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(54) RIVET REMOVAL DEVICE, METHOD FOR REMOVING RIVETS FROM A COMPOUND ASSEMBLY

(57) The disclosure relates to removing rivets from a compound assembly, such as an airplane fuselage, or ship or bridge parts, by providing a rivet removal structure. The rivet removal structure comprises a pin that in an automated manner can punch out rivets from the compound assembly, and is being retracted inside the structure after the punching.

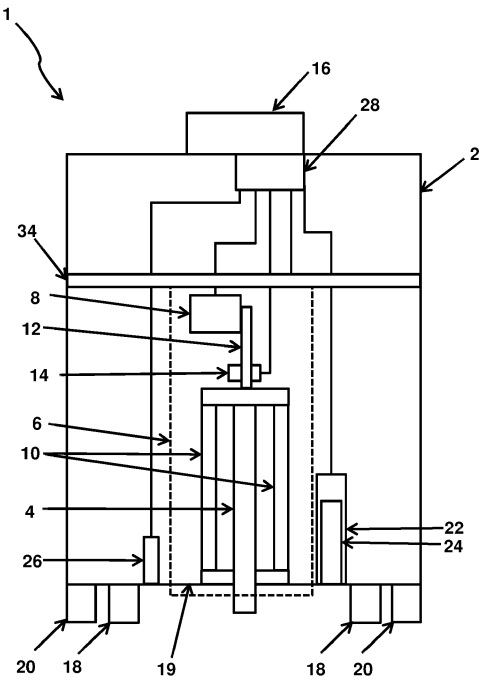

FIG 1

EP 3 881 950 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to a system and a method for removing rivets from a compound assembly.

BACKGROUND TO THE INVENTION

[0002] Rivets are typically used to fixate two or more parts forming a compound object. A rivet is usually not removed during the lifecycle of the object or assembly. The rivet connection is intended to be a permanent connection and can be for example replaced during a maintenance or reparation phase. At the end of the lifetime of the object, the object can be dismantled, e.g. when valuable materials were used that might be re-usable, such as metal or aluminum. Typically the compound objects are dismantled as in their compound state. This might jeopardize the possibility of re-usability, in particular for compound object wherein the two or more parts are of a different material type. In such a situation, it might be that undoing the rivet connection improves the re-usability. A rivet can be removed when the object is deconstructed or disassembled. The removal of a rivet is typically a manual process.

[0003] One way of removing a rivet from a compound object is to drill out manually the entire rivet, and, as such, removing the rivet from the compound object, allowing the riveted parts to be loosened. Another way of removing a rivet is to clamp around the head of the rivet, to break the rivet head from its stem, thus allowing the riveted parts to be loosened.

[0004] The manual removal of rivets is a time consuming and cumbersome process, and is therefore not always economically feasible. The disassembly of, for example, the fuselage of a large airplane, e.g. a Boeing 747, is not economically feasible, as the man-hours needed to manually remove the rivets from the fuselage outweigh the achieved additional value of the separated fuselage parts. While other parts of the airplane are being dismantled or otherwise re-used, this appears not possible for e.g. fuselage panels. This problem is not limited to an airplane fuselage but extends to other riveted compound assemblies, i.a. bridge parts, train parts or ship parts.

[0005] There is need for an improved rivet removal system and method.

SUMMARY OF THE INVENTION

[0006] It is an objection of the invention to provide for a system and a method for removing rivets that obviates at least one of the above mentioned drawbacks. In particular, it is an object of the invention to provide for a system and method that provides for a more economical and/or more effective and/or more efficient removal of rivets.

[0007] According to an aspect of the invention there is provided a rivet removal system for removing rivets from a compound assembly, wherein the system comprises a structure in which a pin is mounted that is adjustable between a retracted position, in which the pin is substantially retracted inside of the structure, and an extended position in which the pin extends substantially outside of the structure for punching out the rivet from the assembly, wherein the pin is returned to its retracted position after punching. The rivet removal system further comprises a drive unit for driving the pin at least between the retracted position and the extended position, wherein the drive unit advantageously comprises a drive source. The structure may, for example, be a housing or a frame. The structure may be open or closed. For example, the structure may comprise a rib-like frame in which an open space between the ribs may be closed by a panel, or may be left open.

[0008] A compound assembly is considered to be an assembly from two or more components that are riveted together as to form a fix connection. When the two or more parts are riveted together, they form a compound object, also denoted as compound assembly. Compound assemblies are widely used, e.g. in bridges, trains or airplanes.

[0009] The drive unit can for example be used to drive the pin from the extended position back to the retracted position after punching out a rivet from the assembly, allowing the rivet removal system to prepare to punch out a following rivet. Preferably, the drive unit can be used to drive the pin from the extended position back to the retracted position after every punching movement. This can be done in the time available between punching out one rivet and punching out an other rivet. Alternatively and/or additionally, the drive unit may drive the pin from the retracted position towards the extended position, i.e. the punching movement, but may also be used to retract the pin, after punching, towards its retracted position. The drive source can, for example, be an electric motor, a magnet or a magnetic motor, a pneumatic drive source or an hydraulic drive.

[0010] By providing the rivet removal system having a drive unit for driving the pin at least between the retracted position and the extended position, an automated system for rivet removal can be obtained. As such, a rivet can be removed in an automated manner, thus reducing time and man power for removing a rivet. This is in particular advantageous when many rivets need to be removed from a compound assembly, such as in an airplane fuselage or a ship. This may provide for a more effective and/or more efficient removing of a rivet from a compound assembly.

[0011] Additionally or optionally, the drive unit may further comprise an elastic element, wherein the elastic element biases the pin towards the extended position. The elastic element can, for example, be a spring, a capacitor, a pneumatic piston or an hydraulic piston. It will be appreciated that the pin might also be biased towards the retracted position. As long as the force applied during the extension of the pin is strong enough to punch out the rivet, and the force applied during the retraction of the pin is strong enough to drive the pin to the retracted position, the desired effect of punching out the rivet is reached. By providing an elastic element, the drive unit may provide a force in one direction and/or the elastic element may provide a force in opposite direction. For example, the elastic element may provide for a more or less immediate release of energy, e.g. to drive the pin outwardly and provide for the punching movement, while the drive source may retract the pin. For example, when using an elastic element, such as a spring or a capacitor, the drive source may load the spring or the capacitor to bias the spring or capacitor to the extended position, and, for the punching movement of the pin, the kinetic energy of the spring or the magnetic energy of the capacitor can be released at once to drive the pin towards the extended position. In the retracted position, the pin can be held in its position, by some locking element. For the punching movement, the pin is released and moves towards the extended position. Preferably, the locking elements are unlocked prior to the punching movement. When the elastic element is biased towards the extended position, the elastic element may be brought in the biased position by the drive source, or another energy source. For the punching movement, the energy of the elastic element may be released at once to drive the pin towards the extended position. The drive source, or another energy source, e.g. a battery, may then bring the elastic element back to its biased position. Of course, the elastic element may be biased towards the retracted position to bring the pin, after the punching movement, back towards the retracted position. The drive unit may then provide for driving the pin towards the extended position, against the bias force of the elastic element. The elastic element may then bring the pin back towards its retracted position. The elastic element preferably is connectable to the pin and/or to the drive source.

[0012] Additionally or optionally, the drive unit may further comprise a drive train. The drive train can, for example, be a transmission arranged to transmit energy of the drive source to the elastic element. In the case of an electric motor as a drive source, the transmission may for example be a gear unit connected arranged on the output shaft of the electric motor and connected to a lever which connects to the elastic element. The elastic element may be part of the drive train, e.g. when the elastic element may be positioned between the pin at one end and the drive source at another end. Alternatively, the elastic element may be arranged in parallel to the drive train, e.g. when the elastic element is connectable to the pin at one end, and to the structure at another end. Many variants are possible.

[0013] Optionally or additionally, the drive train may further comprise a power supply arranged to, by example during a power outage, supply the drive source with power as to cause the drive source to pull the pin to the retracted position where it can be locked by the locking element. The power supply may for example be a battery or a capacitor. The power supply can also be arranged to allow the rivet removal system to operate without the need of an external power supply, such as a power grid, and a such, the system can operate as a self-contained system, or a stand alone system. The rivet removal system may optionally comprise an indicator, such as a LED-light, to indicate that the pin is in the retracted position. The indicator may indicate to a user that energy is stored in the elastic element, even during of a power outage.

