tool or stamping press (both terms are used in the current description and claims and are interchangeable). For example, the cold stamping tool has a blank holder which allows to hold the metallic sheet on its sides. For example, the cold stamping tool consists of several steps, each involving an upper and lower die to produce complex shapes and / or to perform further operations such as punching holes in the part or trimming its sides.
- 15
- 20

- Hot stamping is a forming technology for steel which involves heating a blank of steel, or a preformed part made from a blank of steel, up to a temperature at which the microstructure of the steel has at least partially transformed to austenite, forming the blank or preformed part at high temperature by stamping it and simultaneously quenching the formed part to obtain a microstructure having a very high strength, possibly with an additional partitioning or tempering step in the heat treatment.
- 25

- A multistep hot stamping process is a particular type of hot stamping process including at least one stamping step and consisting of at least two process steps performed at high temperature, above 300°C. For example, a multistep process can involve a first stamping operation and a subsequent hot trimming operation, so that
- 30

the finished part, at the exit of the hot stamping process, does not need to be further trimmed. For example, a multistep process can involve several successive stamping steps in order to manufacture parts having more complex shapes than what can be realized using a single stamping operation. For example, the parts are automatically
5 transferred from one operation to another in a multistep process, for example using a transfer press. For example, the parts stay in the same tool, which is a multipurpose tool that can perform the different operations, such as a first stamping and a subsequent in-tool trimming operation.

A partial hardening hot stamping process is a hot stamping process in which
10 the heat profile to which the blank is submitted is purposely tailored to be different in different areas of the blank, in order to obtain different material properties in these different areas at the end of the hot stamping process. For example, this allows to produce hot stamped parts using a single metallic blank made of a single material which will have different levels of hardness and elongation in different areas of the
15 final part. For example, this allows to produce parts having soft zones and hard zones, said soft zones being able to deform under an impact load in order to absorb energy, whereas said hard zones will resist intrusion by resisting deformation. There are several different technologies to implement partial hardening. For example, the material can be heated at different temperatures in different areas of the blank, the
20 higher temperature areas will be fully austenitic at the exit of the austenitizing furnace resulting in a very hard microstructure after hot stamping, whereas the lower temperature areas will have an intercritical ferrite / austenite microstructure at the exit of the austenitizing furnace resulting in a lower hardness microstructure after hot stamping. For example, the material can be quenched at different quenching
25 speeds in different areas of the blank during the hot stamping step itself, the areas quenched at a higher quenching speed will have a higher hardness than those quenched at a lower speed.

Referring to figures 1 and 11, it is an object of the present invention to manufacture a metallic part 1 comprising at least the following sub-parts:

30 -a first sub-part 11 generally extending along a first direction D1. In the rest of the description, this first direction will be conventionally chosen as the longitudinal direction. Said first direction is perpendicular to a stamping direction S, which will be

in the current description conventionally chosen as the elevation direction, and comprising at least one first side wall 111 (in the case of figure 1 there are two side walls 111 and 112), substantially parallel to said stamping direction, and a first top section 113 linked to at least said one first side wall 111, and generally extending in
5 a plane perpendicular to said stamping direction S,

-a second sub-part 12 connected to said first sub part 11 and generally extending along a second direction D2, also perpendicular to said stamping direction and forming with said first direction an angle α strictly greater than 0° , comprising at least two vertical walls 121 and 122, substantially parallel to said stamping direction,
10 and a second top section 123, connecting said two vertical walls 121, 122, generally extending in a plane perpendicular to said stamping direction.

The metallic part 1 represented in figure 1 is a particular embodiment in which the sub parts are generally omega shaped with straight vertical walls and straight flat top sections. This however it not limitative of the invention, the sub parts can for
15 example have a curved inverted U-shape cross section, i.e. have curved vertical walls and a top section which is limited to a two dimensional line. This is for example the case of the first sub part 11 of the metallic part 1 represented on figure 10.

In a specific embodiment, the angle α between the two main directions D1, D2 of the sub-parts 11, 12 is comprised from 30° to 90° , more specifically from 60°
20 to 90° , even more specifically from 80° to 90° .

When forming the metallic part 1 by stamping a flat metallic blank along the stamping direction S, the first vertical wall 111 is formed by the flow of material in a direction F1, transverse to D1, as represented on figure 1. In the case when a the first sub part 11 also contains a second vertical wall 112, it is formed thanks to a
25 material flow in direction F1'. Simultaneously, the material flows in opposing directions F2 and F2', both transverse to D2 to form the vertical walls 121 and 122 of the second sub-part 12. In transition regions 11T12 between sub parts 11 and 12 the material needs to flow simultaneously in directions F1 and F2 or in directions F1 and F2'. The angle between said directions will be α or its complementary to 180°
30 and since α is strictly greater than 0° , this leads to a simultaneous flow of material

in different directions, which overstretches said material leading to excessive thinning and eventually cracking in the transition regions.

This is illustrated by figure 9A, which is an example of a stamping simulation of a metallic part corresponding to the above description, in which cracks 6 appear
5 in the transition regions 11T12 due to the above-described competing deformation directions.

According to the current invention, in order to manufacture a metallic part according to the invention a blank stack-up 10 is used, as depicted in figure 2. Said blank stack-up 10 comprises at least:

10 -two sub-blanks 101, 102 each substantially corresponding respectively to said first and second sub-parts 11, 12,

-at least one overlap area 100 in which said sub-blanks 101, 102 overlap one another,

During the stamping operation, the area of the blank stack-up 10
15 corresponding to the transition regions 11T12 in which cracks normally occur is now double layered thanks to the presence of the overlap region 100, and both layers have the freedom to slide on to one another thereby preventing the above-described issue of excessive thinning and cracking due to contradictory material flow directions. For example, in the configuration of figure 1, the material of sub-blank
20 101 corresponding to the vertical wall 111 will be free to move in direction F1 while the material of sub-blank 102 corresponding to the vertical wall 121 and 122 will be free to move in directions F2 and F2'.

The inventors have found that, surprisingly, providing the above-described blank stack-up can still result in a metallic part having stamping defects in the
25 transition regions 11T12. Figure 9B is an exploded view of the result of performing a stamping operation on a blank stack-up as described previously. Sub-parts 11 and 12 have been disassembled in order to highlight the forming issues that were encountered. As can be seen, cracks 6 appear both on the first and second sub parts 11, 12.

In the case when cracks still occur as described above, the inventors have found that it was possible to stamp a metallic part according to the invention by modifying the stamping process.

5 A stamping tool generally comprises a punch and a die. The die can be seen as a mold in which the part will be formed, while the punch is used to transfer the shape of the part to the blank by pressing it into the die in the stamping direction. A stamping tool can optionally further comprise a binder, also known as a blank holder, which is used to keep the blank in place during stamping and thus control the flow of material to reach a good quality shape.

10 Figure 3A is a top view of a punch 2 and a binder 3 according to the state of the art. Referring to figure 3B, the inventors have found that, surprisingly, it was possible to solve the cracking issue in the transition zones when using a blank stack-up by providing a punch 2 having a gap 4 in between the areas of the punch corresponding to the first sub-part 11 and the second sub-part 12.

15 Figure 9C is an example of a stamping simulation of a blank stack-up according to the invention using a stamping tool according to the invention, i.e. with a gap 4 between the areas of the punch 3 corresponding to the first and second sub-parts. No cracks were observed in the transition areas 11T12 in this last simulation.

20 In a particular embodiment, the inventors have found that the necessary length of said gap 4 (i.e. the distance g indicated on figure 3B) is linked to the height of the vertical walls of the two contiguous sub-parts in the corresponding transition region 11T12. Indeed, the reason for which cracking occurs when no gap is provided is linked to the flow of material to form said vertical walls, and the amount of material
25 flow is itself linked to the height of said vertical walls. Stamping a part with higher walls means that more material needs to flow to form said walls. Therefore, the higher the vertical walls, the bigger the necessary gap length. On the other hand, the necessary gap length g will never exceed the maximum height of the vertical walls, because as we move away from the connection between the two contiguous
30 sub-parts, the effect of the transition region on the material flow diminishes and is

close to none when the distance from the connection region starts to exceed the height of the vertical walls.

In a particular embodiment, the length g of the gap 4, expressed in mm, is greater than or equal to 30%, preferably 50%, preferably 70% of the height of the highest vertical wall in the transition region 11T12 and lower than or equal to said
5 same height of the highest vertical wall in the transition region 11T12.

In summary, the inventors have found that it is possible to manufacture a metallic part having the above-described characteristics without the occurrence of excessive thinning or cracks in the transition zones by applying the following
10 manufacturing process:

- Provide at least two metallic sub blanks 101, 102 corresponding to the two sub-parts 11,12 of the metallic part 1,

- position said at least two metallic sub blanks 101, 102 in a stamping press to form a blank stack-up 10 comprising at least an overlap region 100 in which said
15 sub blanks overlap one another,

- Perform a stamping operation by pressing said blank stack-up between a punch 2 and a die moving relative to one another in a stamping direction S , wherein said punch 2 optionally comprises at least one gap 4 in between the areas corresponding to said first and second sub-parts 11, 12.

