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(54) METHOD AND DEVICE FOR FASTENING AT LEAST TWO METALLIC WORKPIECES

(57) The invention concerns a method for fastening at least two metallic workpieces (1, 2) together by a punch rivet (3) wherein at least one workpiece (1) is heated to an elevated temperature for setting the punch rivet (3).

Further, the invention concerns a device (10) for fastening at least two metallic workpieces (1, 2) together by a punch rivet (3), comprising a die (5), a riveting punch (6), the riveting punch (6) being moveable toward the die (5), a blank holder (7) for holding the workpieces (1, 2) during movement of the riveting punch (6) toward the die (5) for setting the punch rivet (3) to fasten the workpieces (1,2), wherein a heating element (8) is provided for heating at least one of the workpieces (1, 2).

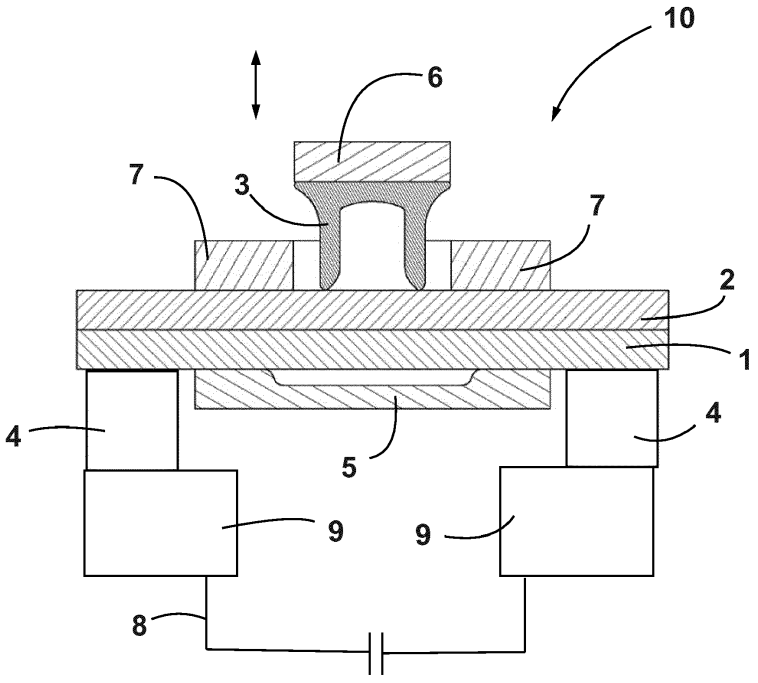

Fig. 1

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Description

[0001] The invention concerns a method for fastening at least two metallic workpieces together by a punch rivet.

[0002] Furthermore, the invention concerns a device for fastening at least two metallic workpieces together by a punch rivet.

[0003] Punch riveting is a joining method which gains increasing importance, in particular in automotive industry. Usually, so called C-rivets are used, for example punch rivets according to EP 0 720 695.

[0004] In automotive industry, punch riveting is in particular used to fasten two or more sheets of metallic workpieces together. Thereby, quality parameters are of course very important. In order to be applicable on the large scale in automotive industry, no significant mechanical and/or aesthetic defects are allowable.

[0005] Traditionally, many parts of automobiles have been made from steel. Today, many efforts are undertaken in order to replace parts of steel by light weight parts made from aluminum or its alloys as well as magnesium and its alloys. However, sheets of heat treated aluminium alloys can show severe cracks after joining by punch riveting. Such cracks are not admissible for quality reasons.

[0006] An object of the invention is to provide a method for fastening at least two metallic workpieces together by a punch rivet which allows fastening workpieces from sheets of heat treated aluminium alloys and other alloys which are difficult to fasten by punch riveting without significant appearance of cracks in the fastening region.

[0007] A further object of the invention is to provide a device for a corresponding method.

[0008] According to the invention, a method for fastening at least two metallic workpieces together by a punch rivet is provided wherein at least one workpiece is heated to an elevated temperature for setting the punch rivet.