[0014] Advantageously, the structure may be connectable to a robot, preferably a robot arm of a robot, in particular as a robot head of the robot arm. Instead of a robot arm, the robot may be provided with another device allowing to connect the structure thereto as a robot head and, advantageously, arranged to position the robot head. To that end, the structure may be provided with a robot-connection element, such that at least a mechanical connection can be established between the structure and the robot arm. Preferably, also an electric connection and/or a data connection and/or an hydraulic or pneumatic connection may be provided. The robot arm can be an articulated robot arm. The robot arm can function as a general positioning means, wherein the robot arm can be used to position the rivet removal system near the compound assembly. By connecting the rivet removal system to the robot, a further automation can be obtained in which the robot arm or robot can move the rivet removal system over the compound assembly to remove the multiple rivets of the compound assembly. By connecting the structure to the robot arm, and by providing the structure as a robot head, the structure can be - at least - moved in a more automated manner over the assembly from which the rivets are to be removed. As such, removing of rivets over a relatively large surface can be done more efficiently and/or more effectively.

[0015] Additionally or optionally, the rivet removal system may further comprise support elements for supporting the structure onto the assembly. The support elements can, for example, be a set of wheels, such as ball wheels, or a set of legs or studs. For example, an underside of the structure may be arranged as one or more support elements. Advantageously, the support elements provide for an adequate distance of the rivet removal system to the compound assembly, in particular of the pin contained in the rivet removal system to the compound assembly, to optimally punch out the rivet. Also, the support elements may maintain the distance between the structure and the assembly, in particular between the pin of the structure and an outer surface of the assembly, also during the punching movement. The use of a set of wheels, such as ball wheels, also allows the rivet removal system to maintain contact with the compound assembly when moving to a different position. Providing wheels as support elements may thus allow for an adequate distance of the structure to the surface as well as for easy movement of the structure over the outer surface of the compound assembly. It will be appreciated that as an alternative to the support elements, distance sensors can be used. The distance sensors can provide for a contactless distance keeping of the rivet removal system to the compound assembly.

[0016] By positioning the structure at a predefined distance from the outer surface, it can be obtained that a bottom side of the structure is approximately parallel to the outer surface of the assembly. As such, an orientation of the structure with respect to the outer surface can be well defined, in particular the orientation of the structure with respect to a . The orientation of the pin, that is mounted in the structure, can thus be well defined as well, and as such, it can be obtained that the pin is oriented approximately transverse with respect to an outer surface of the assembly. By providing the support elements, the distance between the structure, and thus the pin contained in the structure, and the outer surface of the assembly, can be kept constant and predictable. As such, when all support elements are in contact with an outer surface of the assembly, the structure, and the pin contained in it, can be oriented with respect to a transverse direction to the outer surface of the assembly, such that the pin can be approximately aligned along the transverse direction. Thus, the support elements may facilitate the transverse positioning and/or orientation of the pin with respect to the outer surface of the assembly. As such, the support elements may be arranged for orienting the structure, in particular the pin, with respect to the rivet.

[0017] Additionally or optionally, the rivet removal system can further be arranged for positioning the structure, in particular the pin, with respect to the rivet. In one aspect, the support elements may provide for the positioning, in particular orienting, because they maintain a predefined distance between the structure and the outer surface of the assembly. In another aspect, the support elements may provide for positioning as they may allow the movement of the structure over the assembly, e.g. when being arranged as balls or wheels.

[0018] The support elements can preferably, but not necessarily, be sufficiently stiff to prevent deformation of the support element when the system is in contact and supported onto the assembly. The support elements can, for example, be of equal length, resulting in a substantially perpendicular positioning of the pin over the rivet when every support element touches or is in contact with the compound assembly. In an other embodiment of the invention, the rivet removal system may be arranged to measure pressure, forces, or moments within the structure, for example by using force and/or moment sensor or a piezoelectric element fixed to each support element. Comparison of the different pressures measured by the piezoelectric elements may indicate whether the structure is properly positioned onto the compound assembly. Instead of using piezoelectric elements fixed to the support elements, a force/moment sensor may be arranged in a connection between the structure and a robot arm connected to the structure, which may be beneficial in terms of wear and reliability as these sensors do not require direct contact with the outer surface of the assembly. The forces and/or moments measured in the connection between the structure and the robot arm can be used to determine whether the structure is positioned correctly.

[0019] Advantageously, the rivet removal system comprises a positioning unit for positioning the structure with respect to the rivet. The positioning unit is arranged to move the structure towards the rivet, and preferably sufficiently close to the rivet, such that the pin is approximately aligned with the rivet. The positioning unit can be contained in the structure itself, e.g. having an own drive source for moving the structure. Alternatively, the positioning unit may be provided by a robot arm connectable to the rivet removal system. The robot arm can then provide for the movement or displacement of the structure with respect to the assembly and in particular, with respect to the rivets in the assembly. The rivet removal structure can then be brought to a position of a rivet-to-be-removed, such that the pin contained in the structure is advantageously positioned above the rivet such that it can optimally remove the rivet when punching. When the rivet removal structure is connected to a robot, the robot may move the rivet removal structure to a next position.

[0020] Additionally or optionally, the rivet removal system may further comprise a pin alignment system. The pin alignment system can be arranged to align the pin in a direction transverse to a punching direction. The punching direction is considered to be the direction in which the pin moves during the punching movement. Preferably, the punching direction coincides with a longitudinal direction of the pin. For optimal removal of the rivet, it is advantageous that the punching direction is aligned with the axial direction of the rivet. For a more optimal removal, it is advantageous that the pin is aligned with the rivet such that a longitudinal axis of the pin approximately coincides with a longitudinal axis of the rivet. It is generally assumed that the longitudinal axis of the rivet is transverse with respect to an outer surface of the assembly. To provide such alignment, preferably after positioning, the pin alignment system is provided in the rivet removal system. The positioning unit may provide for a gross positioning of the pin with respect the rivet, as opposed to the fine positioning the alignment system provides for. Advantageously, the pin alignment system aligns the position of the pin with respect to the rivet in a direction perpendicular to the punching direction. The positioning system is configured to place the structure with respect to the assembly, and, as such, will provide for an orientation of the pin transverse to the outer surface, or to a tangent plane of a curved surface, of the assembly. The tangent plane is tangent to the surface at the position of the rivet. Then, the alignment system can fine tune the position, and/or orientation, of the pin.

[0021] Advantageously, the pin alignment system provides for a limited translational movement of the pin in a direction transverse to the punching direction. For example, when the rivet removal system is connected to a robot arm, the pin alignment system may align the pin independently from the movement of the robot arm. A possible - minor - offset of the pin due to the positioning by the robot arm can therefore be corrected by the pin alignment system. Additionally the pin alignment system may allow a slightly larger reach of the rivet removal system connected to a robot arm. The pin alignment system can for example be a system allowing limited translational movements in a plane transverse to the punching direction, more particular the translational movement is provided in a plane parallel to the surface of the assembly, or to a tangent plane of the surface, through the rivet, of the assembly. To that end, a two-dimensional translational system can be provided that engages the pin. The pin alignment system can then provide a fine positioning of the pin such that the pin is placed above the rivet head. Additionally or alternatively, the pin alignment system may provide for fine tuning the orientation of the pin with respect to the rivet, in particular with respect to a longitudinal axis of the rivet, which is generally transverse to the outer surface. The pin alignment system may then provide for some final tilting of the pin until the longitudinal axis of the pin is aligned with the rivet longitudinal axis. It may be appreciated that a perfect alignment might not be possible, e.g. due to the orientation of the rivet, or the curvature of the outer surface, or the positioning and alignment of the pin. When positioning the pin above the rivet head and orienting the pin in a direction transverse to the outer surface, the pin is sufficiently placed to provide for an effective removal of the rivet.

