(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 520 454 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.03.2025 Bulletin 2025/11

(21) Application number: **23196228.3**

(22) Date of filing: **08.09.2023**

(51) International Patent Classification (IPC):
B21J 15/02 *(2006.01)* ***B21J 15/08*** *(2006.01)*
B21J 15/26 *(2006.01)* ***B21J 15/28*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B21J 15/025; B21J 15/08; B21J 15/26; B21J 15/285

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(71) Applicant: **Newfrey LLC**
New Britain, CT 06053 (US)

(72) Inventors:
- **DEMIRCIOGLU, Orhan**
  35394 Gießen (DE)
- **REIS, Christian**
  35394 Gießen (DE)
- **SARTISSON, Vadim**
  35394 Gießen (DE)
- **WOLOWIEC, Sabrina**
  35394 Gießen (DE)

(74) Representative: **SBD IPAdmin**
270 Bath Road
Slough, Berkshire SL1 4DX (GB)

(54) **JOINING DEVICE WITH CLAMPING DEVICE AND JOINING METHOD**

(57) Joining method for joining at least two workpieces with a joining device (10) for joining workpieces comprising a joining head having:
- a retaining device (14) for a joining element (20) and by means of which the joining element can be guided along or arranged on a joining axis (X),
- a punch (16) with which a setting movement of the joining element can be executed, the punch being movable along the joining axis by a first drive unit (18), and
- a clamping device (22) with which one or more workpieces can be compressed in a joining direction,
wherein the clamping device (22) is movable through a second drive unit (24) different from the first drive unit (18).

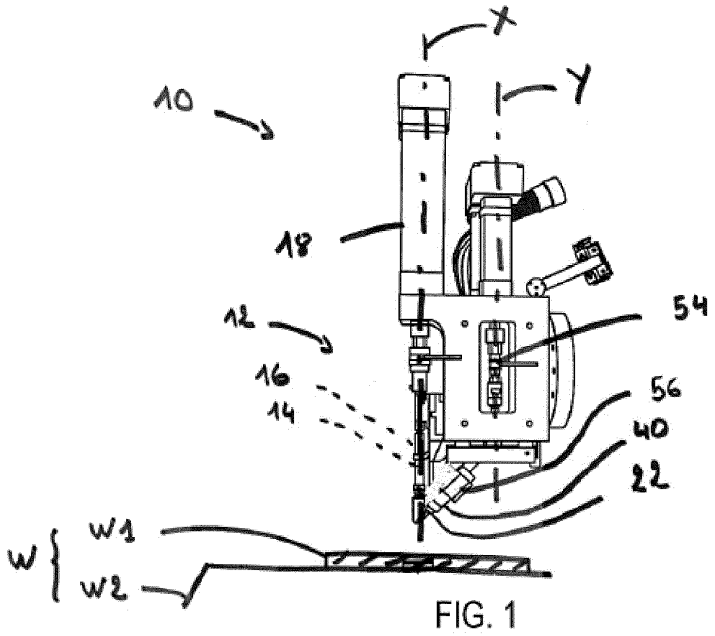


FIG. 1

EP 4 520 454 A1

Description

[0001] The present disclosure relates to a joining device, in particular a joining device adapted to join a workpiece arrangement (for instance at least two sheet or workpieces arranged one above the other) with a joining element and without pre-formed (for example pre-drilled or pre-punched) hole or holes in the component prior to the joining comprising a clamping device. The present invention also relates to a process for joining a workpiece arrangement.

[0002] Joining methods and joining devices of the above-mentioned kind are widely known, especially in the field of punch riveting or direct screwing ... and are used for example in automotive engineering.

[0003] It is known to use during a mechanical joining process a joining device with a punch with which a setting movement can be executed and a clamping device. The clamping device ensures different functions such as pressing together the members of a workpiece arrangement to avoid any gap between the workpieces, avoiding or influencing a possible displacement of adhesive between the workpieces, reducing the workpiece deformation during the joining process.

[0004] Document DE 10 2005 031 917 A1 discloses a method for joining in which, in a first step, a main piston and a clamping device are pressed against the workpieces with a comparatively low force, so that the workpieces are held immovably in contact with one another and with a die.

[0005] Document CH689299 discloses a joining device comprising a clamping device with a probe for checking the position of a rivet or a workpiece.

[0006] Document DE102017106449 for instance discloses a joining device with a hydraulic system and comprising a punch with which a linear, nonrotating setting movement can be executed, a clamping device with which one or more components can be compressed in a joining direction, and with a drive unit that operates in at least two steps with which the punch and the clamping device can be moved by one motor and several gearboxes.

[0007] DE102012019809A1 discloses a method for punch riveting two sheets arranged one above the other on a base of a punch riveting device, between which an adhesive is introduced. The joining device to perform the method comprises a C-frame with a die, a punch and a clamping device. An electric motor is arranged to drive the punch and the clamping device.