[0009] According to the invention, at least one of the workpieces to be fastened is heated to an elevated temperature for setting the punch rivet. Thereby, the at least one workpiece can be heated only before setting the punch rivet so that the punch rivet is set at a still elevated temperature during the setting of the punch rivet. However, it is also possible to begin the heating before setting the punch rivet and to continue the heating during setting of the punch rivet. In any case, heating of the at least one workpiece leads, in comparison with room temperature, to a higher ductility of the at least one workpiece which is made of a metal or an alloy. This, in turn, allows providing connected workpieces which are free from cracks in the fastening region. This is one of the quality criterions for parts used in automotive industry.

[0010] As metallic workpieces are to be fastened, the workpieces will be in conductive contact at least during the riveting process. Therefore, it is sufficient to heat at least only one workpiece to an elevated temperature for setting the punch rivet. For example, a lower workpiece can be heated to a desired temperature for setting the punch rivet whereas an upper workpiece receives heating indirectly by contact with the lower workpiece.

[0011] Heating only one workpiece of the workpieces to be connected is, hence, principally sufficient. However, if short cycle times are desired, it is advantageously to heat all workpieces to be connected simultaneously. This allows faster reaching of temperature conditions within the workpieces for a setting of a punch rivet.

[0012] The method according to the invention can be applied to parts of any shape. Preferably, the parts to be connected are sheets, for example sheets with a thickness between 0.1 mm and 5.0 mm.

[0013] The at least one workpiece can be heated with any conventional heating means, for example an oven or a gas burner. However, in order to exactly control a temperature for setting the punch rivet, the at least one workpiece is preferably heated electrically. An electrical heating generally allows a very exact temperature control within the workpieces to be fastened.

[0014] For electrical heating, the at least one workpiece is contacted by electrodes. The electrodes can be made from any material. Preferably, the electrodes are copper electrodes. By contacting the at least one workpiece with electrodes and by applying a voltage, the at least one workpiece is heated as a resistance heater.

[0015] In a further embodiment of the invention, the temperature of the least one workpiece is set to a temperature of 100°C to 250°C, in particular 120°C to 180°C, preferably 130°C to 160°C. In particular for aluminium alloys a temperature of at least 100°C is necessary in order to achieve a good ductility for setting a punch rivet. Temperatures higher than 200°C are not useful as the ductility would be too large. Preferred temperature regions are within 120°C to 180°C, in particular 130°C to 160°C.

[0016] A method according to the invention can be applied to all metallic materials regardless whether steel, aluminium and its alloys or other light weight metals and its alloys like magnesium and its alloys. Preferable, the method is applied to sheets made from heat treated aluminium alloys which are otherwise difficult to fasten with punch rivets without cracks developing.

[0017] In a further aspect, the invention provides a device for fastening at least two metallic workpieces together by a punch rivet, comprising a die, a riveting punch, the riveting punch being moveable toward the die, a blank holder for holding the workpieces during movement of the riveting punch toward the die for setting the punch rivet to fasten the workpieces, wherein a heating element is provided for heating at least one of the workpieces.

[0018] A device according to the invention allows to heat metallic workpieces to be fastened by a punch rivet before and, if applicable, during setting of the rivet. Due to the heating of at least one workpiece, it is possible to produce in particular connected sheets of heat treated aluminium alloys which are at least almost free of cracks in the fastening region.

[0019] Preferably, the heating element is an electrical

heating element. The heating element can comprise copper electrodes for contacting at least one workpiece. The copper electrodes are then part of an electrical circuit so that the workpiece to be heated can be supplied with a voltage. This leads to a heating of the at least one workpiece.

[0020] If copper electrodes are provided, preferably also copper blocks are provided which are in contact with the copper electrodes. Copper is a relatively good electrical conductor. However, the current intensity and current flow needed to heat at least one metallic workpiece made from aluminium alloy would lead to an overheating of the copper electrodes. Therefore, copper blocks are provided which reduce local heating of the electrodes. In this respect, the device can also comprise a cooling circuit wherein the copper blocks are coolable by the cooling circuit. In this variant, very high current densities and current flows are possible which leads to high heating rates for the at least one workpiece to be heated. On the other hand, the electrodes withstand very high current intensities during heating of the at least one workpiece.

[0021] Despite the copper electrodes being in contact with coolable copper blocks, the electrodes may wear in the course of time. Therefore, the copper electrodes are exchangeable.