[0022] Additionally or optionally, the rivet removal system may further comprise at least one distance measuring element for measuring the distance between the structure and the assembly, in particular between the pin and an outer surface of the assembly. An increase in distance may, for example, indicate the presence of a window, a doorway or another hole in the compound assembly. Based on the distance measured by the at least one distance measuring element the pin might be prevented from extending at an unwanted position. By providing such a distance measuring element, safety of the rivet removal system can be increased, as now, it may be prevented that the pin is punched outwardly when there is no material present. Additionally, the distance measuring element may also determine the distance between an outer surface of the assembly and the structure, e.g. an under side of the structure through which the pin can move during the punching. When the distance between the said under side of the structure and the assembly is about a predefined distance, the under side of the structure is about parallel to the outer surface of the assembly, or to a tangent plane through the rivet, such that then, the pin is oriented transverse to the outer surface of the assembly.

[0023] Additionally or optionally, the rivet removal system may further comprise a collar extending outwardly from a side of the structure through which the pin engages. Preferably, the collar may extend between the side of the structure through which the pin engages and the compound assembly when the rivet removal system is positioned onto the compound assembly to close a gap between the compound assembly and the side of the structure through which the pin engages during punching. The collar may, for example, be a compressible foam, or a curtain of e.g. textile or another material. The collar may function as a safety feature, preventing material dislodged by the pin during punching to fly away with the momentum generated by the pin during punching. The collar does not necessarily hold on to dislodged material when the structure is moved away from the compound assembly. The collar may be provided when there are support elements and may then be approximately as high as the support elements. Alternatively, if the support elements are obviated and the at least one distance measuring element measures the distance to allow the structure to be positioned at a predefined distance from the outer surface of the assembly, the collar may approximately as high as the predefined distance.

[0024] Additionally or optionally, the rivet removal system may further comprise a gripping unit arranged to grip a surface of the compound assembly. The gripping unit can be used to hold the surface of the compound assembly, allowing the structure to remove the part of the compound assembly that it holds after removal of the rivets. The gripping unit can be arranged at the same side of the rivet removal structure through which the pin engages or on an other side of the structure. The gripping unit can include, by example but not limited to, suction cups. In an embodiment of the invention the support elements and the gripping unit can be combined, e.g. the gripping elements of the gripping unit may be provided around the support elements.

[0025] Additionally or optionally, the rivet removal system may further comprise a control unit for controlling the punch movement of the pin and/or for controlling the positioning of the structure over the assembly. As such, the control unit may control the positioning unit and/or may control the robot arm, when connected thereto. The control unit may further control the alignment of the pin by controlling the pin alignment system. The control unit might be arranged inside the structure, inside the robot arm, or in a separate structure positioned near the robot arm, for example in a central operation unit or a remote operation unit. The control unit may further be connected, wired or wireless, to a user interface. The user interface may e.g. be an operator panel via which an operator can provide input, e.g. on the positioning of the structure or on the punching movement, etc. In an example, the operator might give the input or command to the rivet removal structure to release the pin for the punching movement.

[0026] Additionally or optionally, the rivet removal system may further comprise a rivet detection unit for detecting a position of the rivet to be removed on the assembly. By providing such a rivet detection unit, the position of the rivet may first be detected, and, then, the rivet removal system may be brought to the detected position of the rivet to position the pin above the rivet. Alternatively and/or additionally, the rivet removal system may be brought to the position of the rivet-to-be-removed, based on known data, such as drawings or computer models of the compound assembly. Also, the rivet detection unit itself may use some information as to where expect a possible rivet, as to limit the search area, and then to detect the exact location of the rivet.

[0027] Additionally or optionally, the rivet detection unit may be arranged inside the structure. The rivet detection unit may preferably be arranged at the side of the structure through which the pin engages. By providing the detection and the pin at the same side of the structure. a more accurate positioning may be possible. Alternatively, the rivet detection unit may be arranged at a different side of the structure. The rivet removal system may additionally be arranged to alternately aim the pin or the rivet detection unit towards the compound assembly. As such, the structure may be rotated between a detection mode, in which the detection unit is oriented towards the assembly, and a punching mode, in which the punch pin is oriented towards the assembly. Such a rotational movement however, may introduce some inaccuracy in the positioning of the pin with respect to the rivet.

[0028] Additionally or optionally, the rivet detection unit may comprise a detection sensor, preferably an eddy current sensor. Alternatively or additionally, the rivet detection unit may comprise a thermographic sensor or an ultrasonic sensor. The rivet detection unit may comprise different types of detection sensors. The rivet detection unit may, for example, use a eddy current sensor and a thermographic sensor, wherein the rivet detection unit may combine or compare the information measured by the sensors to provide a more accurate position of a rivet. The inventors found that using an eddy current sensor provided for a more robust and reliable determination of the location of the rivet.

[0029] Additionally or optionally, the rivet detection unit may provide information, preferably position information, to the control unit and/or to a user interface connectable to the control unit. For example, the comprehensive image a detection unit may produce, can be fed to the control unit and/or to the user interface of the operator. In an embodiment of the invention, the rivet detection unit may comprise an eddy current sensor, which may provide a comprehensive image representing positions of the rivet. Such image can be relatively easy interpreted by an operator, or by a control unit, e.g. in an automated manner. The image an eddy current sensor produces is relatively insensitive to pollution or dirt. By providing an eddy current sensor the locations of the rivets can thus be detected in a robust, simple and reliable manner. The image may be processed, for example by software embedded in the rivet detection unit, to transform the image into position coordinates. The rivet detection unit may provide these positon coordinates to the control unit and/or to the user interface connectable to the control unit as position information. Also a thermographic sensor or an ultrasonic sensor can provide comprehensive images that may be relatively easy to interpret. In an other embodiment of the invention, it may be provided that the rivet removal system is triggered manually by an operator using the user interface. Alternatively or additionally, the position of the rivets may be provided by known data, such as a drawing or a computer model of the assembly.

[0030] Additionally or optionally, the control unit may be configured to control the positioning of the structure based on position information received from the rivet detection unit. As explained above, the position information can be provided by the detection unit, but may also come from readily available data such as drawings or computer models of the compound assembly in which the locations of the rivets are usually indicated.

[0031] According to an other aspect of the invention there is provided a method for removing a rivet from a compound assembly, the method comprising providing a rivet removal system, positioning a structure of the system over the rivet to be removed such that a pin of the system is aligned with the rivet to be removed, and driving the pin to its extended position to punch out the rivet from the assembly. Advantageously, the method may start with a calibration, as to ensure that at least a starting position of the rivet removal system is known.

[0032] Positioning of the structure might be done by a robot arm connected to the structure. By using a robot arm, the system can be moved over a relatively large area, thus having a rather large reach.

[0033] Additionally or optionally, the method for removing a rivet may further comprise providing position information on the position of the rivet to be removed, wherein the position information can be based on pre-known data and/or wherein the position information can be obtainable from a rivet detection unit. The pre-known data can, for example, be CAD-data comprising information of the compound assembly, such as, bot not limited to, dimensions of the compound assembly or positions of rivets in the compound assembly.

[0034] Additionally or optionally, the method for removing a rivet may further comprise positioning the structure based on the provided position information of the rivets. In an embodiment of the invention, both pre-known data and position information obtainable from the rivet detection unit may be used. For example, the pre-known data can be used to position the structure after which the position information provided by the rivet detection unit can be used to control the position of the structure and, if necessary, reposition the structure based on the position information provided by the rivet detection unit. The structure can then be positioned with respect to the assembly such that the pin contained in the structure is approximately above the rivet. Fine tuning of the position and/or orientation of the position of the pin with respect to the rivet, may be done by the pin alignment system.

[0035] Additionally or optionally, the method for removing a rivet may further comprise moving the structure of the system to a next position of a next rivet to be removed for removing the said next rivet. As such, multiple rivets can be removed subsequently. The detection unit may be arranged to detect the position of a rivet, which rivet can then be removed by the pin. Alternatively, the detection unit may scan an area of the compound assembly, and may determine the location of multiple rivets. These multiple rivets may then be removed one-by-one subsequently.