[0008] The mechanical joining processes known normally use a spring-loaded, hydraulic or pneumatic clamping device. The clamping force profile of the clamping device is either estimated considering the spring characteristics or is a constant with hydraulic and pneumatic systems. The entire force applied to the workpiece arrangement by the joining device is formed by the addition of the clamping force and the force generated by the punch. For joining device allowing a one-sided joining process, the entire force acts on the robot supporting the joining device and/or the workpiece arrangement, which leads to a need to provide a robust equipment which is cumbersome, expensive and requires large space. For double-sided joining (like for instance the self-piercing riveting), the entire force leads to the bending of the C-frames used. Such bending causes lateral and angular offsets and has an impact on the joint quality. Larger robots or equipment to avoid these drawbacks are costly, requires space and provide a lower agility.

[0009] An object of the present invention is therefore to provide a joining device which is flexible, compact and a joining method by means of which the joining process can be better controlled and hence performed more effectively.

[0010] Accordingly, the present invention provides a joining device according to claim 1 and a joining method according to claim 13. More particularly, the joining device for joining workpieces comprises a joining head having:

- a retaining device for a joining element and by means of which the joining element can be guided along or arranged on a joining axis,
- a punch with which a setting movement of the joining element can be executed, the punch being movable along the joining axis by a first drive unit,
- a clamping device with which one or more workpieces can be compressed in a joining direction,

wherein the clamping device is movable through a second drive unit different from the first drive unit.

[0011] The addition of a second drive unit to control the clamping device allows the clamping device to be controlled independently or depending on the punch. The clamping device can be controlled and/or monitored on force and/ordisplacement, and in addition with possible with time-delay. The clamping device can apply, during the setting steps of the joining element with the punch different clamping forces to or displacement with regard to the workpieces. The clamping device can be eventually rigidly attached to the second drive unit (without stiffness-reducing measures such as springs or dampers), and thus a precise displacement or force can be applied, without corrective measures. The addition of another drive unit in a joining device is always regarded as a problem, since it increases the weight of the device and complicates the control command. However, in the present case, when a dedicated drive unit is connected to the clamping device, it reduces the space requirements, the price and the weight of the holding parts supporting the joining device. Indeed, thanks to this second drive unit connected to the clamping device, the holding parts of the joining device (robot arms, ...) can be downsized without decreasing the performance of the joining device. Besides, the joining time can be reduced due to a better flexibility for the motion of the punch and the clamping device during the setting steps. Finally, such joining

device, with an independently controlled clamping device can be used to join several different materials and workpieces, and notably brittle cast materials.

[0012] In an embodiment, the second drive unit is a servo-electric drive with a spindle. The servo-electric drive is lightweight, and easy to control. No need of hydraulic or pneumatic connection.. In an embodiment, the first drive unit is a servo-electric drive with a spindle. Alternatively, the first and/or second drive unit could also be a hydraulic and/or pneumatic and/or electric drive unit. A linear or a rotational drive unit may also be considered

[0013] In an embodiment, the second drive unit moves the clamping device along a clamping axis, the clamping axis being parallel to but not confluent with the joining axis. In other words, the clamping axis extends parallel to the joining axis at a non-zero distance. This improves the flexibility for the motion of the clamping device with regard to the retaining device of the punch. The clamping force is still applied at the or in the vicinity of the joining point.

[0014] In an embodiment, the second drive unit is oriented at an angle with regard to the first drive unit, the angle being between 0 and 90 degrees. The compacity or space requirement of the joining device can thus be improved.

[0015] In an embodiment, a thermal device is arranged on the clamping device and moves together with the clamping device. In an embodiment, the thermal device can be a plasma torch, or a laser heating system, and induction heating system, an electric arc or similar. Thus, the joining device may be used to perform a thermally assisted joining process such as a plasma joining or a joining process with plasma cleaning.

[0016] In an embodiment, the clamping device comprises a surface detection unit adapted to detect a surface of the workpiece. The clamping device thus performs several functions. The surface detection can be done with or without contact. For instance, a laser distance measurement can be realized, an inductive or capacitive sensor can also be used. A mechanical contact measurement can equally be implemented. The surface detection of the workpiece may help to determine the best joining parameters (displacements, ...) during the setting step or eventually detect possible mistakes (absence of a workpiece).

[0017] In an embodiment, the joining device is adapted to measure a temperature.

[0018] In an embodiment, the clamping device comprises a hollow cylindrical clamp adapted to be arranged around the punch and the retaining device. Thus, the clamping device does not interfere with the punch or the retaining device but acts on the workpiece area to be joined directly. In an alternative embodiment, the clamping device comprises a clamp having a C-shaped cross-section or a U-shaped cross-section. For instance, the clamping device or clamp is in two parts with a first part having a C or U-shape in cross-section and a second part being cylindrical and hollow. The first part being adapted to face the workpiece arrangement. The second part being adapted to be connected to the rest of the joining device.

[0019] In an embodiment, the clamp has an external diameter between 10 and 30 millimeters. This allows a precise clamping area portion without interfering with the punch or the retaining device. Alternatively, the clamping device may, in cross-section, have a C-shape, have a U-shape, have a ring-shape with apertures or slots arranged at different angles, or be parallelepipedal or be composed of two or more parallelepipeds. In other embodiments, clamping pins or rods may be used. For instance, one, two, three or more clamping pins may be used. The shape of the clamp may be variable along its length. For instance, the three or more pins may be connected to a ring.