20 The stamping of a blank stack-up according to the invention is represented on figures 4 and 5. Figure 4 represents the start of the stamping operation at which point the blank stack-up 10 is fed to the stamping tool – on figure 4 the punch 2 and binder 3 are represented but not the die, for visibility's sake. The punch and the die close on to one another following the stamping direction S to form the metallic part
25 at the end of the stamping operation, as represented on figure 5.

In a specific embodiment as depicted on figures 2 and 4, the punch 2 further comprises at least one positioning pin 22, designed to help position precisely the blank stack-up 10 when feeding it to the stamping tool. Said at least one positioning pin 22 is associated to at least one positioning hole 103 within the sub-blanks. When
30 feeding the blank stack-up 10 to the stamping tool, the positioning holes 103 slide

onto the positioning pins 22 to reach their position in the stamping tool thereby ensuring a precise and reproducible blank positioning. In a particular embodiment, the positioning pins have a tapered shape, narrower at the top and wider at the bottom to ensure good centering when positioning the sub blanks. For example, the
5 positioning pins 22 are substantially conical and the positioning holes 103 are substantially circular, the diameter of said positioning holes 103 being substantially the diameter of the base of said conical positioning pins 22.

In a specific embodiment the stamping operation is a cold forming stamping. In a specific embodiment the stamping operation is hot stamping, optionally multi-
10 step hot stamping, optionally partial hardening hot stamping.

In a specific embodiment, as represented on Figures 11a, b, c and d, the overlap region 100 of the blank stack-up 10 further comprises an imbrication area 1005, said imbrication area 1005 comprising itself a tab 1006 projecting from a first sub-blank and a cavity 1007 in the second sub-blank designed to accommodate
15 said tab 1006 in an interlocked position by the end of the stamping operation. As can be seen on figures 11a, b, c and d depicting the evolution of the blank stack-up 10 in the imbrication area 1005, under the effect of the stamping operation, the tab 1006 is folded into and then slides within the cavity 1007 to eventually reach an interlocked position at the end of the stamping operation (figure 11d). By "interlocked
20 position" it is meant a position in which the tab 1006 and cavity 1007 form a fixed assembly and allow to handle the formed sub parts 11, 12 together in a manner that they do not move relative to one another during handling. Advantageously, this allows to easily handle the metallic part 1 after it has been formed. For example, it allows to easily remove it from the stamping press and handle it to the subsequent
25 processing step.

In a specific embodiment, in order to further assemble the formed sub-parts to ensure the structural strength of the final part, as depicted on figure 2, the overlap area 100 of the sub-blanks further comprises at least one post-assembly area 1004 in which said first and second sub-parts 11, 12 are still overlapping one another after
30 said stamping operation. In this specific embodiment, the manufacturing process further comprises a post-assembly step after the stamping operation during which at least said first and second sub-parts are joined together in said post-assembly

areas 1004. For example, the sub-parts are joined together by spot welding them together to form spot welds 7 as depicted in figure 8. For example, the sub-parts are laser welded, optionally remote laser welded together.

For example, when applying the current invention to a metallic part of an automotive vehicle, this allows to integrate in one single metallic part both longitudinal and transverse structural elements. For example, this allows to integrate in one single part longitudinal front side members and a dash panel cross member. For example, this allows to integrate in one single part side sills and seat cross members. For example, this allows to integrate in one single part roof rails and roof cross members. For example, this allows to integrate in one single part rear side members and rear cross members. By combining various structural elements in one single part, the manufacturing process is simplified, and the part is made more robust because its longitudinal and transverse components are integral to the same part and therefore cooperate together in an optimal manner.

In a particular embodiment, the stamping step is followed by a conforming step in which the shape of the metallic part is further adjusted in the transition areas 11T12. Indeed, because of the presence of the gap 4 in the stamping tool punch 2, the blank material in the transition areas 11T12 corresponding to the gap in the punch is not pressed against the die. The shape of the metallic part in this area will thus not perfectly reproduce that of the die. In a particular embodiment, as represented on figures 6A and 6B, a conforming tool is used having a punch 21 with a smaller gap 41 between the areas corresponding to said first and second sub-parts. Figure 6A represents a stamping punch 2 according to the invention with a gap 4 and figure 6B represents a conforming punch 21 according to the invention with a smaller conforming punch gap 41. By reducing the gap 41 within the conforming tool, the material is pressed more closely into the die and therefore better conforms to the desired shape in the transition areas 11T12. It is possible to reduce the gap 41 in the conforming tool because the part is already formed by stamping and the forces exerted by the conforming operation on the rest of the part will be much lower than during stamping, in such a way that no cracks will occur in the transition areas. In any case it will still be necessary to have a conforming gap 41 which is greater than 0mm. In a particular embodiment, the length of the

confirming gap 41 is comprised from 10% to 80% of the length of the initial stamping punch gap 4, preferably from 10% to 70%, preferably from 10% to 50%, preferably from 20% to 70%, preferably from 20% to 50%.

5 In a particular embodiment, the stamping operation and the conforming operation are performed as two successive stages of a transfer press. For example, they are performed as two successive stages of a cold stamping transfer press. For example, they are performed as two successive stages of a hot stamping multistep process using a transfer press.

10 In a particular embodiment, the stamping operation and the conforming operation are performed successively using an adjustable punch in which the gap 4 at the stamping stage can be reduced to the gap 41 at the conforming stage for example by sliding the punch element corresponding to the sub-part 2 closer to the punch element corresponding to sub-part 11.

15 The above-described configuration of the metallic part, comprising at least a first and a second sub-part 11, 12 should be understood as the most basic possible configuration of a metallic part according to the invention. Referring to figure 7, said metallic part 1 can for example comprise at least two first sub-parts 11 generally extending along said first direction D1, each being connected to said at least one second sub-part 12 generally extending along said second direction D2. In this case, 20 the blank stack-up 10 comprises at least three sub-blanks substantially corresponding to each of said sub-parts, said blank stack-up further comprising at least two overlap areas in which each sub-blank extending in a first direction overlap the sub-blank extending in a second direction. Furthermore, the stamping tool used to manufacture said metallic part will comprise a punch 2 having in this case at least 25 two gaps 4 each corresponding to an area in between first sub-parts 11 and the second sub-part 12.

Any other combination between first and second sub-parts extending along directions D1 and D2 is also possible according to the invention. Indeed, the gist of the invention is to provide a manufacturing process that allows to form the blank 30 material in the transition regions 11T12 without the occurrence of cracks.

In fact, the invention can be generalized to metallic part configurations in which there are even more than two main direction D1, D2. Indeed, the stamping issues solved by the invention occur locally in each transition region 11T12 and each set of transition region is in fact independent from the others.

5 The current invention further covers a metallic part corresponding to the above listed features taken alone or according to any possible combinations and manufactured by the above detailed process, including all possible combinations of optional features of said process.

10 One significant advantage of said metallic part manufactured according to said process is that it is possible, in a specific embodiment, to manufacture a metallic part comprising at least one set of contiguous sub-parts having at least one set of two contiguous vertical walls, e.g. 112 and 121, wherein the curvature radius measured in the transition area 11T12 between said two contiguous vertical walls is extremely low. This is not possible in the prior art stamping technique, without a
15 blank stack-up, because the shape in the transition region needs to be soft, i.e. with a high curvature radius, in order to provide a progressive change in flow direction of the material composing said contiguous vertical walls. For example, in a specific embodiment, the curvature radius measured in the transition area 11T12 between said two contiguous vertical walls is equal to or less than twenty times, more
20 specifically less than ten times, even more specifically less than five times, the smallest sheet metal thickness of said two sub parts. In a specific embodiment, said curvature radius is less than 100mm, more specifically less than 50mm, more specifically less than 20mm, more specifically less than 10mm, more specifically less than 5mm. In a specific embodiment, said curvature radius is 0mm, meaning
25 that said sub-parts form a sharp angle with one another. Providing a metallic structural part with low or even no curvature radius between contiguous side walls allows for optimal resistance of the part in the case of compressive stresses for example in which the different sub-parts extending in different directions need to cooperate with one another to resist compression. For example, in the case of
30 automotive structural parts, this is advantageous to resist with the same parts transverse crashes and longitudinal crashes.

In a specific embodiment the metallic part 1 is made by cold stamping a blank stack-up 10 comprising one of the following materials, either in the form of monolithic blanks or tailor rolled blanks or combined in the form of tailor welded blanks:

- Steel having a chemical composition comprising in weight %: $0.13\% < C < 0.25\%$, $2.0\% < Mn < 3.0\%$, $1.2\% < Si < 2.5\%$, $0.02\% < Al < 1.0\%$, with $1.22\% < Si+Al < 2.5\%$, $Nb < 0.05\%$, $Cr < 0.5\%$, $Mo < 0.5\%$, $Ti < 0.05\%$, the remainder being Fe and unavoidable impurities and having a microstructure comprising from 8% to 15% of retained austenite, the remainder being ferrite, martensite and bainite, wherein the sum of martensite and bainite fractions is comprised from 70% to 92%.
- 10 With this composition, the steel sheet has, as measured in the rolling direction, a yield strength comprised from 600MPa to 750MPa and an ultimate tensile strength comprised from 980MPa to 1300MPa while keeping a total elongation above 19%.