[0022] In the following, the invention is further illustrated in an example. Thereby, reference is made to the enclosed drawing. In the drawing show:

Fig. 1 a	device according to the invention;
Fig. 2a and 2b	dies;
Fig. 3a and 3b	sheets of aluminium alloys fastened at room temperature;
Fig. 4a to 4d	sheets of aluminium alloy fastened at 150°C;
Fig. 5a to 5d	sheets of aluminium alloy fastened at 150°C.

[0023] In Fig. 1, a device 10 for punch riveting is depicted. The device 10 comprises a die 5 and a riveting punch 6. The riveting punch 6 is movable up and down as indicated by the arrow in Fig. 1. The device 10 further comprises two or more electrodes 4 for which are made from copper or another high conducting material. Copper, however, is the preferred choice for the electrodes 4. The electrodes 4 are connected to one or more copper blocks 9. The copper blocks 9, in turn, are connected to a cooling circuit (not depicted). In particular, the copper blocks 9 are structured so that water can pass through internal channels of the copper blocks 9. However, it is also possible that the copper blocks 9 are cooled by simply winding some loops of a flexible tube around the copper blocks 9 so that cooling is achieved in this way. Moreover, the copper blocks 9 may alternatively also be connected indirectly or directly to a cooling circuit. In any case, the copper blocks 9 can be cooled by a further element of the device 10.

[0024] For fastening two or more workpieces 1, 2 like sheets of an aluminium alloy, the same are positioned between the die 5 and the riveting punch 6. The riveting punch 6 carries a punch rivet 3. In order to hold the workpieces 1, 2 in position during the fastening process, the workpieces 1, 2 are hold by a blank holder 7. Before the riveting punch 6 is lowered in order to place the punch rivet 3 within the workpieces 1, 2, a lower workpiece 1 is heated by a heating element 8. The heating element 8 comprises the copper electrodes 4. As shown in Fig. 1, the lower workpiece 1 is placed on the die so that simultaneously the electrodes 4 are conducted. However, the electrodes could also be flexible so that the electrodes 4 are positioned on a lateral side of the lower workpiece 1. It is also possible that the electrodes 4 are clamping element which clamp both workpieces 1, 2 so that both workpieces 1, 2 are electrically conducted.

[0025] For setting the punch rivet 3, first at least the lower workpiece 1 is heated by the heating element 8 with the electrodes 4. The lower workpiece 1 is heated by resistance heating. The heating is continued at least until the riveting punch 6 is lowered. Although not necessary, the heating can also be continued during the fastening process. However, usually that is not necessary as the riveting process is much faster than a temperature loss of the workpieces 1, 2. As can be seen in Fig. 1, the workpieces 1, 2 to be fastened are in close contact with each other before the riveting process. As both workpieces 1, 2 are made of a metallic material, i.e., a metal or alloys, the upper workpiece 2 will also be heated even when only the lower workpiece 1 is contacted with the electrodes 4. In this manner, the workpieces 1, 2 are heated to suited temperatures. Suited temperatures for later setting of the punch rivet 3. For aluminium alloys which are heat treated, suitable temperatures are in the temperature region 100°C to 200°C. In particular suited temperatures lie between 130°C and 180°C.

[0026] For achieving the necessary temperature increase before and, if applicable, during the rivet setting process, a power source is provided for the electrodes 4. The power source can operate with up do 14V direct current and a current of to 10 kA. Due to the high current intensities, the copper blocks 9 are water cooled so that the device 10 operates despite very high current densities.

[0027] In Fig. 2a and 2b typical dies 5 are shown which were used in order for a punch rivet fastening of workpieces 1, 2 without and with heating. The dies 5 are commercially available from Böllhoff GmbH. Fig. 2a depicts a so called PZ geometry; Fig. 2b depicts a so called FM geometry.

[0028] All punch riveting experiments were performed by using sheets of an aluminium alloy. The aluminium alloy was of the grade EN AW 7075 T6. This alloy was chosen because this alloy is setting the highest demands for mechanical joining.

[0029] In Fig. 3a and 3b photographs of a top view of two workpieces 1, 2 of an aluminium alloy EN AW 7076 T6 are shown. The workpieces 1, 2 where fastened by a

C-rivet at room temperature. As clearly visible, independent of the die 5, in both cases cracks are observed. This is the case for the FM geometry (Fig. 3a) as well as PZ geometry (Fig. 3b).