[0020] In an embodiment, the joining device comprises a load measurement system. For example, the load measurement system is a load cell. The load measurement system may be integrated within the joining device or more particularly the clamping device (internal system) or may be external. The load cell measures the clamping force and thus an exact control and command of the clamping force profile can be done. In another embodiment, the clamping force measurement could be realized via the motor current or by installing a central load cell for both joining and the clamping axis. The punch may also comprises its own load measurement system.

[0021] The present invention is also directed to a joining method for joining at least two workpieces with a joining device comprising the following steps of:

- providing a workpiece arrangement comprising an upper workpiece surface and a lower workpiece surface,
- providing a joining device as above-described, the joining device being arranged at a non-zero distance above the workpiece arrangement,
- moving the clamping device along the clamping axis until the clamping device contacts the upper workpiece surface,
- applying a first pre-determined clamping force,
- applying a second pre-determined clamping force,
- setting a joining element within the workpiece arrangement by moving the punch along the setting device to move the joining element into the workpiece arrangement.

[0022] Such method allows a better control of the joining process. For instance, the clamping device can apply a high first pre-determined clamping force to the workpiece, to close any gap which might be present between the workpiece or, during a thermally assisted joining process to optimize the heat transfer between the first and the second workpiece. Due to the design of two axis (clamping axis and joining axis), the clamping force may thus be decreased, and may even thus be cancelled) by the setting force on a need basis and replaced by the setting force. Depending on the process parameters,

materials to be joined and joining element, the setting of the clamping force and setting force may be freely implemented.

[0023] In an embodiment, the clamping device comprises a sensor unit providing force, displacement and time data. In an embodiment, clamping force profile and clamping device displacement profile and/or clamping force profile and joining element displacement profile and/or clamping force and time profile are recorded. All data or values in relation to force or displacement can thus be evaluated. Such data can be used by a control unit to determine the best joining parameter.

[0024] The invention and its advantages will be better understood from the reading of the following description, given by way of example only and with reference to the accompanying drawings, of which:

Fig. 1 shows a perspective view of a joining device according to the invention with a clamping dive, a punch and a retaining device;
Fig. 2A and Fig. 2B show a perspective view of a cylindrical clamp comprised in the clamping device of a joining device according to the invention;
Fig. 3shows sectional view of the front end of a joining device according to the invention;
Fig. 4A to Fig. 4G show different possible steps of a joining process according to the invention with, for each step, the corresponding clamping force profile;
Fig. 5A to Fig. 5G show different possible embodiments in cross section of a clamping device of a joining device according to the invention.

[0025] The embodiments of the disclosure will be best understood by reference to the drawings, wherein the same reference signs designate identical or similar elements. It will be readily understood that the components of the disclosed embodiments, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following detailed description of the embodiments of the systems and methods of the disclosure is not intended to limit the scope of the disclosure, as claimed, but is merely representative of possible embodiments of the disclosure.

[0026] Fig. 1 shows a perspective view of a joining device 10. The joining device 10 is adapted to carry out a method for joining a workpiece arrangement W comprising at least a first and a second workpiece W1, W2 (or sheet) arranged one above the other, together with a joining element. The joining device comprises a joining head 12, which can be moved freely in the space by means of a robot (not represented). Eventually, as an alternative, the joining device can be fixed to a structure and the workpieces to be joined moved toward the joining device when needed. Said joining head 12 being for instance mounted on one arm of the robot. The joining device 10 or joining head 12 comprises retaining device 14, a punch 16 and a first drive unit 18. The retaining device 14, punch 16 and first drive unit 18 are arranged longitudinally extending along a joining axis X.

[0027] The retaining device 14 is adapted to retain a joining element 20. The joining element 20 may, for example, be a pin, a screw, a rivet, ... More particularly the joining element 20 may be similar or substantially similar to the joining element described in EP22165638.2 from the applicant. The retaining device 14 guides or arranged the joining element 20 along the joining axis X. The punch 16 is adapted to drive or actuate the joining element 20 toward the workpiece arrangement W in order to carry out the joining. The retaining device 14 and the punch 16 may be both arranged coaxially to the joining axis X. The punch 16 may be adapted to penetrate the retaining device 14 in order to drive the joining element 20 toward and into the workpiece arrangement W. The punch 16 allows a setting movement of the joining element 20. Notably, the punch 16 allows a linear setting movement. The punch 16 is movable along the joining axis X by the first drive unit 18. The first drive unit 18 is an operating module comprising a motor, notably a servo motor or a servo drive adapted to move to a specific position, speed or torque based on an input signal from a controller. The first drive unit 18 controls the punch 16 along the joining axis X. In other embodiments, the first drive unit 18 could also be a hydraulic and/or pneumatic and/or electric drive unit. A linear or a rotational drive unit may also be considered.