[0036] Additionally or optionally, the method for removing a rivet may further comprise moving the pin to an engaged position, between the retracted position and the extended position, in which the pin extends outwardly for engaging to a rivet head of the assembly. The engaged position can be a position between the retracted position, in which the pin is substantially retracted inside of the structure, and the extended position in which the pin extends substantially outside of the structure for punching out the rivet from the assembly. In the engaged position, the pin can engage the rivet head. A supervisor may then visually check if the pin, when in the engaged position, engages the rivet head before allowing the rivet removal system to drive the pin to its extended position to punch out the rivet from the assembly. Alternatively and/or additionally, at least one camera may be used to visualize the position of the pin with respect to the rivet, which data may be analyzed by the control unit prior to the punching movement.

[0037] According to an other aspect of the invention, there is provided a control unit configured for controlling the removal of a rivet of a compound assembly using a rivet removal system.

[0038] Additionally or optionally, the control unit can be further configured to provide a position signal based on position information of the rivet to be removed and/or the control unit can be further configured to output the position information to a user interface.

[0039] According to an other aspect of the invention, there is provided a method for dismantling a fuselage of an airplane, comprising, removing the rivets from the fuselage.

[0040] According to an other aspect of the invention, there is provided for a robot comprising a rivet removal system for removing at least one rivet of a riveted compound assembly. By providing a robot to which the rivet removal system is mounted as a robot head, the rivet removal system can be moved over the assembly in an automated manner. The robot may have a relatively large reach over the compound assembly.

BRIEF DESCRIPTION OF THE DRAWING

[0041]

Fig. 1 is a schematic view of a rivet removal system.
Fig. 2 is a schematic view of a rivet removal system.
Figs. 3A, 3B and 3C is a rivet removal system positioned on a compound assembly with different pin positions.
Fig. 4 is a flowchart representation of a process according to a method for removing rivets.

DETAILED DESCRIPTION

[0042] Fig. 1 shows a schematic representation of a rivet removal system 1. The system 1 comprises a structure 2 in which a pin 4 is adjustably mounted. The pin 4 is shown in Fig. 1 in a retracted position, in which the pin 4 is substantially retracted inside of the structure 2. In the embodiment illustrated in Fig. 1, the structure 2 can for example be envisioned as a rib like structure, with ribs forming a frame in which the pin 4 can be mounted. The pin 4 is driven by a drive unit 6. The drive unit 6, in this embodiment, comprises a drive source 8, which can be an electromotor 8. The drive unit 6 further comprises an elastic element 10, which can be a spring 10. The drive unit 6 further comprises a drive train 12, which can be a mechanical transmission 12. In this example, the spring 10 is mounted around the pin 4 and biases the pin 4 towards an extended position in which the pin extends substantially outside of the structure 2 for punching out a rivet from a compound assembly. The electromotor 8 then pulls the pin 4 from the extended position back to the retracted position after the punching movement. Alternatively, the elastic element may be biased towards the retracted position of the pin 4. The elastic element 10 can then be for example a tension spring 10. The drive unit 8 then needs to drive the pin 4 towards the extended position against the force of the spring 10. In the extended position, the spring 10 is extended as well, and wants to pull the pin 4 back towards the retracted position to which it is biased. As such, the spring 10 may provide for, additional, safety as, after the punching movement, it provides for the retracting of the pin 4 towards the retracted position. It can thus be obviated that the pin 4 may remain stuck in the extended position.

[0043] The pin 4 might be locked in the retracted position by a locking element 14. As illustrated in Fig. 1, the locking element 14 is here arranged to engage to the drive train 12. In other embodiments, the locking element 14 might be arranged to, for example, engage the pin 4, the spring 10 and/or the electromotor 8. The locking element 14 can release the drive train 12, and thus the pin 4, when the system 1 is positioned over a rivet. The spring 10 may then drive the pin 4 to the extended position allowing the pin 4 to punch out the rivet. The locking element 14 can also prevent the spring 10 from driving the pin 4 to the extended position when the system 1 is not positioned over a rivet, for example during a power outage. The drive unit 6 may optionally comprise a power supply arranged to, by example during a power outage, supply the drive source 8 with power as to cause the drive source 8 to pull the pin 4 to the retracted position where it can be locked by the locking element 14. The power supply may for example be a battery or a capacitor. The power supply can also be arranged to allow the system 1 to operate without the need of an external power supply, such as a power grid, and as such, the system 1 can operate as a self-contained system, or a stand-alone system.

[0044] The system 1 can advantageously be connected to a robot arm of a robot, in particular as a robot head of the robot arm, through a connection block 16. In the embodiment illustrated in fig. 1, the connection block 16 is shown on a side of the structure 2 opposite of a side 19 through which the pin 4 engages. In other embodiments, the connection block 16 might be mounted on any other side of the structure 2. The connection block 16 can form a mechanical connection to a robot arm of a robot, but might also comprise a power connection, for example to provide power to the electromotor 8 and/or the power supply, and/or a communication/data connection, for example to send and/or receive instructions between a control unit 28 comprised by the system 1 and the robot. Alternatively to the electromotor, the drive source can be a pneumatic drive source provided with the robot arm and that can be coupled into the system 1 via the connection block 16.

[0045] The system 1 further comprises support elements 18 for supporting the structure 2 onto the compound assembly. The support elements 18 are preferably of equal length and extend from a side of the system 1, preferably from the side of the system 1 that is configured to allow the pin 4 to engage through, the so-called under side or pin-side 19 of the system 1. The equal length of the support elements 18 may ensure that, when the structure 2 is positioned onto a flat or curved surface of the compound assembly, the under side 19 of the structure 2 is about parallel to the outer surface of the assembly, or a tangent plane through the rivet of the assembly. When the under side 19 is parallel to the assembly, and the pin 4 is mounted transverse to the under side 19, then the pin 4 is positioned substantially perpendicular to the surface of the compound assembly, i.e. the pin 4 is positioned parallel or preferably in line to a rivet in the compound assembly.

[0046] The support elements 18 might contain sensors arranged to detect whether the support elements 18 have made contact with the compound assembly. These sensors can for example be force sensors, moment sensors and/or pressure sensors. A sensor measuring no force, moment or pressure might provide an indication that the structure 2 is not positioned correctly onto the compound assembly. These sensors can alternatively be arranged in the connection block 16.

[0047] The rivet removal system 1 further may comprise a pin alignment system 34, here shown in Fig. 1. The pin alignment system 34 is arranged inside the structure 2. The pin alignment system 34 is arranged to adjust the position of the pin 4 along a direction transverse to a punching direction. For example, the pin alignment system 34 can be arranged as an XY-translation system, meaning that it can adjust the position of the pin by translatory movement in two opposed perpendicular directions in a plane perpendicular to a longitudinal axis of the pin. Such XY-translation systems are known and are used to adjust the position of an object in a plane by translation. Alternatively, other alignment systems can be used, e.g. a tilting mechanism can be considered to adjust the angular orientation of the pin with respect to, preferably, The control unit 28 is arranged to control the pin alignment system 34 to adjust the pin 4 in a direction transverse to a punching direction in order to align the pin 4 with a rivet. The pin alignment system 34 is illustrated in Fig. 1 as being arranged near the control unit 28. It will however be appreciated that the pin alignment system 34 may be arranged elsewhere in the structure 2.

[0048] The system 1 further comprises a collar 20 extending outwardly from the side 19 of the structure 2 through which the pin 4 engages. The collar 20 extends outwardly from the structure 2 to the compound assembly when the structure 2 is positioned on the compound assembly to close a gap between the compound assembly and the side 19 of the structure 2 through which the pin 4 engages during punching. The collar 20 may, for example, be a compressible foam or some sort of curtain. The collar 20 may function as a safety feature, preventing material dislodged by the pin 4 during punching to fly away with the momentum generated by the pin 4 during punching. The collar 20 does not necessarily hold on to dislodged material when the structure 2 is moved away from the compound assembly.

[0049] The system 1 further comprises a rivet detection unit 22 arranged inside the structure 2. As illustrated in Fig. 1, the rivet detection unit 22 can be arranged at the side 19 of the structure 2 through which the pin 4 engages. As illustrated in Fig. 2, the rivet detection unit 22 might also be positioned at another side of the structure 2. The rivet detection unit 22 comprises a rivet detection sensor 24, which can preferably be an eddy current sensor 24. The eddy current sensor 24 may generate an image showing an indication of the position of rivets when the structure 2 is positioned near or on the compound assembly. The rivet detection unit 22 might be arranged to translate the image provided by the eddy current sensor 24 into position information.