[0030] In Fig. 4 to 4d corresponding photographs are shown for workpieces 1, 2 of the same material but fastened at the temperature at 140°C (fig. 4a, 4b) and 150°C (Fig. 4c, 4d) with the FM geometry. In Fig. 5a to 5d analogous results are shown for the PZ geometry also at 140°C (Fig. 5a, 5b) and 150°C (Fig. 5c, 5d). Independent of the geometry, in both cases no cracks are observed. This clearly indicated that fastening of the workpieces 1, 2 with a so called C-rivet at the temperature of about 140°C to 160°C leads to a crack free connection of the workpieces 1, 2.

[0031] According to the invention, the temperature for the setting process can be adapted for the workpieces 1, 2 to be fastened in order to achieve an optimum ductility during the setting process. Therefore, the number of possible combinations of rivets and workpieces 1, 2 to be fastened is significantly increased.

Claims

1. Method for fastening at least two metallic workpieces (1, 2) together by a punch rivet (3) wherein at least one workpiece (1) is heated to an elevated temperature for setting the punch rivet (3).

2. Method according to claim 1 wherein the at least two workpieces (1, 2) are heated to an elevated temperature.

3. Method according claim 1 or 2 wherein the at least two workpieces (1, 2) are sheets.

4. Method according to one of claims 1 to 3 wherein the at least one workpiece (1) is heated electrically.

5. Method according to claim 4 wherein the at least one workpiece (1) is contacted by electrodes (4).

6. Method according to claim 5 wherein the electrodes are copper electrodes (4).

7. Method according to one of claims 1 to 6 wherein the temperature of at least one workpiece (1) is set to a temperature of 100°C to 250°C, in particular 120°C to 180°C, preferably 130°C to 160°C.

8. Method according to one of claims 1 to 7 wherein the at least two workpieces (1, 2) are each made of an aluminum alloy.

9. Device (10) for fastening at least two metallic workpieces (1, 2) together by a punch rivet (3), comprising a die (5), a riveting punch (6), the riveting punch (6) being moveable toward the die (5), a blank holder (7) for holding the workpieces (1, 2) during movement of the riveting punch (6) toward the die (5) for setting the punch rivet (3) to fasten the workpieces (1, 2), wherein a heating element (8) is provided for heating at least one of the workpieces (1, 2).

10. Device (10) according to claim 9 wherein the heating element (4) is an electrical heating element (4).

11. Device (10) according to claim 9 or 10 wherein the heating element (4) comprises copper electrodes (4) for contacting at least one workpiece (1).

12. Device (10) according to claim 11 wherein copper blocks (9) are provided, the copper blocks (9) being in contact with the copper electrodes (4).

13. Device according to claim 12 further comprising a cooling circuit wherein the copper blocks (9) are coolable by the cooling circuit.