[0028] The joining device 10 further comprises a clamping device 22 adapted to compress or press the workpiece arrangement in the joining direction. The clamping device 22 is movable and controlled by a second drive unit 24. The second drive unit 24 is different from the first drive unit 18. For instance, the second drive unit may be less powerful than the first drive unit 18. In other embodiments, depending on the joining process, the second drive unit and the first drive unit may be similar drive units with similar power. The second drive unit 24 comprises a servo-electric drive and thus the clamping device 22 is controlled by its own servo-electric drive. In a possible alternative embodiment, the second drive unit 24 could also be a hydraulic and/or pneumatic and/or electric drive unit. A linear or a rotational drive unit may also be considered. The second drive unit 24 moves and control the clamping device 22 along a clamping axis Y. In a first embodiment, the clamping axis Y may be parallel to the joining axis X, but extending from said joining axis at a non-zero distance. In a second embodiment, the clamping axis Y may be coaxial with the joining axis (in such case, for example the first and second drive unit may be arranged one above the other or concentric with each other with for instance a hollow motor). The first drive unit may be arranged with an angle with regard to the second drive unit 24. The angle may be between 0 and 90 degrees. In an embodiment, the clamping device may be driven by its own robot. In such case, for instance a command can be sent from a control command to the robot controlling the clamping device. The robot executes

the command and carries out the clamping process independently from the rest of the joining device and setting equipment. Then, the setting process with the first drive and the punch can be started (for instance a signal may be sent by the robot to start the setting process or an integrated system may automatically send a command to start the setting process of the joining element). The setting and clamping steps may also occur simultaneously.

[0029] A control command can control the first and second drive unit 18, 24 independently and/ or dependently of each other depending on the requirements of the joining process.

[0030] The clamping device 22 may comprise a clamp 26. Different shapes of clamps are possible, as depicted in Fig. 5A to Fig. 5G. For instance, as depicted in Fig. 5C (but also in Fig. 2A and Fig. 2B), the clamp 26 may have a portion forming a U-shape in sectional view. The clamp has an outside diameter between 10 and 30 mm. The clamp 26 defines a recess and the joining element 20 is adapted to be moved within the recess for its setting. More particularly, the punch 16 and at least a portion of the retaining device 14 can be guided inside the recess. As depicted in Fig. 2A and Fig. 2B, the clamping device or clamp is in two parts with a first part having a C or U-shape in cross-section and a second part, directly connected to the first part, being cylindrical and hollow. The clamp may also be a hollow cylindrical clamp 26', as visible in Fig. 5A. In another embodiment, the clamp 26" may have a C-shape in a cross-sectional view, as shown in Fig. 5B. The clamp 26‴ may also be curved in cross-section view, as visible in Fig. 5D or be composed by two curved parts defining a recess as visible in the clamp $26^{(4)}$ of Fig. 5E. In another embodiment, a straight pin can also be implemented as a clamp $26^{(5)}$ as depicted in Fig. 5F or two straight posts $26^{(6)}$ as visible in Fig. 5G defining an area in which the joining element 20 can be moved to be set by the punch..

[0031] The clamp 26, 26', 26", 26'", $26^{(4)}$, $26^{(5)}$, $26^{(6)}$ extends longitudinally between the first end 28 and the second end 30 along the joining axis X. A chamfer may be arranged at the first end 28. The first end 28 comprises a contact surface 32 adapted to contact the workpiece arrangement W. The clamp 26, 26', 26", 26'", $26^{(4)}$, $26^{(5)}$, $26^{(6)}$may comprise on its lateral side a window 34. On the second end 30, an attachment portion 38 for the attachment of the hollow cylindrical clamp 26 to the rest of the clamping device 22 is arranged.

[0032] In all the embodiments of Fig. 5A to Fig. 5G, the attachment portion 38 extends from the clamp 26, 26', 26", 26'", $26^{(4)}$, $26^{(5)}$, $26^{(6)}$ to the rest of the clamping device. As better seen in Fig. 3, the attachment portion may at least partially extend parallel to the joining axis X at a non-zero distance from the outer surface of the clamp, in order to avoid any interference with the punch or the retaining device.

[0033] The clamping device 22 may comprise a surface detection unit 40 adapted to detect an upper surface of the workpiece arrangement W. The surface detection unit 40 may comprise a laser adapted to measure without contact the distance from the workpiece, or a capacitive sensor or an inductive sensor or any other contactless proximity sensor. Alternatively, the surface detection unit 40 may comprise a device for a mechanical or touch measurement for tactile surface recognition. The surface detection may be realized with or without additional component.

[0034] The clamping device 22 may comprise a load measurement system or an integrated load cell 54 adapted to directly measure the clamping force F applied by the clamping device 22 to the workpiece arrangement W. The load measurement system 54 will measure the clamping force and send it to a control unit to monitor and/or control the correct implementation of the setting steps (better described below).

[0035] The clamping device 22 comprises a recess or a portion adapted to receive or connect a thermal device 56 directly to the clamping device. In other words, the thermal device is arranged on the clamping device. The thermal device 56 is for instance a plasma torch. The plasma torch will thermally assist the joining process. Patent publication EP3515632A1 from the applicant explains for instance how the plasma torch may assist the joining process. In other embodiments, the thermal device may be a laser heating system, and induction heating system, an electric arc or similar equipment.

[0036] Fig. 4A to Fig. 4G shows the different possible step of a joining method according to the present invention. A clamping force (F) vs. time (t) curve is associated with each schematic representation of the various process steps.

[0037] In a first step, visible in Fig. 4A, the joining device 10 is arranged (for instance by the robot mentioned above) above the workpiece arrangement W. The joining device 10 does not contact the workpiece arrangement W. The workpiece arrangement comprises at least two workpieces (or sheets) W1, W2 arranged one above the other. In other embodiments, more than two workpieces may be used. The workpieces may be made in high strength material or brittle cast material or extrusion material. Optionally, an adhesive is provided between the two workpieces.

