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

(11) **EP 4 140 615 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.03.2023 Bulletin 2023/09

(21) Application number: **21192693.6**

(22) Date of filing: **24.08.2021**

(51) International Patent Classification (IPC):
B21J 15/04 *(2006.01)* ***B21J 15/14*** *(2006.01)*
B21J 15/28 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B21J 15/04; B21J 15/043; B21J 15/142; B21J 15/28

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Airbus Operations GmbH**
21129 Hamburg (DE)

(72) Inventors:
- **Roye, Thorsten**
  21129 Hamburg (DE)
- **Jendrny, Jörg**
  21129 Hamburg (DE)

(74) Representative: **Isarpatent**
Patent- und Rechtsanwälte Barth
Charles Hassa Peckmann & Partner mbB
Friedrichstrasse 31
80801 München (DE)

(54) METHOD FOR INSTALLING A BLIND FASTENING DEVICE, AND USE OF A LONGITUDINAL PASSAGE OF A SLEEVE OF A BLIND FASTENING DEVICE

(57) A method for installing a blind fastening device (100; 100a) in a bore (28; 28a) provided in a structure (20; 20a) having a first (A) and second side (B) is proposed. Furthermore, a use of a longitudinal passage (32; 32a) of a sleeve (31'; 31a'), provided for forming part of a blind fastening device (100; 100a) and installed in such a structure (20; 20a), for performing an inspection of the sleeve (31'; 31a') or of at least a portion thereof via the passage (32; 32a) or for performing additional work on the sleeve (31'; 31a') and/or in the vicinity thereof on the second side (B) of the structure (20; 20a) via the passage (32; 32a) or for performing both inspection and additional work is proposed. The installed sleeve comprises a deformed sleeve zone (33; 33a) engaging the structure on the second side. The longitudinal passage is configured for at least partially receiving a core bolt (105; 105a) in such a manner that the core bolt can be accessed from the first side and can be tightened with respect to the installed sleeve.

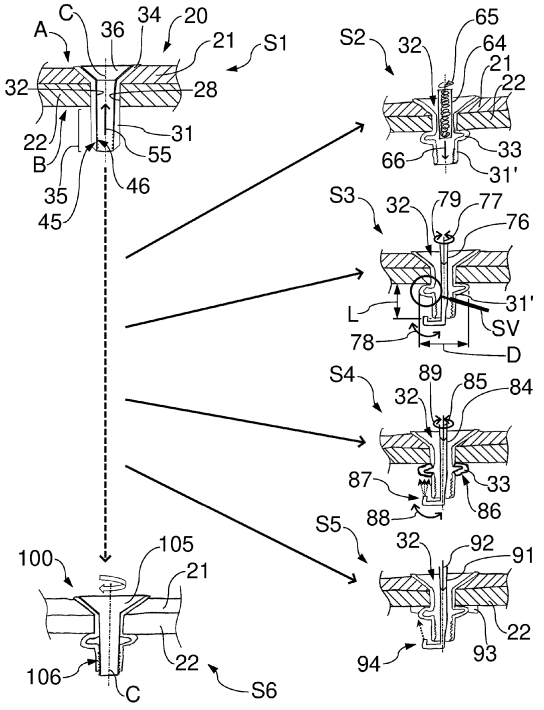

Fig. 3

EP 4 140 615 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to a method for installing a blind fastening device in a bore provided in a structure, in particular in the field of aircraft or spacecraft production. Furthermore, the invention relates to a use of a longitudinal passage of a sleeve provided for forming part of a blind fastening device, particularly of a blind fastening device of this kind, in particular in the field of aircraft or spacecraft production.

TECHNICAL BACKGROUND

[0002] Although the invention may be useful in various applications, e.g. in the production of structures that are generally shaped in the manner of a closed box or similar, the invention and the underlying problem will be explained in the following in exemplary manner with regard to the manufacturing of structures in aircraft or spacecraft production, without limiting the invention to that effect.

[0003] In the field of manufacturing of aircraft or spacecraft, today, blind fasteners are considered useful for enabling efficient automated production. A reason for this is that for installing the fastener, access is only necessary from a single side of the structure. Also, blind fasteners are used today for applications such as, for example, the closing of box-like structures. Furthermore, blind nuts are installed today widely in aircraft structures and are used for fastening a component using a bolt.