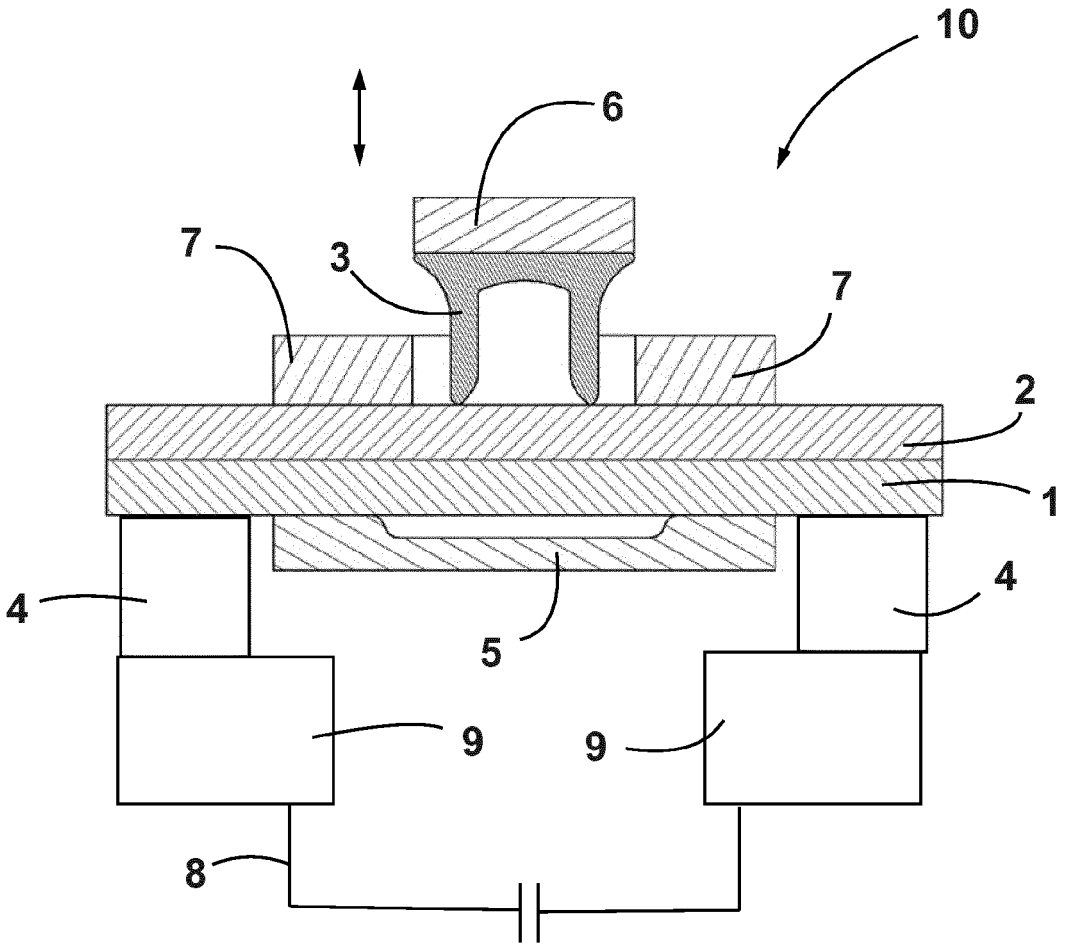

Fig. 1

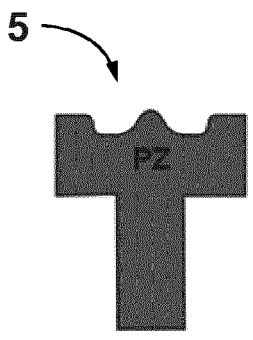

Fig. 2a

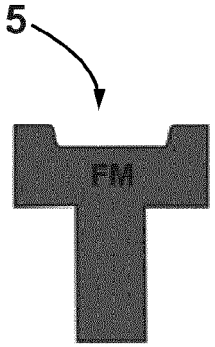

Fig. 2b

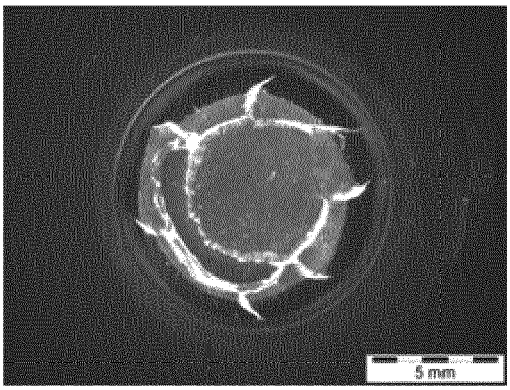

Fig. 3a

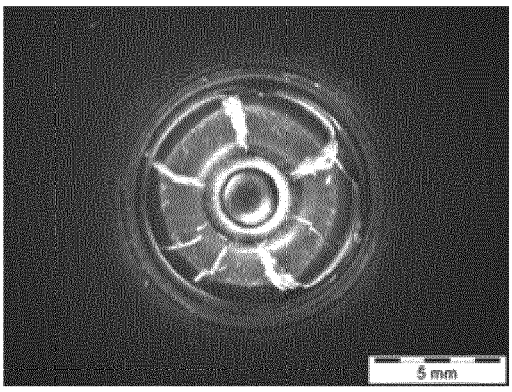

Fig. 3b

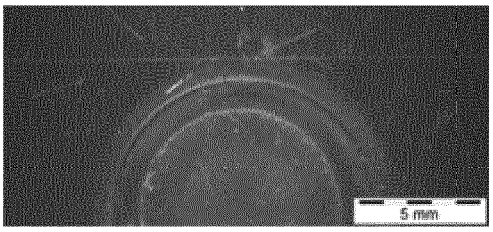

Fig. 4a

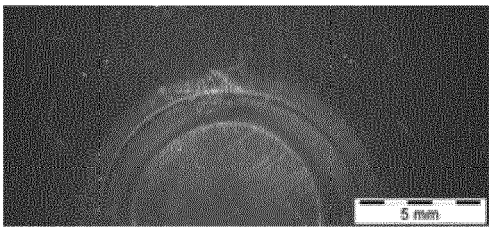

Fig. 4c

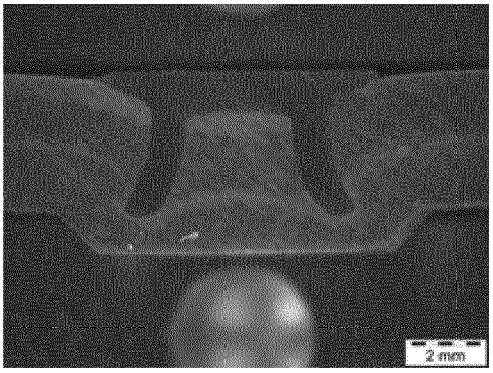

Fig. 4b

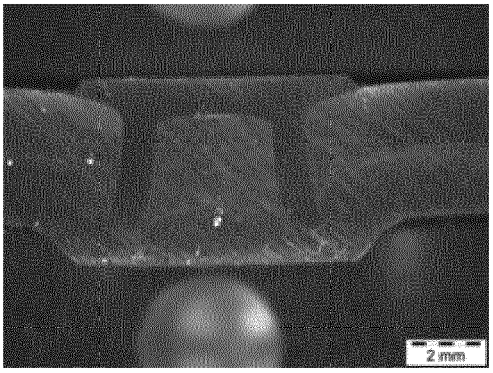

Fig. 4d

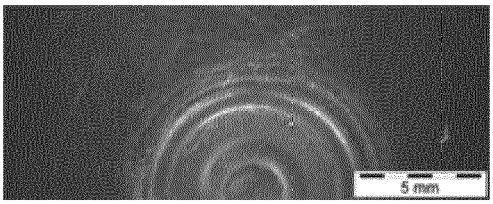

Fig. 5a

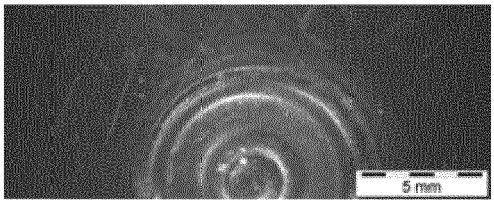

Fig. 5c

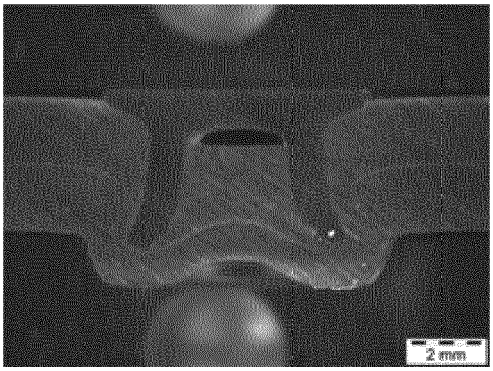

Fig. 5b

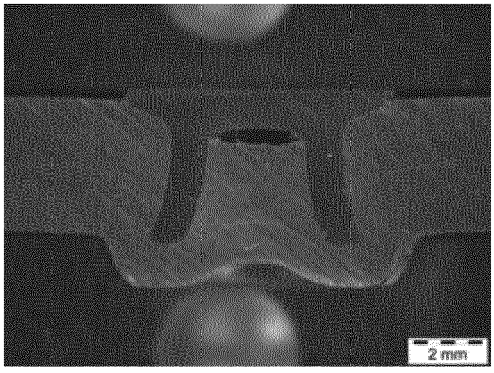

Fig. 5d

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 6971

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2003/167621 A1 (WANG PEI-CHUNG [US] ET AL) 11 September 2003 (2003-09-11) * paragraphs [0003], [0004], [0014], [0026]; figures *	1-6,8-11	INV. B21J15/02 B21J15/08 B21J15/10
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TECHNICAL FIELDS SEARCHED (IPC)

B21J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 June 2017	Charvet, Pierre

CATEGORY OF CITED DOCUMENTS

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