[0038] In a second step, the clamping device 22 is moved toward the workpiece arrangement W until it contacts the upper surface of the workpiece arrangement (see Fig. 4B). The upper surface may be recognized by the surface detection unit 40 described above, which can be realized via a function integrated in the already existing parts or which can be an additional component. For instance, a resistance force signal may be sent to a controller to determine the contact with the upper surface of the workpiece. If the joining process is thermally assisted by a plasma torch for instance, the plasma torch 56 may heat the workpiece arrangement, as schematically visible in Fig. 4B.

[0039] A gap (not represented) between the work-

pieces may be detected by the clamping device 22 by the analysis of the force/time or force/displacement profile of the clamping device, notably though the load measurement system or load cell. In the case where a gap is detected, the clamping device 22 is controlled by a control unit to close the gap by applying for instance a greater clamping force (see for instance fig. 4C). In an alternative embodiment, such gap may also be already closed by the initial pre-determined clamping force. Any adhesive retained into the gap is thus displaced to the side.

[0040] A first pre-determined clamping force F1 is then applied to the workpiece arrangement W(see Fig. 4D). In Fig. 4D, the clamping force vs. time curve shows a rather important first pre-determined clamping force F1. In case of a thermally assisted joining process, a great clamping force may be advantageous for allowing heat transmission between the first workpiece and the at least second workpiece. In another alternative, the clamping force may remain very limited in order to avoid or limit heat transmission between two workpieces.

[0041] In Fig. 4E, the clamping force F is reduced to prevent the heat transfer to the lower workpiece. An excess of heat in the upper workpiece compared to the lower workpiece takes place. By varying the clamping force in the setting process, the heat flow between the workpieces can be specifically controlled. For example, when the clamping force is reduced, the entire force (comprising the clamping and the setting force) is reduced. When the clamping force is reduced, during a thermally assisted joining process, the upper workpiece can be heated and the heat transmission of the upper workpiece to the lower workpiece is reduced, such that for instance in case of an upper workpiece in high strength steel, the strength of the material or the flow stress is locally reduced which allows to reduce as well the setting force.

[0042] In Fig. 4F, the clamping force F reaches a second pre-determined clamping force F2 corresponding to the setting step. As soon as the clamping force reaches the second pre-determined value, the joining element 20 can be set by the punch 16 within the workpiece arrangement W. The joining element 20 may also be set before. The joining element 20 is pressed through the at least two workpieces W1, W2 with a determined setting force. The effort applied during the setting step to the joining equipment corresponds to the addition of the setting force and the clamping force. The clamping force during the setting step may be controlled at a lower of higher level depending on the setting parameters. It is to be noted that the setting force may also be reduced by the thermal device, as described in more details in EP3515632A1.

[0043] In a last step, the clamping device 22 is moved back to an exit position (see Fig. 4G). By recording the force/displacement or force/time profile, conclusions can be drawn about a possible spring back of the workpieces after setting.

joining device 10
workpiece arrangement W
a first and a second workpiece W1, W2
joining head 12
retaining device 14
punch 16
first drive unit 18
joining axis X
joining element 20
clamping device 22
second drive unit 24
clamping axis Y
clamp 26, 26', 26", 26'", $26^{(4)}$, $26^{(5)}$, $26^{(6)}$
first end 28
second end 30
contact surface 32
window 34
attachment portion 38
surface detection unit 40
sensor unit 42 (temperature)
load measurement system or load cell 54
clamping force F
thermal device 56
first pre-determined clamping force F1
second pre-determined clamping force F2

Claims

1. Joining device (10) for joining workpieces comprising a joining head having:

- a retaining device (14) for a joining element (20) and by means of which the joining element can be guided along or arranged on a joining axis (X),
- a punch (16) with which a setting movement of the joining element can be executed, the punch being movable along the joining axis by a first drive unit (18),

and

- a clamping device (22) with which one or more workpieces can be compressed in a joining direction,

Characterized in that the clamping device (22) is movable through a second drive unit (24).

2. Joining device (10) according to claim 1, wherein the second drive unit (24) is a servo-electric drive with a spindle,.

3. Joining device (10) according to claim 1 or 2, wherein the second drive unit (24) moves the clamping device (22) along a clamping axis (Y), the clamping axis being parallel to but not confluent with the joining axis

'X).

4. Joining device (10) according to claim 1 or 2, wherein the second drive unit (24) is oriented with regard to the first drive unit (18) at an angle between 0 and 90 degrees.

5. Joining device (10) according to any of the preceding claims, wherein a thermal device (56) is arranged on the clamping device and moves together with the clamping device.

6. Joining device (10) according to any of the preceding claims, wherein the thermal device is a plasma torch.

7. Joining device (10) according to any of the preceding claims, wherein the clamping device comprises a surface detection unit (40) adapted to detect a surface of the workpiece.

8. Joining device (10) according to any of the preceding claims, wherein the first drive unit is a servo-electric drive with a spindle.

9. Joining device (10) according to any of the preceding claims, wherein the clamping device comprises a U-shaped clamp (26) adapted to be arranged around the punch and the retaining device.