- Steel having a chemical composition comprising in weight %: $0.15\% < C < 0.25\%$, $1.4\% < Mn < 2.6\%$, $0.6\% < Si < 1.5\%$, $0.02\% < Al < 1.0\%$, with $1.0\% < Si+Al < 2.4\%$, $Nb < 0.05\%$, $Cr < 0.5\%$, $Mo < 0.5\%$, the remainder being Fe and unavoidable impurities and having a microstructure comprising from 10% to 20% of retained austenite, the remainder being ferrite, martensite and bainite. With this composition, the steel sheet has, as measured in the rolling direction, a yield strength comprised from 850MPa to 1060MPa and an ultimate tensile strength
- 15
- 20 comprised from 1180MPa to 1330MPa while keeping a total elongation above 13%.

-Fully martensitic steel wherein the composition of the fully martensitic steel comprises in % weight: $0.15\% \leq C \leq 0.5\%$.

-Dual phase steel having a microstructure comprising at least martensite and ferrite and having a UTS of at least 590MPa.

- 25 -Dual phase steel having a microstructure comprising at least martensite and ferrite and having a UTS of at least 780MPa.

-Dual phase steel having a microstructure comprising at least martensite and ferrite and having a UTS of at least 980MPa.

In a specific embodiment the metallic part is made by hot stamping a blank stack-up 10 comprising one of the following materials, either in the form of monolithic blanks or tailor rolled blanks or combined in the form of tailor welded blanks:

5 -Steel having a composition comprising in % weight: $0.06\% \leq C \leq 0.1\%$, $1\% \leq Mn \leq 2\%$, $Si \leq 0.5\%$, $Al \leq 0.1\%$, $0.02\% \leq Cr \leq 0.1\%$, $0.02\% \leq Nb \leq 0.1\%$, $0.0003\% \leq B \leq 0.01\%$, $N \leq 0.01\%$, $S \leq 0.003\%$, $P \leq 0.020\%$ less than 0,1% of Cu, Ni and Mo, the remainder being iron and unavoidable impurities resulting from the elaboration. With this composition range, the yield strength of the corresponding area after hot stamping is comprised from 700 to 950MPa, the tensile strength from 950MPa to 10 1200MPa and the bending angle is above 75° .

-Steel having an ultimate tensile strength after hot stamping which is comprised from 1300MPa to 1650MPa and a yield strength which is comprised from 950MPa to 1250MPa.

15 -Steel having an ultimate tensile strength after hot stamping which is comprised from 1300MPa to 1650MPa, a yield strength which is comprised from 950MPa to 1250MPa and a bending angle which is above 75° .

20 -Steel having a composition comprising in % weight: $0.20\% \leq C \leq 0.25\%$, $1.1\% \leq Mn \leq 1.4\%$, $0.15\% \leq Si \leq 0.35\%$, $Cr \leq 0.30\%$, $0.020\% \leq Ti \leq 0.060\%$, $0.020\% \leq Al \leq 0.060\%$, $S \leq 0.005\%$, $P \leq 0.025\%$, $0.002\% \leq B \leq 0.004\%$, the remainder being iron and unavoidable impurities resulting from the elaboration. With this composition range, the ultimate tensile strength of the corresponding area of the part after hot stamping is comprised from 1300MPa to 1650MPa and the yield strength is comprised from 950MPa to 1250MPa.

-Steel having a tensile strength after press-hardening higher than 1800 MPa.

25 -Steel having a composition which comprises in % weight: $0.24\% \leq C \leq 0.38\%$, $0.40\% \leq Mn \leq 3\%$, $0.10\% \leq Si \leq 0.70\%$, $0.015\% \leq Al \leq 0.070\%$, $Cr \leq 2\%$, $0.25\% \leq Ni \leq 2\%$, $0.015\% \leq Ti \leq 0.10\%$, $Nb \leq 0.060\%$, $0.0005\% \leq B \leq 0.0040\%$, $0.003\% \leq N \leq 0.010\%$, $S \leq 0,005\%$, $P \leq 0,025\%$, %, the remainder being iron and unavoidable impurities resulting from the elaboration. With this composition range, 30 the tensile strength of the corresponding area after hot stamping is higher than 1800 MPa.

-Steel having a composition which comprises in %weight : C : 0.15 - 0.25 %, Mn: 0.5 – 1.8 %, Si : 0.1 – 1.25 %, Al : 0.01 – 0.1 %, Cr : 0.1 – 1.0 %, Ti: 0.01-0.1 %, B: 0.001 - 0.004 %, P $\leq$ 0.020 %, S $\leq$ 0.010 %, N $\leq$ 0.010 % and comprising optionally one or more of the following elements, by weight percent: Mo $\leq$ 0.40 %, Nb $\leq$ 0.08 %, Ca $\leq$ 0.1 %, the remainder of the composition being iron and unavoidable impurities resulting from the smelting.

- Steel having a composition which comprises in %weight : C : 0.26 - 0.40 %, Mn: 0.5 – 1.8 %, Si : 0.1 – 1.25 %, Al : 0.01 – 0.1 %, Cr : 0.1 – 1.0 %, Ti: 0.01-0.1 %, B: 0.001 - 0.004 %, P $\leq$ 0.020 %, S $\leq$ 0.010 %, N $\leq$ 0.010 % and comprising optionally one or more of the following elements, by weight percent: Ni $\leq$ 0.5 %, Mo $\leq$ 0.40 %, Nb $\leq$ 0.08 %, Ca $\leq$ 0.1 % the remainder of the composition being iron and unavoidable impurities resulting from the smelting. With this composition range, the tensile strength of the corresponding area after hot stamping is higher than 1350 MPa and the bending angle is higher than 70°.

-Steel having a composition which comprises in %weight : C : 0.2 - 0.34 %, Mn: 0.50 – 1.24 %, Si: 0.5 – 2 %, P $\leq$ 0.020 %, S $\leq$ 0.010 %, N $\leq$ 0.010 %, and comprising optionally one or more of the following elements, by weight percent: Al: $\leq$ 0.2 %, Cr $\leq$ 0.8 %, Nb $\leq$ 0.06 %, Ti $\leq$ 0.06 %, B $\leq$ 0.005%, Mo $\leq$ 0.35%, the remainder of the composition being iron and unavoidable impurities resulting from the smelting. With this composition range, the tensile strength of the corresponding area after hot stamping is equal to or higher than 1000 MPa and the bending angle is higher than 55°.

-Steel having a composition which comprises in %weight : C : 0.13 - 0.4 %, Mn: 0.4 – 4.2 %, Si : 0.1 – 2.5%, Cr $\leq$ 2 %, Mo $\leq$ 0.65 %, Nb $\leq$ 0.1 %, Al $\leq$ 3.0 %, Ti $\leq$ 0.1 %, B $\leq$ 0.005 %, P $\leq$ 0.025 %, S $\leq$ 0.01 %, N $\leq$ 0.01 %, Ni $\leq$ 2.0%, Ca $\leq$ 0.1 %, W $\leq$ 0.30%, V $\leq$ 0.1%, Cu $\leq$ 0.2%, and verifying the following combination: $114 - 68 \cdot C - 18 \cdot Mn + 20 \cdot Si - 56 \cdot Cr - 60 \cdot Ni - 36 \cdot Al + 38 \cdot Mo + 79 \cdot Nb - 17691 \cdot B < 20$, the remainder of the composition being iron and unavoidable impurities resulting from the smelting. For example, this composition is used when hot stamping the part using a multistep process.

-Steel which is coated with an aluminum-based metallic coating. By aluminum based it is meant a coating that comprises at least 50% of aluminum in weight. For example, the metallic coating is an aluminum-based coating comprising 8 – 12% in weight of Si. For example, the metallic coating is applied by dipping the base material in a molten metallic bath. Advantageously, applying an aluminum-based metallic coating avoids the formation of surface scale during the heating step of the hot stamping process, which in turns allows to produce the parts by hot stamping without a subsequent sand blasting operation. Furthermore, the aluminum-based coating also provides corrosion protection to the metallic part while in service, for example on an automotive vehicle.

-Steel which is coated with an aluminum-based metallic coating comprising from 2.0 to 24.0% by weight of zinc, from 1.1 to 12.0% by weight of silicon, optionally from 0 to 8.0% by weight of magnesium, and optionally additional elements chosen from Pb, Ni, Zr, or Hf, the content by weight of each additional element being inferior to 0.3% by weight, the balance being aluminum and optionally unavoidable impurities. Advantageously, this type of metallic coating affords very good corrosion protection on the part, as well as a good surface aspect after hot stamping.

In a specific embodiment, at least one element of the rear structure is made by hot stamping a laser welded blank comprising at least one sub blank having an aluminum based metallic coating and said aluminum coated sub-blanks are prepared before-hand by ablating at least part of the metallic coating on the edges to be welded. Advantageously, this removes part of the aluminum present in the coating, which would pollute the weld seam and deteriorate its mechanical properties.

In a particular embodiment, at least one sub-blank of the blank stack-up comprises at least one area having at least one side topped with an emissivity increasing top layer. Said emissivity increasing top layer is applied on the outermost surface of said sub-blank. Said emissivity increasing top layer allows the surface of said sub blank to have a higher emissivity compared to the same sub-blank which is not coated with said emissivity increasing top layer. Said emissivity increasing top layer can be applied either on the top or the bottom side of a sub-blank. Said emissivity increasing top layer can also be applied on both sides of said sub-blank.