[0004] In a conventional approach, after the blind fasteners have been installed, for the purpose of quality control the correct installation thereof can be checked on the "blind" or hidden side for example visually, using e.g. an endoscope, through access holes in the structure. Additional work steps, for instance for conservation of the connection against corrosion, to secure electrical conductivity, or for marking of the connection, are accordingly carried out by manual processes, which require at least some access to the "blind" side of the fastener. Such conventional procedures of inspecting the connection or performing further work, like conservation or marking, are time-consuming and expensive manufacturing steps.

[0005] Also, the manual processes of inspecting or carrying out further work on the fastener on the "blind" side just described cannot be performed if the structure where the fasteners are installed is truly blind, i.e. if there are no access openings at all that would allow these operations.

[0006] In FR 2 999 707 A1, for example, a method for installing a blind fastener having a breaking point has been proposed, wherein the method includes receiving acoustic signals during the installation process. FR 2 999 707 A1 describes that using this process, it is possible to follow the installation and make sure that the installation and resulting assembly fulfill the mechanical requirements regarding traction and preload.

[0007] As an example, another blind rivet is described in WO 2018/007324 A1 and in US 2019/ 0186522 A1. The rivet comprises a screw and a bushing. The bushing has an essentially cylindrical body having a deformation zone that is initially cylindrical and is designed to form an external bulge, as well as a tapped portion engaging with a threaded portion of the screw. In order to install the blind rivet, the bushing is inserted into a bore of a structure from the side of a first surface thereof, a collar of the bushing is maintained in contact with the first surface, and axial traction is applied to the screw in order to form the external bulge. Then, the screw is screwed into the bushing until a head of the screw contacts the collar of the bushing.

[0008] Also, in an existing method for installing a blind fastener, a bushing or sleeve may be installed and fixed in a first step using a dedicated installation pin, which is then removed in a subsequent step before inserting the final core bolt to complete the connection.

[0009] Against this background, it would in particular be desirable to be able to perform quality control and/or additional work steps ("re-work"), like e.g. conservation, painting, sealing, marking, in a more efficient manner and/or render such quality control and additional work steps possible also if the fastening device is installed into a really blind structure, such as a completely closed box-type structure.

SUMMARY OF THE INVENTION

[0010] In view of this, the problem to be solved by the present invention is to enable more efficient quality control and/or additional work on blind fastening devices and/or to enable or facilitate the production of efficient and reliable blind structures.

[0011] According to the present invention, this problem is solved by a method for installing a blind fastening device having the features of claim 1 and/or by a use of a longitudinal passage having the features of claim 15.

[0012] Accordingly, the invention provides a method for installing a blind fastening device in a bore provided in a structure. The structure has a first side and a second side. The method comprises steps of:

- inserting a sleeve into the bore from the first side of the structure;
- using a core element arranged in a longitudinal passage of the sleeve and accessible from the first side, forming a deformed sleeve zone engaging the structure on the second side thereof to install the sleeve in the structure;
- removing the core element from the longitudinal passage of the installed sleeve;
- inserting at least one inspection device at least partly into or through the longitudinal passage of the installed sleeve, performing inspection of the installed sleeve or of at least a portion thereof using the inspection device, and removing the inspection device

from the longitudinal passage;
and/or
inserting a working device at least partly through the longitudinal passage of the installed sleeve, performing additional work, on the second side of the structure, on the installed sleeve and/or in the vicinity thereof using the working device, and removing the working device from the longitudinal passage; and

- inserting a core bolt into the longitudinal passage of the installed sleeve and tightening the core bolt with respect to the installed sleeve, wherein the core bolt in particular is or corresponds to the core element or is another element.

[0013] Further, the invention provides a use of a longitudinal passage of a sleeve, provided for forming part of a blind fastening device and installed in a structure having a first side and a second side,

- for performing an inspection of the sleeve or of at least a portion thereof via the longitudinal passage or
- for performing additional work on the sleeve and/or in the vicinity thereof on the second side of the structure via the longitudinal passage or
- for performing both of the inspection and the additional work.

[0014] The sleeve is partially arranged within a bore provided in the structure. Moreover, the sleeve comprises a deformed sleeve zone engaging the structure on the second side thereof. The longitudinal passage of the sleeve is configured for at least partially receiving a core bolt in such a manner that the core bolt can be accessed from the first side and can be tightened with respect to the installed sleeve.

[0015] An idea underlying the invention is to perform, between two steps of a two-step installation process of a blind fastening device, one or more operations related to quality control, or one or more operations related to "re-work" to be done on the seated sleeve, or both quality control and "re-work" operations, by using an access to a blind side of a structure through a passage extending through the sleeve of the fastening device and in particular temporarily unblocked between these two steps. In particular, the operations of checking and/or performing additional work ("re-work") are carried out between the installation of the sleeve and the final installation of the core bolt.