10. Joining device (10) according to claim 9, wherein the clamp (26) has an external diameter between 10 and 30 millimeters.

11. Joining device (10) according to any of the preceding claims, wherein the clamping device (22) comprises an integrated load measurement system (54).

12. Joining method for joining at least two workpieces with a joining device comprising the following steps of:

- providing a workpiece arrangement (W) comprising an upper workpiece and a lower workpiece,
- providing a joining device (10) according to any of claims 1 to 11, the joining device being arranged at a non-zero distance above the workpiece arrangement, the joining device being loaded with a joining element;
- moving the clamping device (22) along the clamping axis until the clamping device contacts the upper workpiece surface,
- applying a first pre-determined clamping force (F1),
- setting a joining element (20) within the workpiece arrangement by moving the punch and/or the retaining device along the setting device to move the joining element into the workpiece arrangement.

13. Joining method according to claim 12, wherein the clamping device (22) comprises a sensor unit providing force, displacement and time data.

14. Joining method according to claim 12 or claim 13, wherein clamping force profile and clamping device displacement profile and/or clamping force profile and joining element displacement profile and/or clamping force and time profile are recorded.

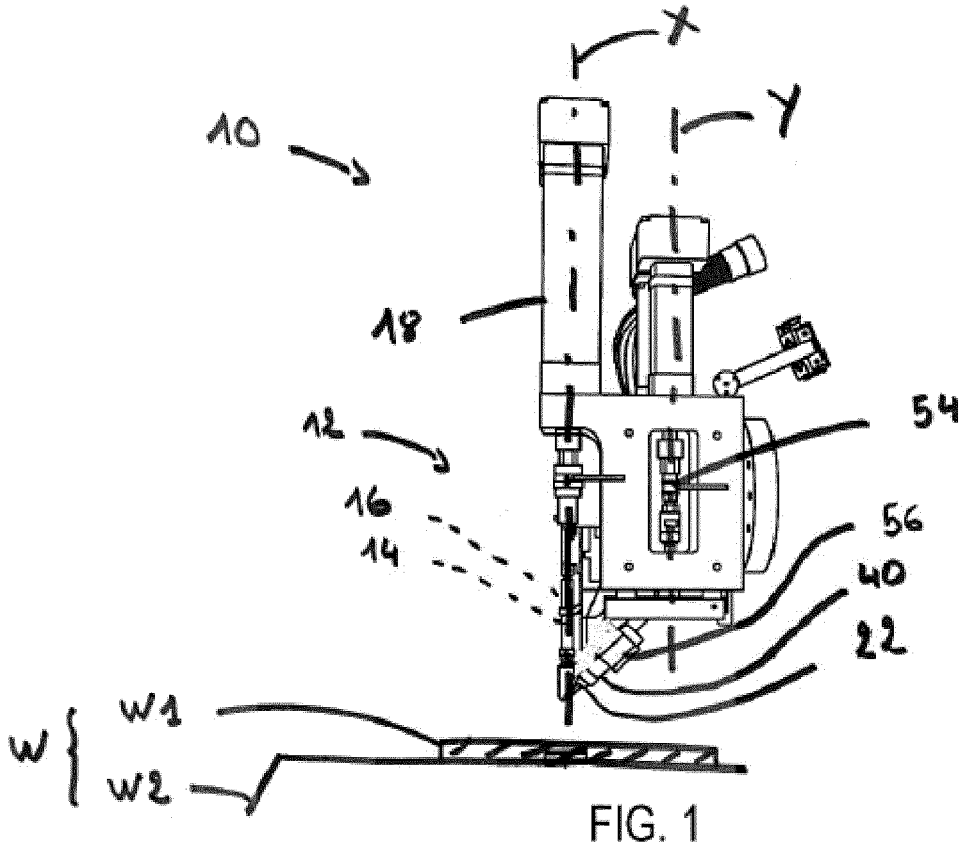


FIG. 1

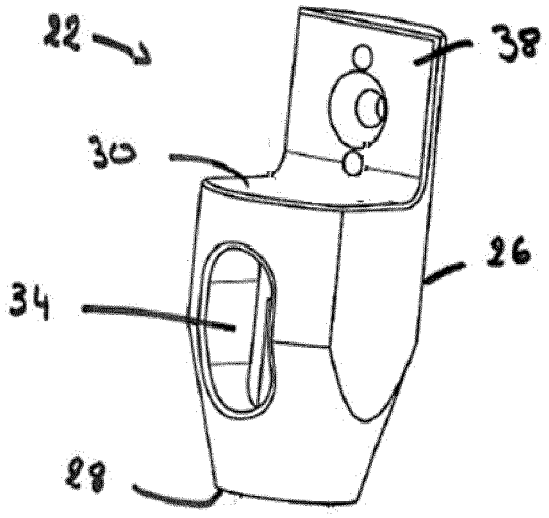


FIG. 2A

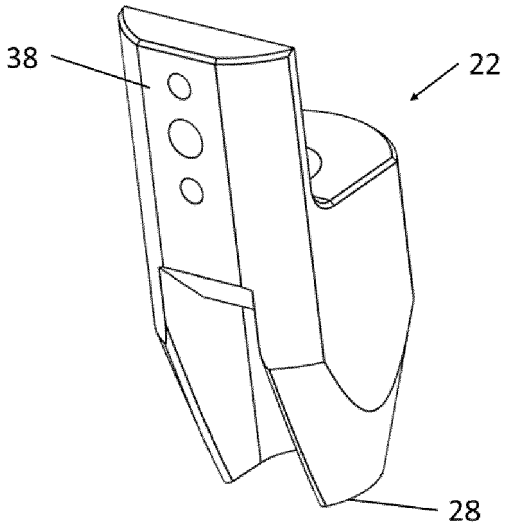


Fig. 2B

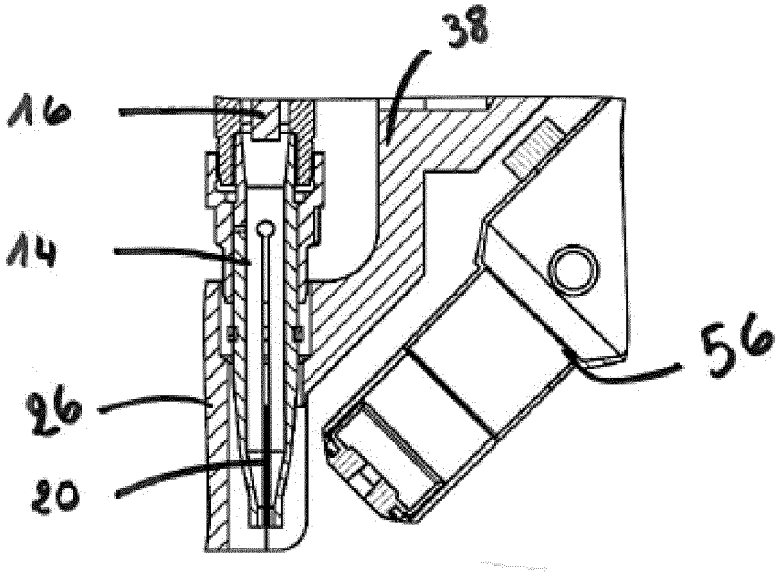
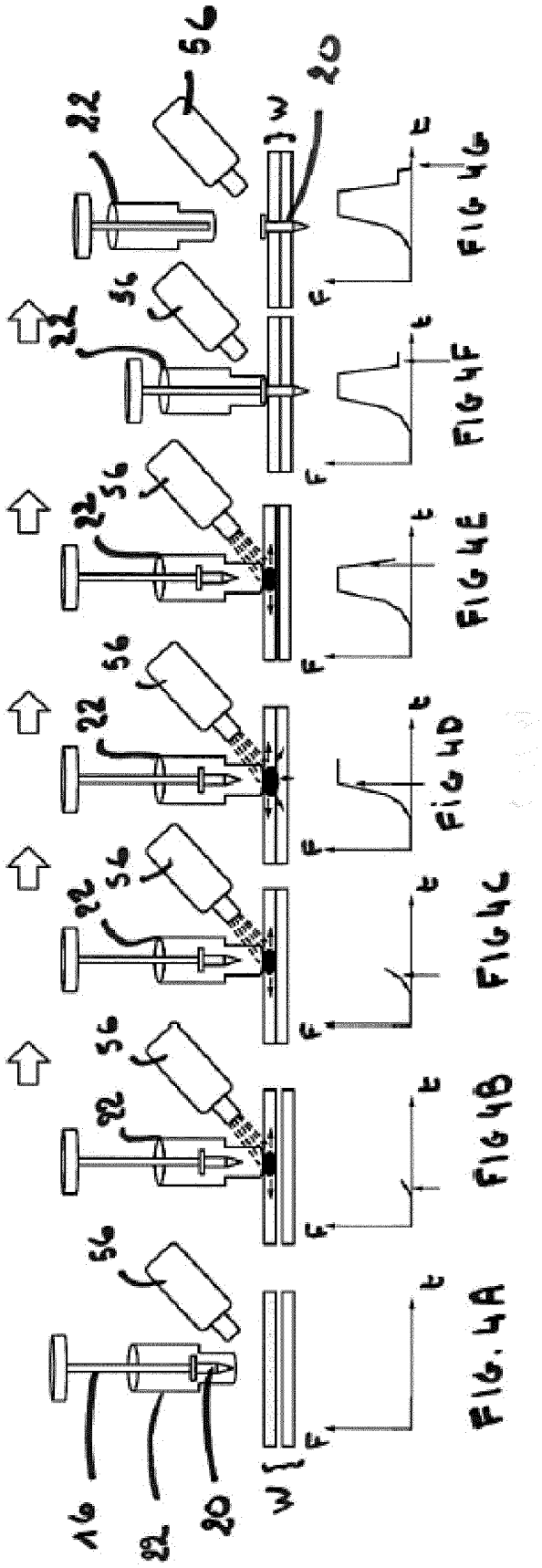