If said sub-blank comprises a metallic coating, such as described previously, the emissivity increasing top layer is applied on top of said metallic coating. Indeed, for the emissivity increasing top layer to increase the emissivity of the surface, it needs to cover the outermost surface of the sub-blank. Advantageously, said emissivity increasing top layer will allow to increase the heating rate of said sub-blank and therefore increase the productivity of the heating step of the hot stamping process. When using several sub blanks of differing thicknesses, said emissivity increasing top layer is advantageously applied to the sub-blanks having the highest thickness in order to decrease the difference in heating time between the different sub-blanks and therefore increase productivity, increase the hot stamping process window and overall allow to obtain a final part having homogeneous surface properties.

The current invention further covers a metallic part on the body of an automotive vehicle corresponding to the above listed features taken alone or according to any possible combinations and manufactured by the above detailed process, including all possible combinations of optional features of said process.

The current invention further covers the use of such a metallic part to assemble an automotive vehicle body.

The current invention further covers an automotive vehicle comprising at least one such metallic part.

CLAIMS

1. Manufacturing process to produce a metallic part (1) by stamping a blank stack-up (10) according to a stamping direction (S),
said metallic part (1) comprising at least:
- 5 -a first sub-part (11) generally extending along a first direction (D1), perpendicular to said stamping direction (S), and comprising at least one first side wall (111), substantially parallel to said stamping direction (S), connected to a first top section (113), generally extending in a plane perpendicular to said stamping direction (S),
- 10 -a second sub-part (12) connected to said first sub-part (11) and generally extending along a second direction (D2), perpendicular to said stamping direction (S) and forming with said first direction (D1) an angle α strictly greater than 0° , comprising at least two vertical walls (121, 122), substantially parallel to said stamping direction (S), and a second top section (123) connecting said two
- 15 vertical walls (121, 122), generally extending in a plane perpendicular to said stamping direction (S),
said blank stack-up (10) comprising at least:
- two sub-blanks (101, 102) each substantially corresponding to said first and second sub-parts (11, 12),
- 20 -at least one overlap area (100) in which said sub-blanks (101, 102) overlap one another,
said manufacturing process comprising at least the steps of:
- providing said at least two metallic sub blanks (101, 102),
 --positioning said at least two metallic sub blanks (101, 102) in a stamping press
- 25 to form a blank stack-up (10) comprising at least an overlap region (100) in which said sub blanks (101, 102) overlap one another,
- performing said stamping operation by pressing said blank stack-up (10) between a punch (2) and a die moving relative to one another in said stamping direction (S), wherein said punch (2) comprises at least one gap (4) in between
- 30 the areas corresponding to said first and second sub-parts (101, 102).

2. Manufacturing process according to claim 1, wherein said first and second directions (D1, D2) along which extend said first and second sub parts form with one another an angle α comprised from 30° to 90°.
- 5 3. Manufacturing process according to claim 2, wherein said first and second directions (D1, D2) along which extend said first and second sub parts form with one another an angle α comprised from 60° to 90°.
4. Manufacturing process according to claim 3, wherein said first and second
10 directions (D1, D2) along which extend said first and second sub parts form with one another an angle α comprised from 80° to 90°.
5. Manufacturing process according to any one of claims 1 to 4, wherein said punch
15 (2) further comprises at least one positioning pin (22) associated to at least one positioning holes (103) in the corresponding area of the sub-blank designed in a way that when feeding said sub-blank to said stamping tool, said at least one positioning hole (103) slides onto said at least one positioning pin (22) to ensure good positioning of said sub-blank.
- 20 6. Manufacturing process according to claim 5, wherein said at least one positioning pin (22) is of substantially conical shape and said at least one positioning hole (103) is of substantially circular shape, the diameter of said hole (103) being substantially the diameter of the base of the positioning pin (22).
- 25 7. Manufacturing process according to any one of claims 1 to 6, wherein said stamping operation is performed by hot stamping.
8. Manufacturing process according to any one of claims 1 to 6, wherein said
30 stamping operation is performed by cold stamping.
9. Manufacturing process according to any one of claims 1 to 7, said overlap region (100) of said blank stack-up (10) further comprises an imbrication area (1005), said imbrication area (1005) comprising itself a tab (1006) projecting from a first

sub-blank and a cavity (1007) in the second sub-blank designed to accommodate said tab (1006) in an interlocked position by the end of the stamping operation.

- 5 10. Manufacturing process according to any one of claims 1 to 9, wherein said overlap area (100) further comprises at least one post-assembly area (1004) in which said first and second sub-parts (11, 12) are still overlapping one another after said stamping operation is performed and wherein said manufacturing process further comprises a post-assembly step after said stamping operation in
10 which at least said first and second sub-parts (11, 12) are joined together in said at least one post-assembly area (1004).
11. Manufacturing process according to claim 10, wherein said post-assembly step is performed by spot welding.
15
12. Manufacturing process according to claim 11, wherein said post-assembly step is performed by laser welding.
13. Manufacturing process according to any one of claims 1 to 12, wherein said
20 stamping operation is followed by a conforming operation using a conforming punch (21) comprising a conforming gap (41) in between the areas corresponding to said first and second sub-parts, said conforming gap (41) being smaller than the gap (4) of the initial stamping tool (2).
- 25 14. Manufacturing process according to any one of claims 1 to 13, wherein said metallic part (1) comprises at least two sub-parts generally (11) extending along said first direction (D1) and each being connected to said at least one second sub-part (12) generally extending along said second direction (D2), wherein said blank stack-up (10) comprises at least three sub-blanks substantially
30 corresponding to each of said sub-parts, said blank stack-up further comprising at least two overlap areas (100) in which each sub-blank (101) extending in a first direction (D1) overlap the sub-blank (102) extending in a second direction (D2).

15. Metallic part (1) manufactured according to any one of claims 1 to 14.
16. Metallic part (1) according to claim 15 comprising at least one set of contiguous
5 sub-parts (11, 12) having at least one set of two contiguous vertical walls (111,
121) wherein the curvature radius measured in the transition area (11T12)
between said two contiguous vertical walls is equal to or less than twenty times
the smallest thickness of said two sub parts.
- 10 17. Metallic part (1) according to claim 15 or 16, designed to be used on the body of
an automotive vehicle.
18. Automotive vehicle comprising at least one metallic part (1) according to claim
17.
- 15