[0050] As illustrated in Fig. 1, the system 1 further comprises a distance measuring element 26 for measuring the distance between the structure 2 and the compound assembly. Fig. 1 shows one distance measuring element 26, but a plurality of distance measuring elements 26 may be present distributed over the pin-side 19 of the structure 2 through which the pin engages. Distance measuring elements 26 may also be arranged at other sides of the structure 2. Distance measuring elements 26 arranged at other sides of the structure 2 may be used to detect and prevent collision between the structure 2 and its surroundings. The at least one distance measuring element 26 may provide for a more safe operation, preventing the pin 4 to be released when the distance detected is larger than a predefined threshold, which may suggest an opening or a hole in the assembly.

[0051] The system 1 further comprises a control unit 28. The control unit 28 can be arranged for controlling the punch movement of the pin 4. The control unit 28 can for example be configured to control also the locking element 14 to release the pin 4, allowing the spring 10 to drive the pin 4 to the extended position for punching out a rivet. The control unit 28 can further be configured to decide whether the structure 2 is in a position to punch out a rivet based on position information. Position information can be received by the rivet detection unit 22 and/or through the communication connection in connection block 16. The positioning information provided through the communication connection in connection block 16 can be positioning information provided by the robot about its current positioning. The positioning information provided through the communication connection in connection block 16 can also be positioning information provided by pre-known data, such as CAD-data of the compound assembly. Alternatively, such pre-known data may be received via a wireless communication element from a remote source, e.g. a user interface, or an operator panel, or a remote computer. The control unit 28 may further use distance information received from the distance measuring unit 26. The distance information provided by the distance measuring unit 26 may indicate the presence of a window, doorway or other hole in the compound assembly.

[0052] Figs. 3A, 3B and 3C schematically show some steps of a method for removing a rivet 32 from a compound assembly 30 with a rivet removal system 1 positioned on the compound assembly 30 with different pin positions. Figs. 3A, 3B and 3C show a compound assembly 30 with a rivet 32. The rivet removal system 1 is here shown in a simplified representation. It may be appreciated that a rivet removal system according to Fig. 1 or Fig. 2 can be used. The rivet removal system 1 is shown comprising a structure 2 and a pin 4. Fig. 3A shows the pin 4 in a retracted position, in which the pin is substantially within the structure 1. Fig. 3B shows the pin 4 in an engaged position, in which the pin engages the rivet head of the assembly. Fig. 3C shows the pin in an extended position, in which the pin extends substantially out of the structure 1 for punching out the rivet. It is noted that the step of engaging the pin to the rivet head, in which the pin is in the engaged position, can be left out.

[0053] In the retracted position shown in Fig. 3A, the pin 4 is substantially retracted inside the structure 1. The pin 4 can be in the retracted position between punching or when the rivet removal system 1 is not in use. In this position, the pin can be locked by a locking element 14, or can be held otherwise, e.g. by an elastic element or by the drive source. When the pin is in the retracted position, this allows a safe movement of the structure over the assembly without accidental collision of the pin 4 with an external object. Movement of the structure 2 over the compound assembly can therefore be achieved more easily and/or more safely if the pin 4 is not extending beyond the structure 2.

[0054] The engaged position shown in Fig. 3B is a position in between the retracted position and the extended position. In the engaged position, the pin 4 extends outwardly for engaging the rivet 32 of the compound assembly 30. The pin 4 can for example be driven from the retracted position to the engaged position by activating the electromotor 8 to apply a holding force equal to the force exerted by the spring 10. The locking element 14 might now be released. The electromotor 8, or another drive source, can now be controlled to release the holding force and allowing the pin 4 to move from the retracted position to the engaged position. The holding force can be reapplied when the pin 4 reaches the engaged position. In that case, the engaged position is an intermediate position including a stop moment. It might also be appreciated that the engaged position can be an intermediate position in a continuous movement from the retracted position to the extended position. For example, a first source of energy might be released to move or to allow to move the pin from the retracted to the engaged position. Once in the engaged position, a second source of energy, releasing more energy than the first source, can be released, to drive the pin further to the extended position. Then, a more or less continuous punching movement of the pin can be achieved between the retracted position and the extended position. The first source and the second source can e.g. be an elastic element that releases its energy in two steps, or can be two different elastic elements, or can be a drive source and an elastic element. Many combinations are possible. In an other embodiment, the locking element 14 can be arranged to reengage when the pin 4 reaches the engagement position, such that electromotor 8 does not need to keep applying the holding force. The engaged position can be used e.g. to check whether the pin 4 is positioned correctly with relation to the rivet 32. This check can for example be done by a human operator, who visually controls the positioning of the pin 4. The check can also be done instrumentally with use of instruments available on the structure 2, such as the rivet detection unit 22, or instruments available in the surrounding of the structure 2. It shall be appreciated that an embodiment of the invention does not necessarily include the engaged position. In some embodiments of the invention the pin 4 may only be driven between the retracted position and the extended position.

[0055] Fig. 3C shows the pin 4 in the extended position, in which the pin 4 extends substantially outside of the structure 2 in which it has punched out the rivet 32 from the compound assembly 30. The pin 4 might be moved to the extended position from the retracted position or from the engaged position. In both cases the elements holding the pin 4 in position, which can be the locking element 14 or the holding force applied by the electromotor 8, are disengaged, allowing the spring 10 to drive the pin 4 to the extended position. The spring 10 is thus biased towards the extended position of the pin 4. The pin 4 will remain in the extended position after punching out the rivet 32 depending on the how the spring 10, or an other elastic element 10, is mounted in the structure 2. For example, a tension spring 10 might be used as elastic element 10, as shown in fig. 1. In the extended or engaged position, the tension spring 10 might be extended beyond its resting position. The inertia of the pin 4 and the tension spring 10 might cause the tension spring 10 to compress beyond its resting position when driving the pin 4 outwards, resulting in the tension spring 10 pulling the pin 4 back into the structure 2. The pin 4 will then be slowed down, and at a maximum extension the sign of the direction of the movement of the pin 4 will change. The electromotor 8 can preferably be reengaged to pull the pin 4 back to the retracted position after the maximum extension is passed, to minimalize the energy required by the electromotor 8 to pull the pin 4 back to the retracted position by recuperating the energy applied by the tension spring 10 when pulling back the pin 4 to the resting position of the tension spring 10.

[0056] Fig. 4 is a flowchart representation of a process according to a method for removing rivets. The method represented in Fig. 4 is assumed to provide a rivet removal system 1 as illustrated in Fig. 1, comprising a pin alignment system 34 and having each of the rivet detection unit 22, the distance probe 26 and the pin 4 to be arranged at the side 19 of the structure 2 through which the pin 4 engages.

[0057] Block 100 represents the start of the process. The start can be seen as activating the rivet removal system 1 and external systems, such as a robot arm to which the structure 2 of the rivet removal system 1 can be connected. Pre-known data is loaded into the position information. The pre-known data can for example be CAD-data of a fuselage 30 containing the coordinates of the rivets in the fuselage 30. The pre-known data can also contain a starting coordinate, for example when nothing is known about the fuselage 30. The position information can be loaded into a memory included in the control unit 28 or in an external memory. At the start, the rivet removal system 1 is assumed to be near a compound assembly 30, such as an airplane fuselage 30.

[0058] In block 102, the structure 2 is positioned on or to the fuselage 30. The positioning is based on position information, in the first step containing only pre-known data. The position information can contain the coordinates of rivets 32 to be removed. Positioning of the structure 2 on the fuselage 30 is here achieved by controlling the robot arm to which the structure 2 is connected. The robot arm can for example be controlled by the control unit 28 or by a separate control unit, which in turn may communicate with the control unit 28 to exchange position information or other information. Other information can for example be a trigger signal to drive the pin 4 to the extended position or an inhibitor signal to prevent the pin 4 from being driven to the extended position. Other information can also be a warning signal derived from the distance measuring element 26 indicating that the difference between the structure 2 and the fuselage 30 is above a predetermined threshold, thus being not safe to punch the pin. Positioning of the structure 2 on the fuselage 30 entails that all the support elements 18 are in contact with the fuselage 30. Sensors, such as force sensors, moment sensors or pressure sensors, might be present in the support elements 18 to determine whether the support elements 18 are in contact with the fuselage 30.