FIG. 3


56
22
20
W
E
F
FIG. 4A
FIG 4B
FIG 4C
FIG 4D
FIG 4E
FIG 4F
FIG 4G

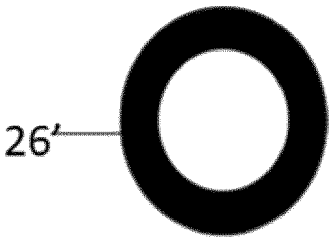


Fig. 5A

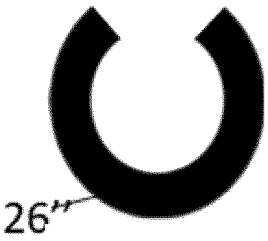


Fig. 5B

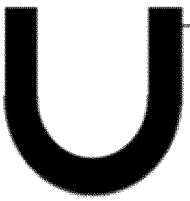


Fig. 5C

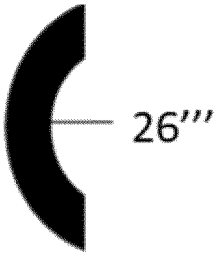


Fig. 5D

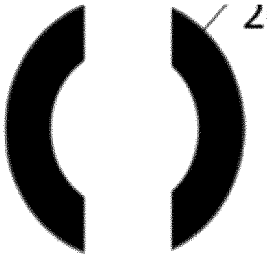


Fig. 5E

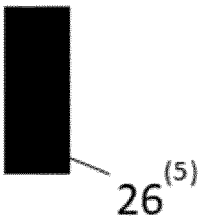


Fig. 5F

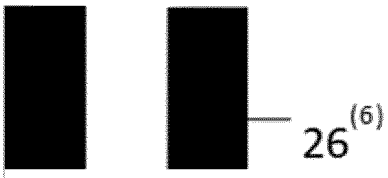


Fig. 5G

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 19 6228

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	JP 2007 203307 A (KAWASAKI HEAVY IND LTD) 16 August 2007 (2007-08-16)	1,2,4,7, 8,10,11, 13,14	INV. B21J15/02 B21J15/08
Y	* paragraphs [0019], [0020], [0044] - [0057], [0092] - [0094], [0147] - [0149], [0158]; figures *	5,6,9	B21J15/26 B21J15/28
X	CN 103 962 496 A (SUZHOU ICOOLMACH EQUIPMENT MFG CO LTD) 6 August 2014 (2014-08-06) * figures *	1,3,4,12	
X	DE 103 59 879 A1 (SCHMIDT HEIKO [DE]) 12 August 2004 (2004-08-12) * paragraphs [0016] - [0026]; figures *	1,3,4,12	
X	DE 10 2016 007332 A1 (DAIMLER AG [DE]; WILHELM BÖLLHOFF GMBH & CO KG [DE]) 21 December 2017 (2017-12-21) * paragraphs [0041], [0042]; figures *	1,3,4,12	
X	DE 103 19 411 A1 (SACHSENBERG KAI [DE]) 18 November 2004 (2004-11-18) * figures *	1,3,4,12	TECHNICAL FIELDS SEARCHED (IPC) B21J
X	DE 199 05 527 A1 (BOELLHOFF GMBH [DE]) 17 August 2000 (2000-08-17) * figures *	1,3,4,12	
Y	CN 104 607 557 A (UNIV JILIN) 13 May 2015 (2015-05-13) * figures *	5	
Y	US 2021/283712 A1 (REIS CHRISTIAN [DE] ET AL) 16 September 2021 (2021-09-16) * figures *	5,6	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 February 2024	Charvet, Pierre

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 19 6228

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 4 610 072 A (MUELLER RUDOLPH R M [DE]) 9 September 1986 (1986-09-09) * figure 15 * -----	9	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	22 February 2024	Charvet, Pierre

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 19 6228

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-02-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2007203307 A	16-08-2007	JP 4885552 B2	29-02-2012
		JP 2007203307 A	16-08-2007
CN 103962496 A	06-08-2014	NONE	
DE 10359879 A1	12-08-2004	NONE	
DE 102016007332 A1	21-12-2017	NONE	
DE 10319411 A1	18-11-2004	NONE	
DE 19905527 A1	17-08-2000	NONE	
CN 104607557 A	13-05-2015	NONE	
US 2021283712 A1	16-09-2021	CN 109862987 A	07-06-2019
		DE 102016115463 A1	22-02-2018
		EP 3500391 A1	26-06-2019
		JP 7037545 B2	16-03-2022
		JP 2019532228 A	07-11-2019
		KR 20190041498 A	22-04-2019
		US 2021283712 A1	16-09-2021
		WO 2018033645 A1	22-02-2018
US 4610072 A	09-09-1986	CA 1253317 A	02-05-1989
		DE 3446978 A1	14-08-1985
		ES 8605079 A1	01-03-1986
		ES 8609612 A1	01-09-1986
		FR 2557227 A1	28-06-1985
		GB 2152415 A	07-08-1985
		GB 2185204 A	15-07-1987
		GB 2187986 A	23-09-1987
		IT 1209929 B	30-08-1989
		JP H0757409 B2	21-06-1995
		JP S60231545 A	18-11-1985
		US 4610072 A	09-09-1986

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE 102005031917 A1 **[0004]**
- CH 689299 **[0005]**
- DE 102017106449 **[0006]**
- DE 102012019809 A1 **[0007]**
- EP 22165638 **[0027]**
- EP 3515632 A1 **[0035] [0042]**