[0016] In the present invention, the core element that is arranged in the longitudinal passage of the sleeve for being used for forming the deformed sleeve zone may be a temporary core element which is not identical to the final core bolt but is a separate element and may be of different type, or instead the core element may be or correspond to the core bolt which, in this case, is used to form the deformed sleeve zone, temporarily removed from the longitudinal passage and, after the inspection and/or additional work, is re-inserted into the longitudinal passage as the final core bolt and tightened.

[0017] The invention in particular contributes to securing the performance of blind fasteners used in closed-box structures and to enabling implementation of truly blind structures that it has not been possible to produce hitherto, or that could be produced hitherto only with considerable difficulty and expense. Also, the invention significantly facilitates automated production of closed box structures, and in particular of really blind structures with substantially no access to the blind side. Because quality control and re-work on blind fastening devices are made possible by the invention in the production of truly blind structures, assembly concepts can be envisaged that were not feasible hitherto.

[0018] When installing a plurality of blind fastening devices, in particular a large number thereof, the invention advantageously makes it possible to economically inspect substantially all of them for correct installation, and to make sure all of the fastening devices are correctly set. In particular, the invention also makes it possible to ensure that each of the fastening devices complies not only with the mechanical requirements, but also with requirements that may necessitate additional treatment of the fastening device or in the vicinity thereof on the blind side, such as requirements of electrical conductivity and lightning strike compatibility and/or resistance to corrosion, for example. This may be advantageous in particular for fastening devices in closed boxes or "blind" installations.

[0019] Further, the invention in particular makes it possible to employ quality control and testing procedures that hitherto could not be used on blind fasteners, such as eddy current testing for detection of flaws or cracks in the deformed sleeve zone, for example.

[0020] Specifically, the invention in particular proposes to perform some or all checks required or desirable to secure the quality of the installation, and/or additional work which may comprise work steps such as sealing or painting operations, on the blind side of the fastening devices, between two fastener installation steps - the installation of the sleeve, and the installation of the final core bolt - via access through the sleeve element.

[0021] In particular, advantageously, the invention enables to check up to 100 percent of the deformed part of the blind fastening devices even in truly blind applications. Hence, the number and dimensions of the blind fastening devices can be even more precisely selected to meet the relevant requirements without unnecessarily increasing work load and structural weight.

[0022] Advantageous improvements and developments of the invention are contained in the dependent claims as well as in the description referring to the drawings.

[0023] According to a development, the inspection of the installed sleeve comprises non-destructive testing of the installed sleeve or of at least a portion thereof. The non-destructive testing may in particular by carried out using an electromagnetic non-destructive testing proce-

dure, for example using eddy-current testing, or using a laser-based non-destructive testing procedure, for example a non-destructive testing procedure including laser scanning. Other non-destructive testing procedures may be used in other developments.

[0024] In particular, the non-destructive testing is performed in a non-contact manner, but non-destructive testing involving contact is conceivable in alternative developments, too.

[0025] In accordance with a development, the method comprises inserting, using and removing, as the inspection device, a non-destructive testing device. The non-destructive testing device may, in particular, be an electromagnetic testing device. In an advantageous development, the non-destructive testing device may be an eddy-current testing device. In a further advantageous development, the non-destructive testing device may be a laser-based testing device, for example a testing device configured to perform laser scanning.

[0026] In particular, in a development the non-destructive testing device is a device configured for performing intrusive non-destructive testing, in other words non-destructive testing including intrusion into an opening or a passage, more specifically into the longitudinal passage of the sleeve. In particular, the non-destructive testing device comprises at least a forward portion insertable into the longitudinal passage of the installed sleeve. The forward portion may, for example, be formed as or comprise a probe that is used to perform the non-destructive testing.

[0027] Using non-destructive testing, it can hence be checked in an economical manner whether the properties, in particular the geometrical dimensions and/or deformation mode, meet pre-defined requirements. Also, it can be economically and reliably verified that the sleeve is free from cracks or other mechanical anomalies that might appear when forming the deformed sleeve zone. In particular, using the insertable forward portion, it is possible to make use of the unblocked passage for performing non-destructive testing in advantageous manner.

[0028] According to a development, the inspection of the installed sleeve comprises visual inspection of the installed sleeve or of at least a portion thereof on the second side of the structure, in particular visual inspection of the deformed sleeve zone or of a portion thereof.