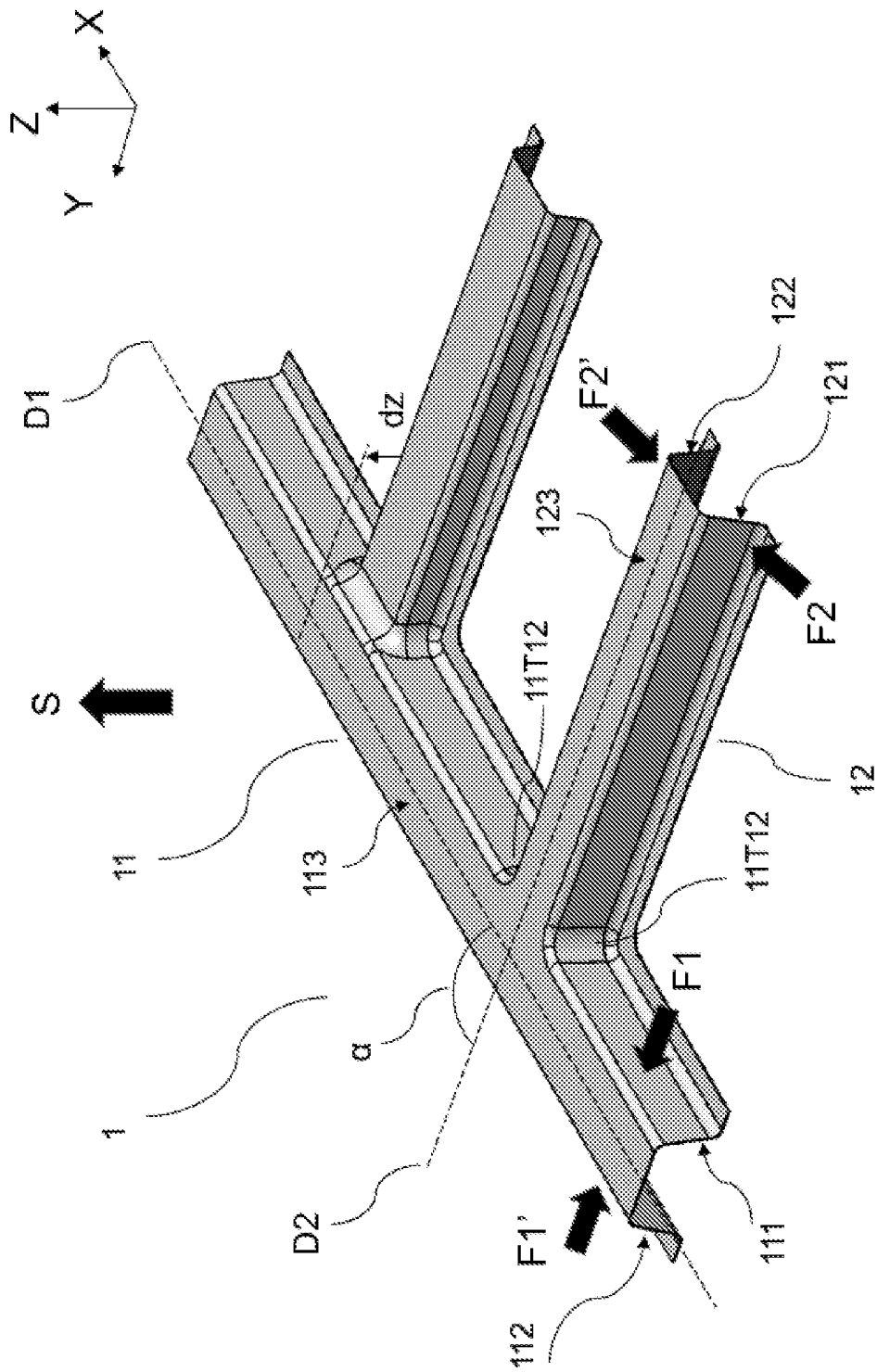


Fig. 1

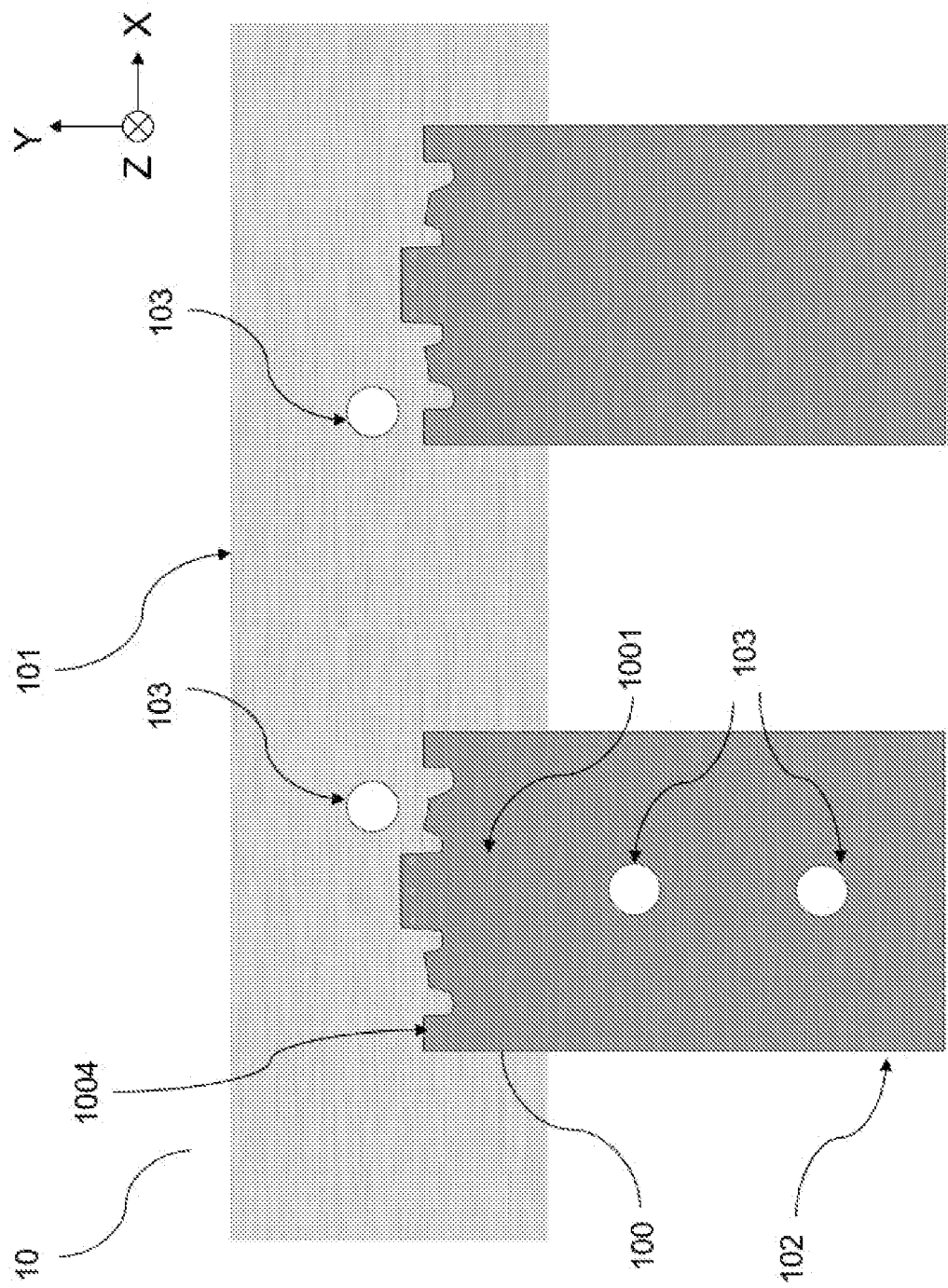


Fig. 2

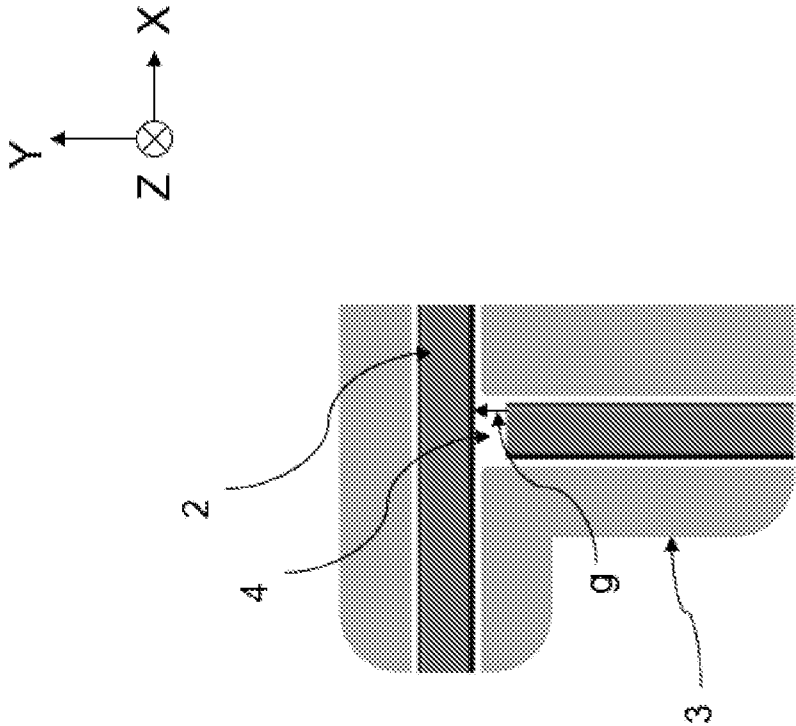


Fig. 3B

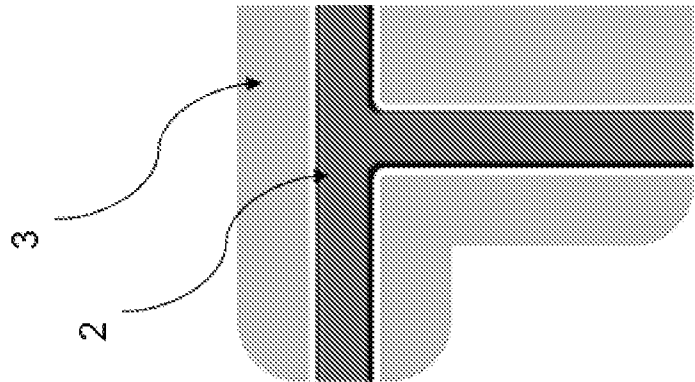