[0059] The positioning of the structure 2 might depend entirely on the CAD-data. The CAD-data could, however, be a representation of the fuselage 30 as intended before the construction of the fuselage 30. It might be possible that an actual position of a rivet 32 deviates from the planned position of the rivet 32 present in the CAD-data. Therefore, in block 104, the rivet detection unit 22 will, after the positioning of the structure 2, detect the actual position of the rivet 32. The control unit 28 will, based on the distance between the actual position of the pin 4 and the actual position of the rivet 32, decide if alignment is necessary. The pin 4 may be perfectly or almost perfectly aligned with the rivet 32 right after the positioning of the structure 2 hence no alignment is necessary. The distance between the actual position of the pin 4 and the actual position of the rivet 32 may be within the reach of the pin alignment system 34. The control unit 28 will control the pin alignment system 34 to align the pin 4 with the rivet 32, represented in block 106. In an other scenario, the distance between the actual position of the pin 4 and the actual position of the rivet 32 may be too large to be compensated by the pin alignment system 34 or no rivet 32 may be detected. In this case the structure 2 will need to be repositioned.

[0060] The information gathered by the rivet detection unit 22 in block 104 might be used to update the position information. Updating the position information with actual coordinates can be of interest when multiple fuselage of the same type are to be dismantled. The position information gathered after the disassembly of a few similar fuselages might be used to create a probability distribution function.

[0061] In block 108, the drive unit 6 will drive the pin 4 to the engaged position. The control unit 28 controls the drive unit 6 to drive the pin 4 to the engaged position. The engaged position can be used to check whether the pin 4 is positioned correctly with relation to the rivet 32. This check can for example be done by a human operator, who visually controls the positioning of the pin 4. The check can also be done by repeating the rivet detection step of block 104. In some embodiments, block 108 is omitted, and block 110 will be executed after block 106.

[0062] In block 110, the drive unit 6 will drive the pin 4 to the extended position for punching out the rivet 32. The control unit 28 can be arranged to require a trigger signal before controlling the drive unit 6 to drive the pin 4 to the extended position. The trigger signal may come from a human operator or from an external processor. The control unit 28 can also be arranged to hold the pin

4 in the retracted position or the engaged position even when a trigger signal is given, for example when sensors in the support elements 18 indicate that the structure 2 is not positioned correctly.

[0063] In block 112, the drive unit 6 may drive the pin 4 to the retracted position. Block 112 will substantially always be executed, or at least be attempted, right after block 110, as there is no reason to keep the pin 4 in the extended position after punching out a rivet 32.

[0064] In block 114 it is determined whether other rivets 32 are present based on the position information. The process may end if all rivets 32 are removed or assumed to be removed. This assumption can be achieved when all the rivets 32 originally present in the CAD-data or detected by the detection unit 22 are removed or when the rivet removal structure 1 has covered the surface of the fuselage 30 reachable by the rivet removal structure 1. The process will continue to block 116 if any rivets 32 are still present or when a part of the surface of the fuselage 30 has not yet been covered by the rivet removal structure 1.

[0065] In block 116 the control unit 28 decides if repositioning is necessary. The rivet detection unit 22 may have detected a second rivet 32 which is also within the range of the positioning unit, such as the robot arm. Then, the robot arm can simply move the structure 2 to the next position. Otherwise, the rivet detection unit 22 may have detected that no rivet 32 remains within the range of the pin alignment system 34. In principle is the pin alignment system 34 for the fine-tuning of the position of the pin, and is usually not arranged to reach two adjacent rivets, unless they are located relatively close to each other. Usually, repositioning is necessary and the process continues at block 102.

[0066] The disclosure relates to removing rivets from a compound assembly, such as an airplane fuselage, or ship or bridge parts, by providing a rivet removal structure. The rivet removal structure comprises a pin that in an automated manner can punch out rivets from the compound assembly, and is being retracted inside the structure after the punching.

[0067] Herein, the invention is described with reference to specific examples of embodiments of the invention. It will, however, be evident that various modifications, variations, alternatives and changes may be made therein, without departing from the essence of the invention. For the purpose of clarity and a concise description features are described herein as part of the same or separate embodiments, however, alternative embodiments having combinations of all or some of the features described in these separate embodiments are also envisaged and understood to fall within the framework of the invention as outlined by the claims. The specifications, figures and examples are, accordingly, to be regarded in an illustrative sense rather than in a restrictive sense. The invention is intended to embrace all alternatives, modifications and variations which fall within the spirit and scope of the appended claims. Further, many of the elements that are described are functional entities that may be implemented as discrete or distributed components or in conjunction with other components, in any suitable combination and location.

Claims

1. Rivet removal system for removing rivets from a compound assembly; wherein the system comprises a structure in which a pin is mounted that is adjustable between a retracted position, in which the pin is substantially retracted inside of the structure, and an extended position in which the pin extends substantially outside of the structure for punching out the rivet from the assembly, wherein the pin is returned to its retracted position after punching; further comprising a drive unit arranged for driving the pin at least between the retracted position and the extended position.

2. Rivet removal system according to claim 1, wherein the drive unit further comprises an elastic element, wherein the elastic element biases the pin towards the extended position.

3. Rivet removal system according to claim 1 or 2, wherein the drive unit comprises a drive source that is arranged to return the pin from the extended position to the retracted position.

4. Rivet removal system according to any of the preceding claims, wherein the structure is connectable to a robot arm of a robot, in particular as a robot head of the robot arm.

5. Rivet removal system according to any of the preceding claims, further comprising support elements for supporting the system onto the assembly.

6. Rivet removal system according to any of the preceding claims, further comprising a positioning unit for positioning the structure with respect to the rivet.

7. Rivet removal system according to any of the preceding claims, further comprising a pin alignment system arranged to align the pin in a direction transverse to a punching direction.

8. Rivet removal system according to any of the preceding claims, further comprising at least one distance measuring element for measuring the distance between the structure and the assembly.

9. Rivet removal system according to any of the preceding claims, further comprising a collar extending outwardly from a side of the structure through which the pin engages.

10. Rivet removal system according to any of the preceding claims, further comprising a control unit for controlling the punch movement of the pin and/or for controlling the positioning of the structure over the assembly.

11. Rivet removal system according to any of the preceding claims, wherein the system further comprises a rivet detection unit for detecting a position of the rivet to be removed.

12. Rivet removal system according to claim 11, wherein the rivet detection unit is arranged inside the structure.

13. Rivet removal system according to claim 11 or 12, wherein the rivet detection unit comprises a detection sensor, preferably an eddy current sensor.

14. Rivet removal system according to claim 11, 12 or 13, wherein the rivet detection unit provides position information to the control unit and/or to a user interface connectable to the control unit.

15. Rivet removal system according to claim 14, wherein the control unit is configured to control the positioning of the structure based on position information received from the rivet detection unit.

16. Method for removing a rivet from a compound assembly, the method comprising

- providing a rivet removal system according to any of the claims 1 - 15;
- positioning a structure of the system over the rivet to be removed such that a pin of the system is aligned with the rivet to be removed; and
- driving the pin to its extended position to punch out the rivet from the assembly.

17. Method for removing a rivet according to claim 16, further providing position information on the position of the rivet to be removed; wherein the position information is based on pre-known data and/or wherein the position information is obtainable from a rivet detection unit.

18. Method for removing a rivet according to claim 17, further comprising positioning the structure based on the provided position information.

19. Method for removing a rivet according to any of the claims 16 - 18, further comprising moving the structure of the system to a next position of a next rivet to be removed for removing the said rivet.

20. Method for removing a rivet according to any of the claims 16 - 19, further comprising moving the pin to an engaged position, between the retracted position and the extended position, in which the pin extends outwardly for engaging to a rivet head of the assembly.

21. Control unit configured for controlling the removal of a rivet of a compound assembly using a rivet removal system according to any of the claims 1 - 15.

22. Control unit according to claim 21, wherein the control unit further is configured to provide a position signal based on position information of the rivet to be removed and/or to output the position information to a user interface.