Fig. 3A

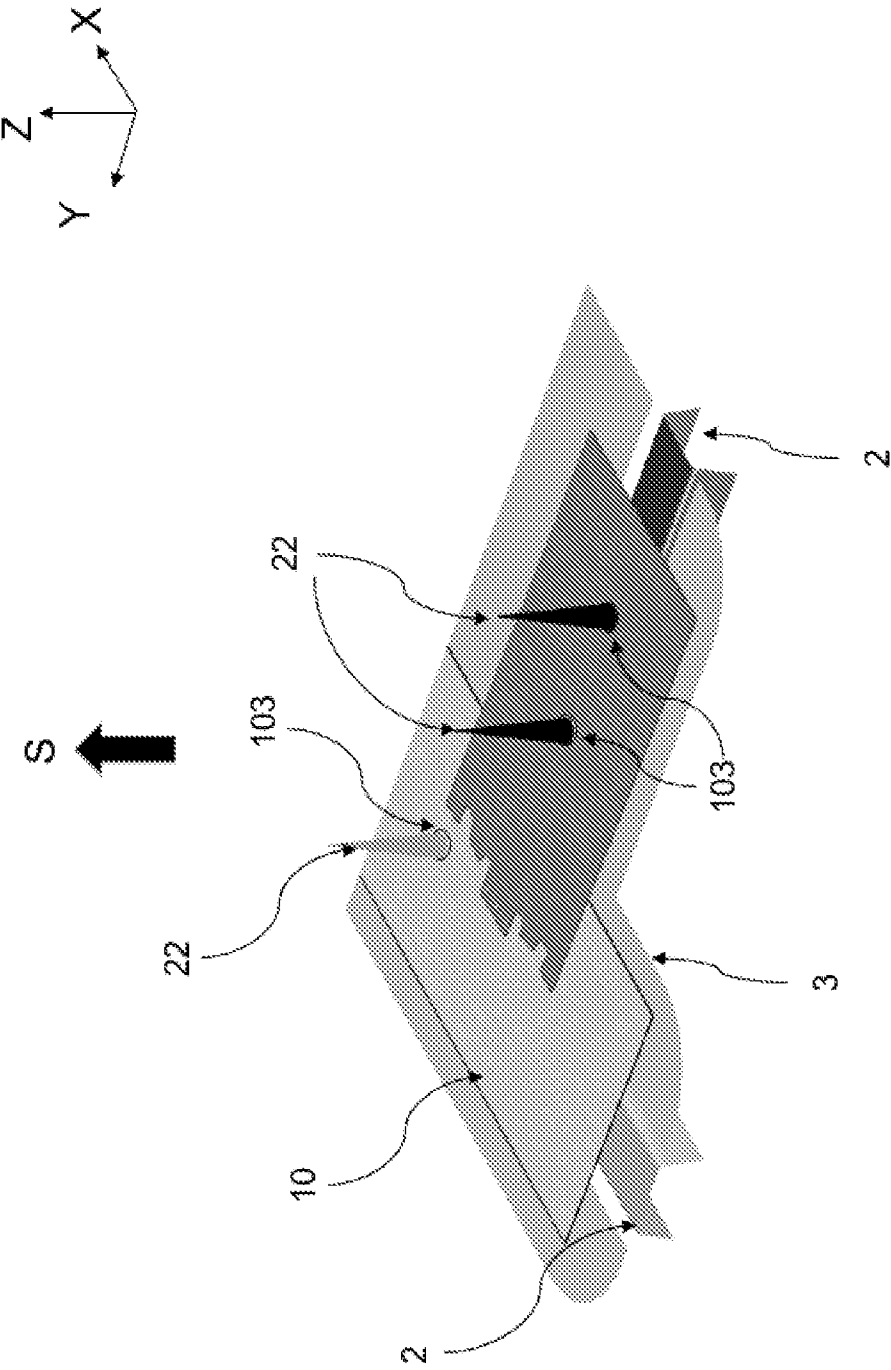


Fig. 4

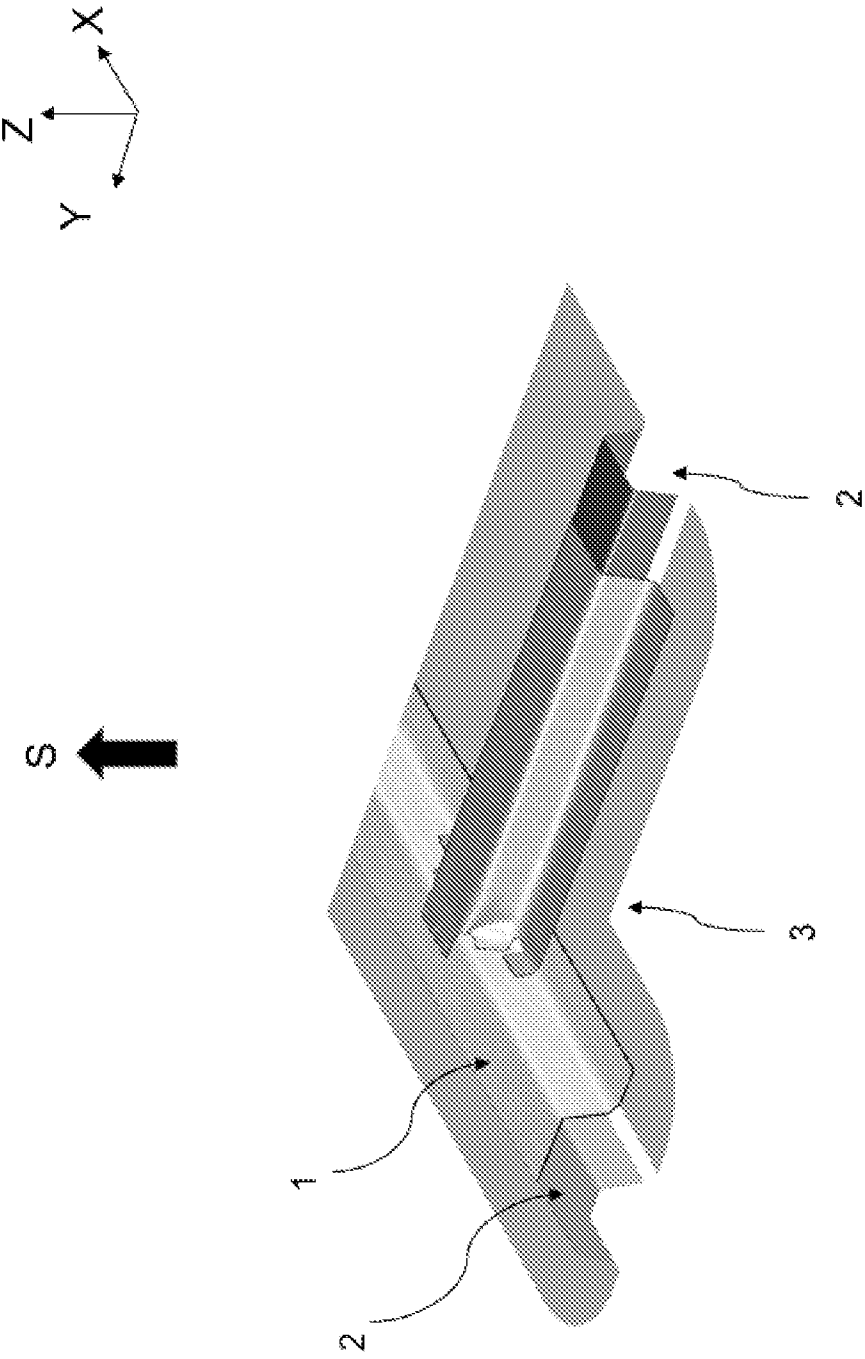


Fig. 5

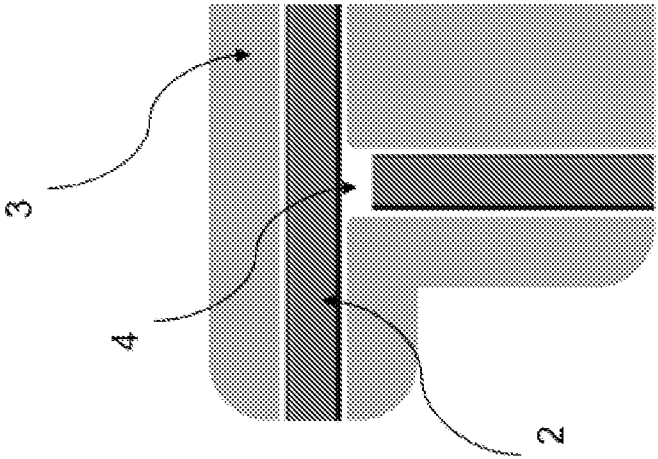
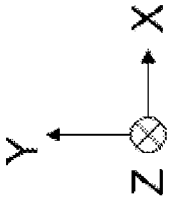


Fig. 6A

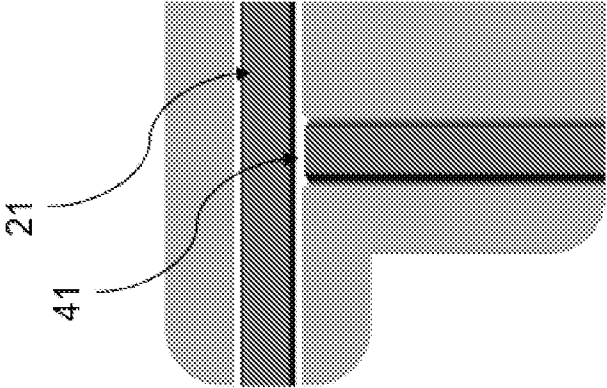


Fig. 6B

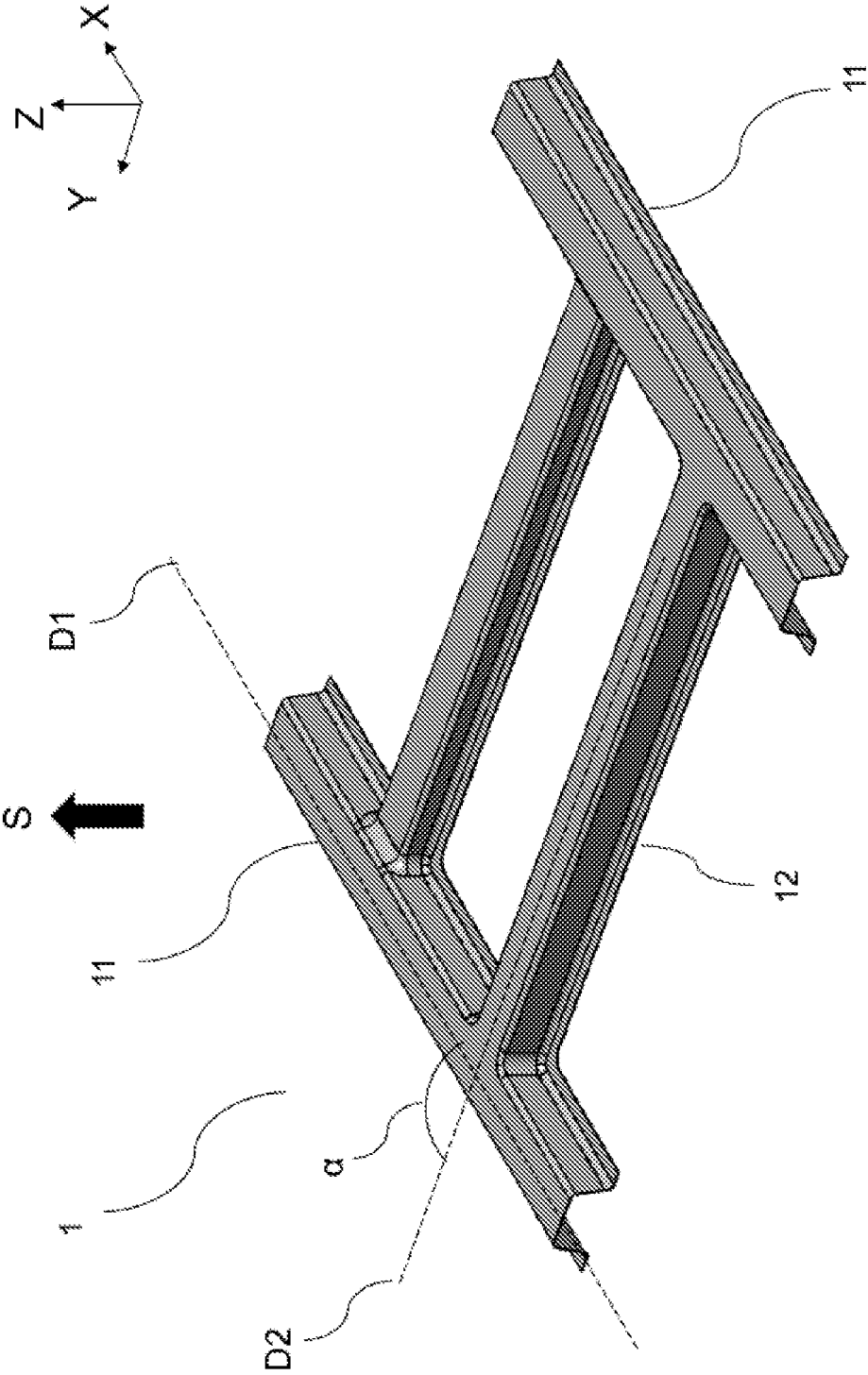


Fig. 7

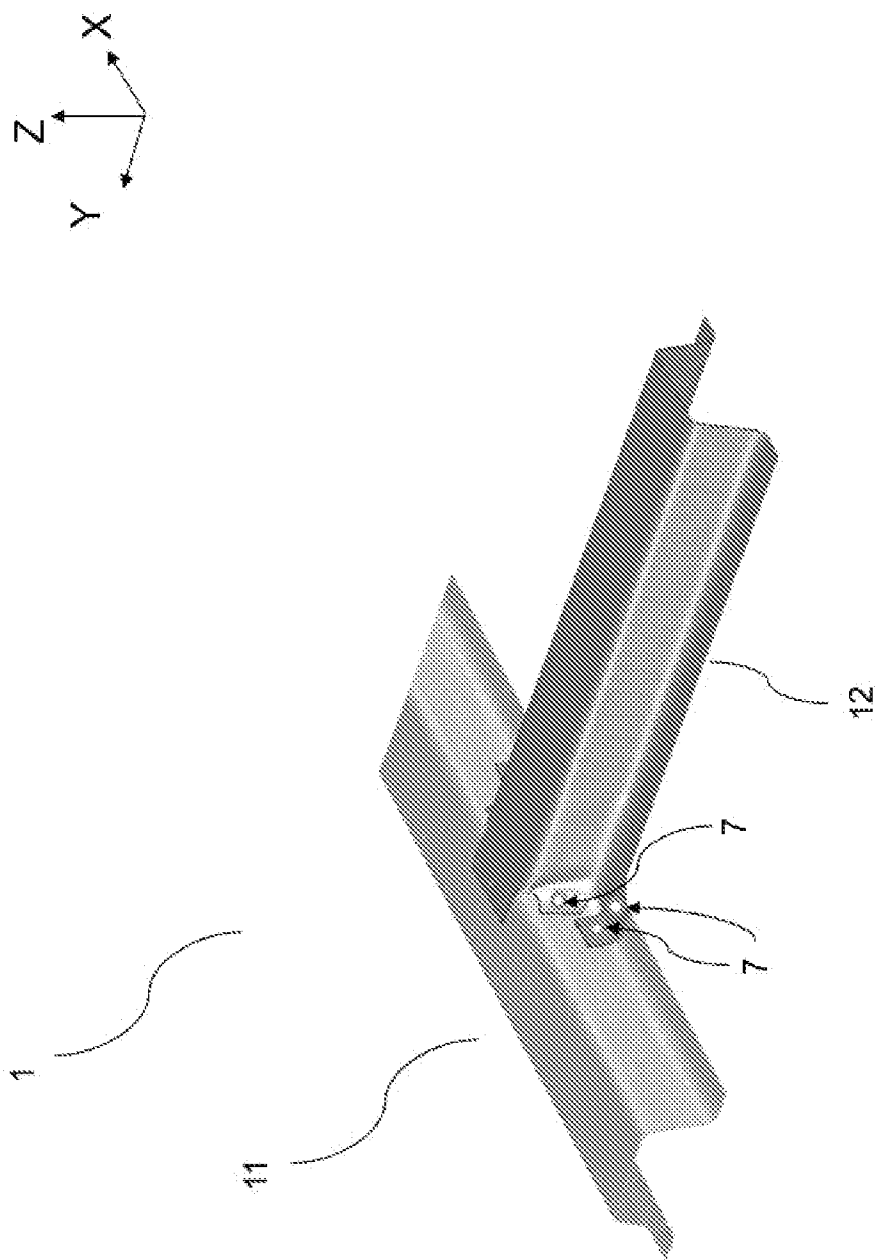


Fig. 8

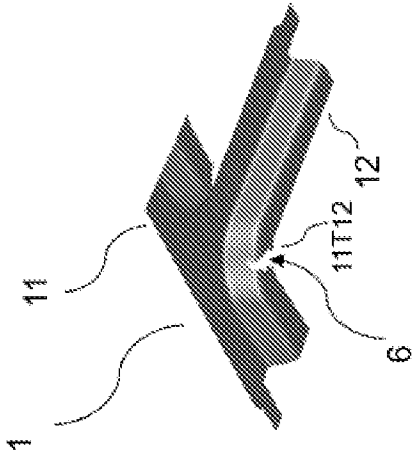
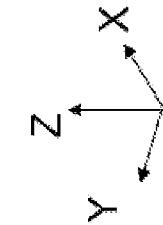