23. Method for dismantling a fuselage of an airplane, comprising, removing the rivets from the fuselage according to the method of any of claims 16 - 20.

24. Robot comprising a rivet removal system according to any of the claims 1 - 15, wherein the rivet removal system is mounted as a robot head to the robot.

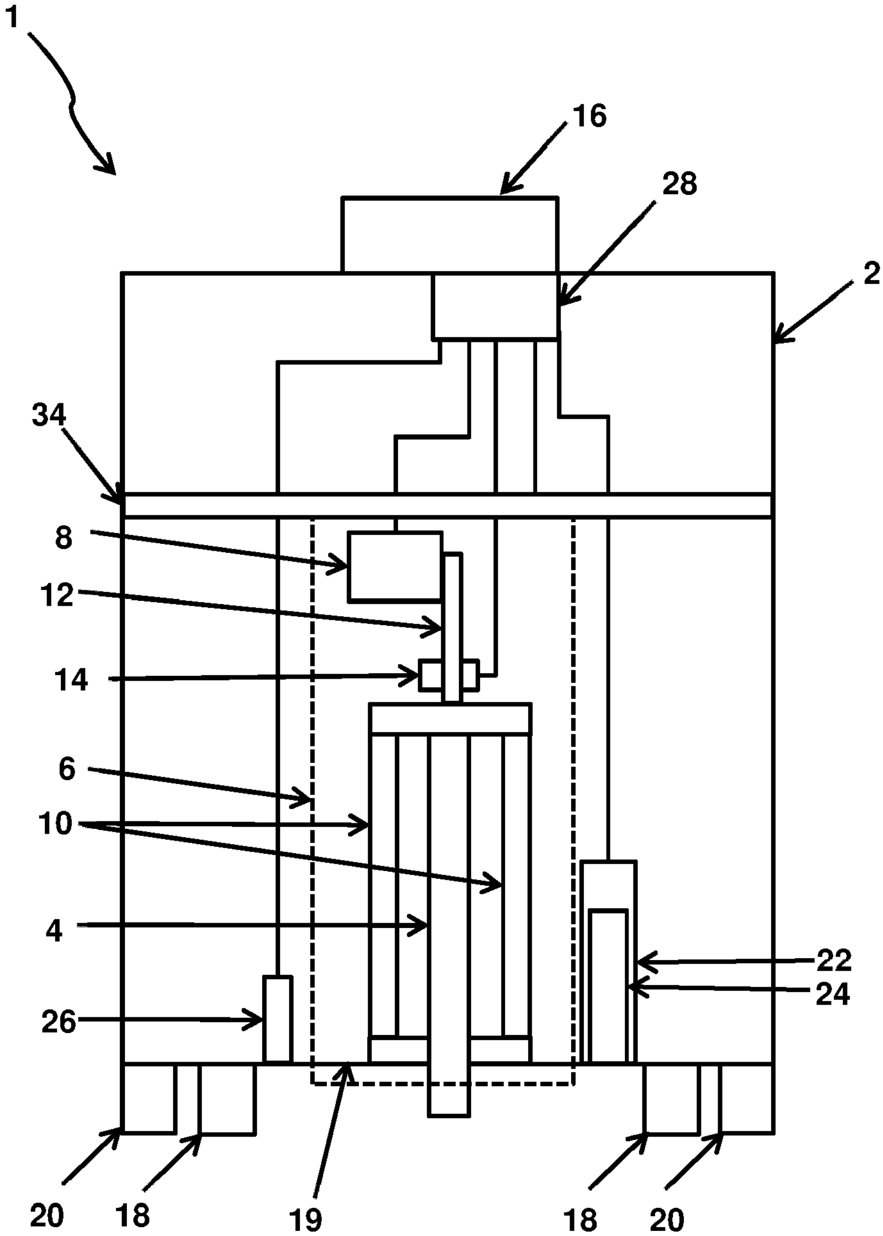

FIG 1

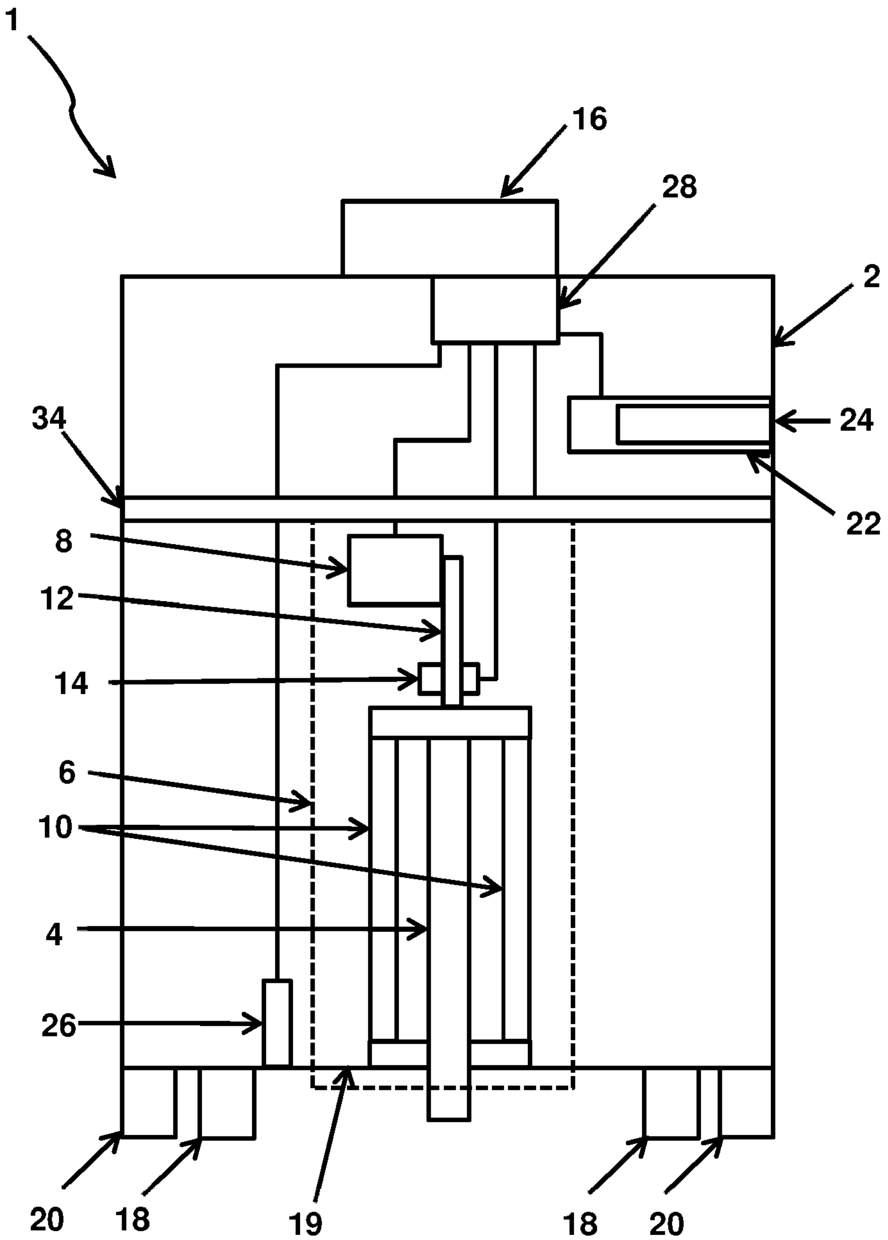

FIG 2

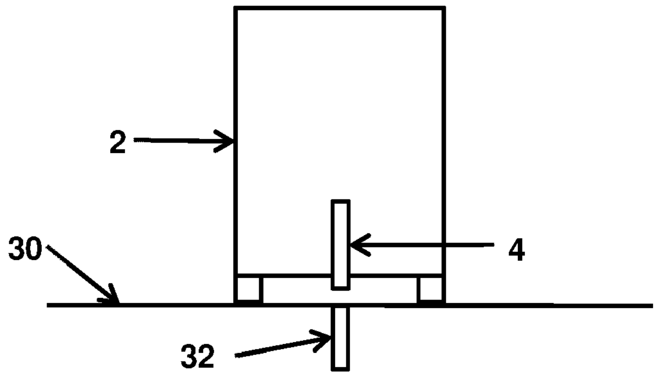

FIG 3A

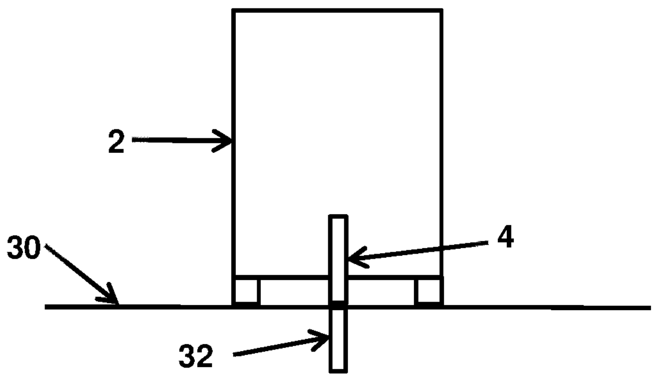

FIG 3B

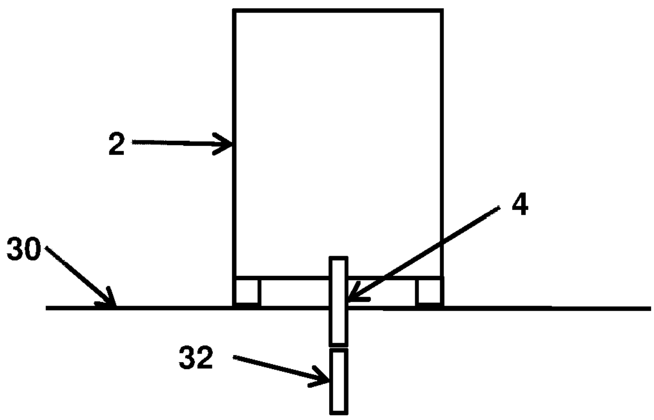

FIG 3C

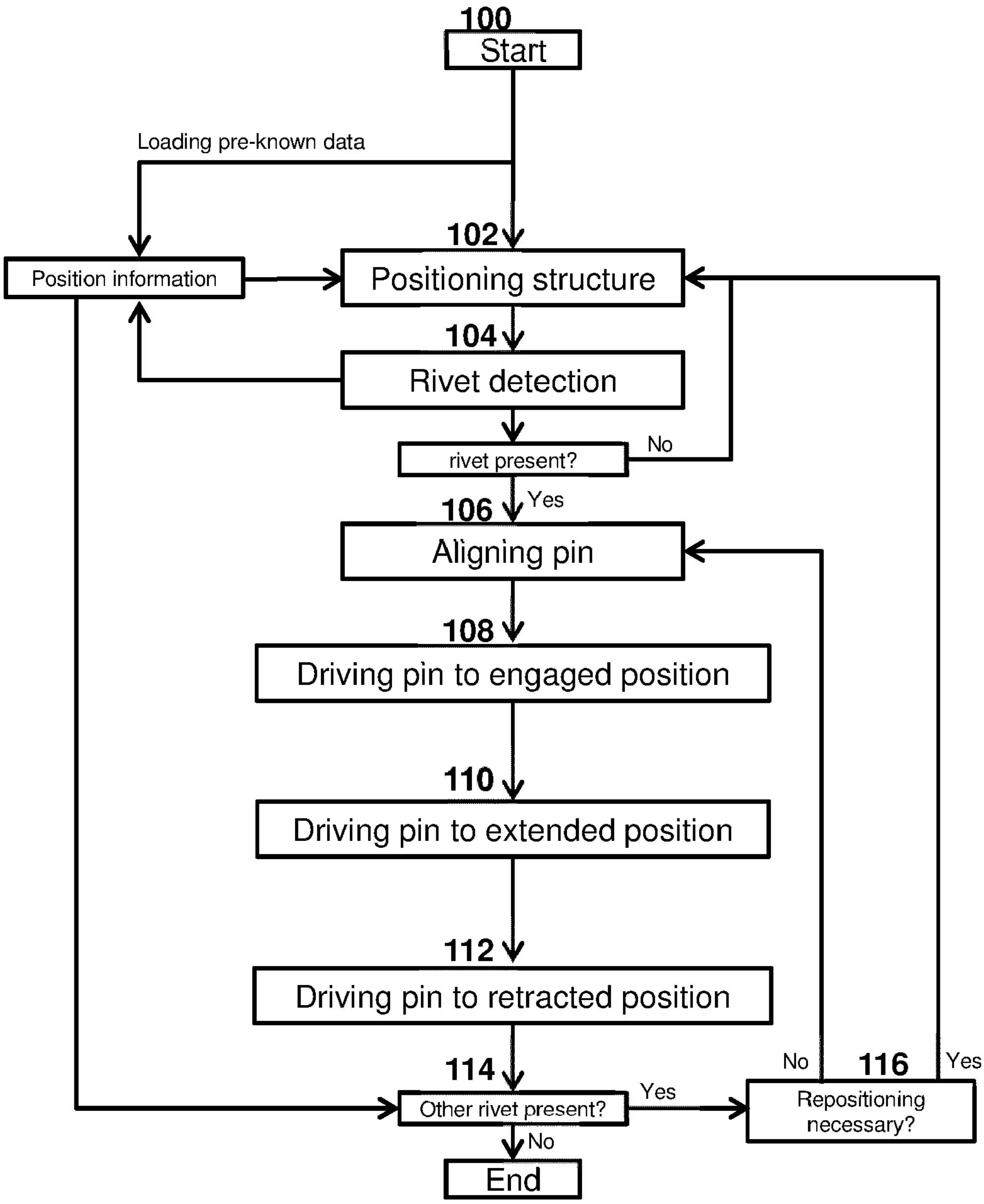
100
Start
Loading pre-known data
102
Position information
Positioning structure
104
Rivet detection
rivet present?
No
Yes
106
Aligning pin
108
Driving pin to engaged position
110
Driving pin to extended position
112
Driving pin to retracted position
114
Other rivet present?
Yes
No
End
No
116
Yes
Repositioning necessary?

FIG 4

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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 3422

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 4 365 401 A (OGREN ROBERT S) 28 December 1982 (1982-12-28) * column 4, line 27 - column 8, line 38; figures 1-3 * -----	1,4-7,9, 16,19,23	INV. B21J15/50 B21J15/28
X	US 3 176 399 A (MARINO ANTHONY J ET AL) 6 April 1965 (1965-04-06) * column 2, line 25 - column 4, line 37; figures 1, 9-10 * -----	1-5,16, 19,23	
X	DE 101 35 587 A1 (EADS DEUTSCHLAND GMBH [DE]) 13 February 2003 (2003-02-13) * paragraphs [0016] - [0017], [0021] - [0023], [0036]; figures 2, 4 * -----	8,10-15, 17,18, 20,22,24	
A	GB 955 381 A (EURATOM) 15 April 1964 (1964-04-15) * page 3, lines 79-115; figures 1, 3 * -----	20	

TECHNICAL FIELDS SEARCHED (IPC)

B21J
B25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 October 2020	Augé, Marc

2

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
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons
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EPO FORM 1503 03.82 (P04C01)

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Application Number

EP 20 16 3422

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 20 16 3422

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7, 9, 16, 19, 23

   Rivet removal system and method with details of the pin drive construction.

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2. claims: 8, 10-15, 17, 18, 20-22, 24

   Rivet removal system and method, as well as control unit and robot with details of robot automation control.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 16 3422

22-10-2020

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4365401	A	28-12-1982	NONE			
US 3176399	A	06-04-1965	NONE			
DE 10135587	A1	13-02-2003	CA	2453484	A1	20-02-2003
			DE	10135587	A1	13-02-2003
			EP	1409186	A1	21-04-2004
			PL	365275	A1	27-12-2004
			US	2004238497	A1	02-12-2004
			WO	03013775	A1	20-02-2003
GB 955381	A	15-04-1964	BE	613309	A	31-07-1962
			FR	1322835	A	05-04-1963
			GB	955381	A	15-04-1964
			NL	286244	A	22-10-2020