Fig. 9A

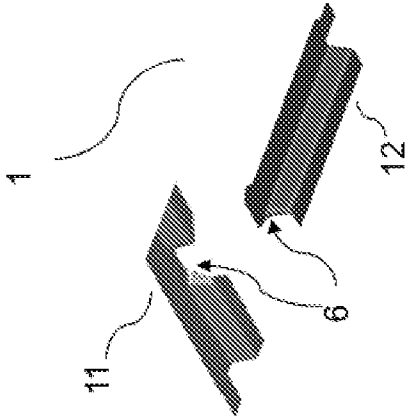


Fig. 9B

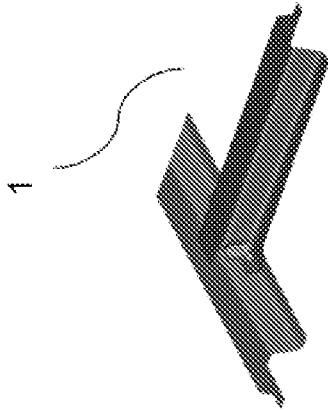


Fig. 9C

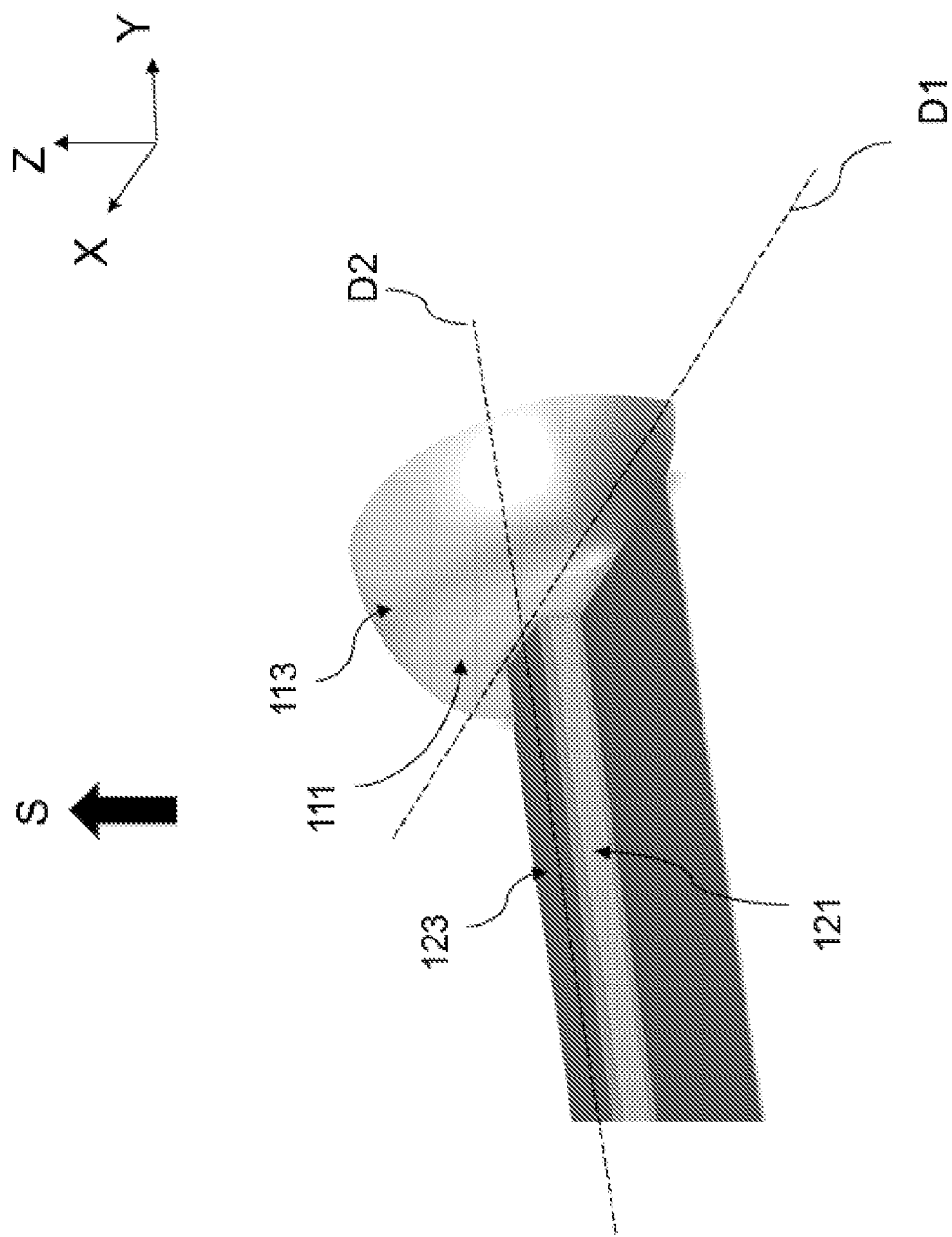


Fig. 10

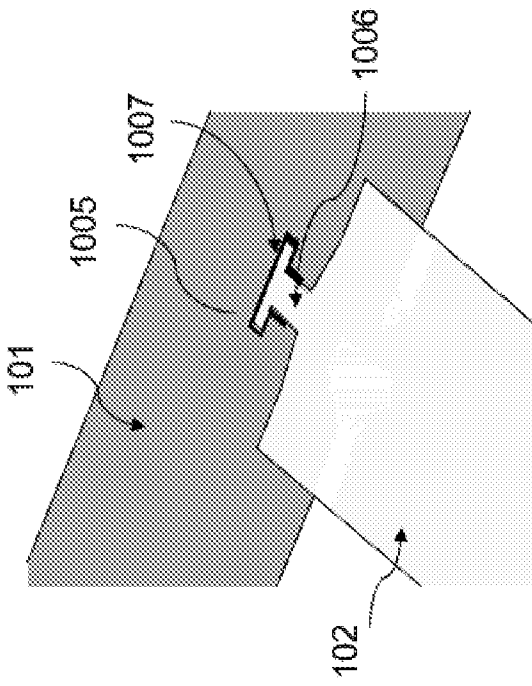


Fig. 11a

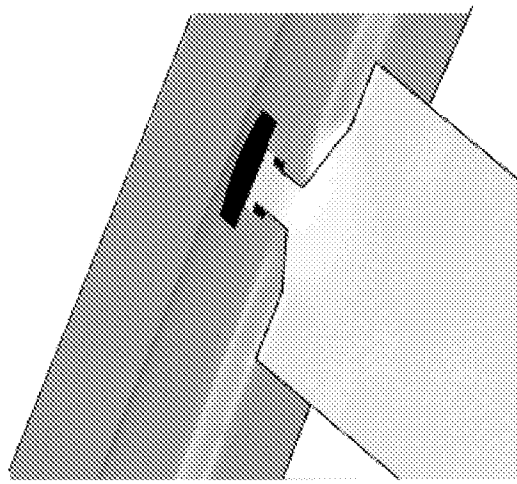


Fig. 11c

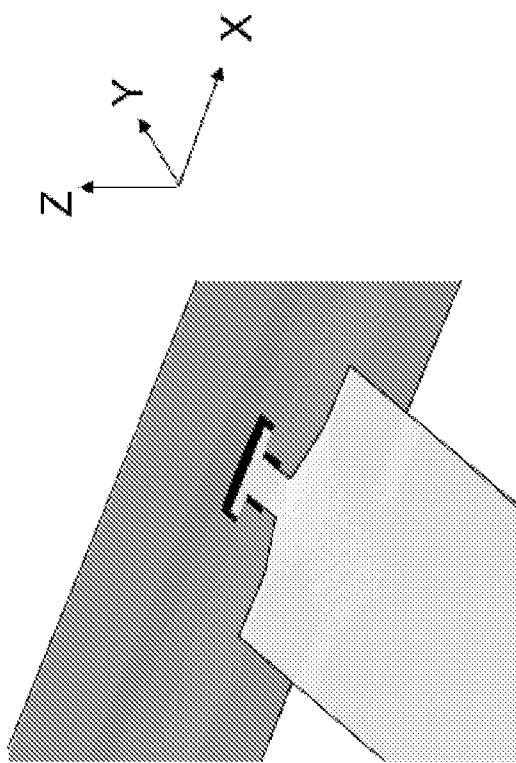


Fig. 11b

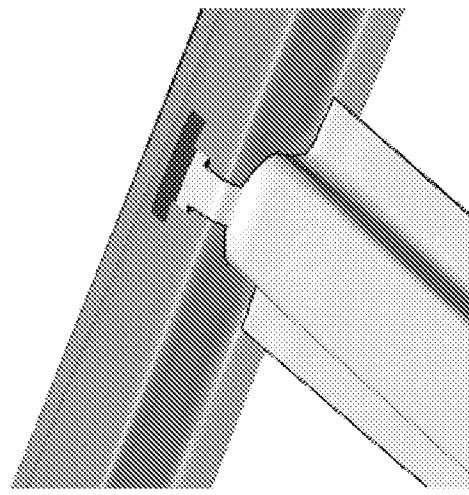


Fig. 11d

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/054982

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	B21D22/02	B21D22/20
	B21D47/04	B21D53/58
	B21D22/26	B21D35/00
	B62D25/00	B62D25/02
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)		
B21D B62D		
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.
X	KR 2023 0065070 A (POSCO CO LTD [KR]) 11 May 2023 (2023-05-11)	1-4, 7-15, 17, 18
Y	paragraphs [0004], [0055], [0059], [0060], [0097] - [0101], [0121]; figures -----	5, 6, 16
Y	KR 2009 0091910 A (SEWON PREC IND CO LTD [KR]) 31 August 2009 (2009-08-31) abstract; figures -----	5, 6
A	JP 2007 029966 A (TOPRE CORP) 8 February 2007 (2007-02-08) cited in the application abstract; figures -----	1-18
A	JP 2014 008508 A (JFE STEEL CORP) 20 January 2014 (2014-01-20) abstract; figures -----	1-18
	----- -/--	
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
20 December 2023		08/01/2024
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 Knecht, Frank

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2023/054982

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP S49 12837 B1 (N.N.) 27 March 1974 (1974-03-27) abstract; figures -----	1-18
X	EP 3 115 281 A1 (NIPPON STEEL & SUMITOMO METAL CORP [JP]) 11 January 2017 (2017-01-11)	15-18
A	paragraphs [0068], [0076]; figure 16 -----	1-14
Y	WO 2023/032953 A1 (NIPPON STEEL CORP [JP]) 9 March 2023 (2023-03-09) paragraphs [0077], [0093], [0107]; figure 1; tables 1-1 -----	16
X	EP 2 823 928 A1 (JFE STEEL CORP [JP]) 14 January 2015 (2015-01-14)	15-18
A	figures -----	1-14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2023/054982

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-15, 17, 18

Manufacturing process to produce a metallic part by stamping a blank stack-up comprising first and second sub-parts, at least one overlap area in which said sub-blanks overlap one another, and pressing the blank stack-up between a punch and a die, wherein said punch comprises at least one gap in between the areas corresponding to said first and second sub-parts.

Metallic part produced by the method of claim 1.

2. claim: 16

Metallic part according to claim 15 comprising at least one set of contiguous sub-parts having at least one set of two contiguous vertical walls wherein the curvature radius measured in the transition area between said two contiguous vertical walls is equal to or less than twenty times the smallest thickness of said two sub parts.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2023/054982

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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