[0029] In accordance with a development, the method comprises inserting, using and removing, as the inspection device, a borescope comprising a forward portion that is insertable into and through the longitudinal passage of the installed sleeve.

[0030] Such visual inspection can additionally contribute to the safety and reliability of the structure that is produced, and anomalies that due to their nature may not or not easily be detectable using the chosen non-destructive testing procedure can be discovered and corrected.

[0031] According to a development, the inspection of the installed sleeve includes inspecting a geometry of the installed sleeve. In particular, the inspection of the installed sleeve may include inspecting actual geometrical dimensions of a portion of the installed sleeve protruding from the second side of the structure. More particularly, the inspection may include inspecting an axial length of the portion of the installed sleeve protruding from the second side of the structure and/or a width or outer diameter of the deformed sleeve zone. Dimensional values may relatively easily be detected and compared to a set of target values and provide a useful indication regarding whether the installation of the sleeve has been accomplished as desired or, on the contrary, an anomaly occurs.

[0032] In accordance with an improvement, the inspection of the installed sleeve includes testing the installed sleeve or at least a portion thereof for the presence of cracks and/or includes inspecting the deformed sleeve zone for the presence of a target mode of deformation or for the presence of an undesired mode of deformation or both. In this manner, it can be ensured that the sleeve is appropriately installed and securely mechanically fixed in the bore and/or has the required mechanical resistance.

[0033] According to a development, performing the additional work on the installed sleeve includes coating or re-coating at least a portion of the installed sleeve, in particular by coating or re-coating the deformed sleeve zone or at least a portion thereof. In this way, even in case of installing the blind fastening device in a fully blind structure, it can be made sure that the sleeve and in particular the deformed sleeve zone are properly coated, and, for instance, corrosion resistance of the sleeve and/or electrical conductivity and lightning strike compliance can be ensured.

[0034] In a development, the method comprises inserting, using and removing, as the working device, a coating applying device comprising a forward portion that is insertable into and through the longitudinal passage of the installed sleeve and is formed with a coating material outlet region. The coating material outlet region may in particular be configured as a nozzle adapted for ejection of the coating material. Accordingly, the coating material can be delivered in a targeted manner onto a target region.

[0035] According to a development, performing the additional work on the installed sleeve includes applying a sealant, for example along a contact region between the deformed sleeve zone and the structure on the second side thereof, wherein the sealant in particular is applied as a liquid or as a paste-like material. This may contribute to ensure that the sleeve is tightly sealed against the structure, even in case the structure is truly blind.

[0036] In a development, the method comprises inserting, using and removing, as the working device, a sealant applying device comprising a forward portion that is insertable into and through the longitudinal passage of the installed sleeve and is formed with a sealant outlet region.

The sealant outlet region may in particular be configured as a nozzle adapted for ejection of the sealant.

[0037] The application of sealant and/or coating in line with the developments described above, i.e. the sealing or painting operations performed using the access via the longitudinal passage, make it possible to efficiently secure corrosion resistance, lightning strike performance, tightness and/or conservation in closed structures.

[0038] According to a development of the invention, the blind fastening device is a blind rivet. Further, according to a development, the blind fastening device comprises a blind rivet nut. In particular, the sleeve of the blind fastening device may be formed as a blind rivet nut.

[0039] In particular, the blind fastening device may be a high-strength blind fastening device.

[0040] In an implementation, for forming the deformed sleeve zone, the core element may in particular be axially moved while the sleeve is maintained in its position relative to the bore and/or the core element may, for forming the deformed sleeve zone, be rotated while the sleeve is maintained in its position and orientation relative to the bore. Accordingly, the invention may in various developments thereof be used in connection with so-called pull-type blind fastening devices, in which, for forming the deformed sleeve zone, an axial pulling motion is imparted to the core element, or the invention may be used in connection with so-called thread-type blind fastening devices, in which, for forming the deformed sleeve zone, a rotational motion is imparted to the core element. Also, in further developments, the invention may be used in connection with blind fastening devices in which pulling and threading motion of the core element are combined.

[0041] In a development, the sleeve is provided, within a part of a section of the sleeve that protrudes from the second side of the structure after insertion of the sleeve into the bore, with an internal thread engageable with an external thread of the core element. In particular, the final core bolt comprises an external thread engageable with the internal thread of the installed sleeve and the step of inserting and tightening the core bolt comprises screwing the core bolt into the installed sleeve.

[0042] Using a sleeve that is provided with a thread, for threaded engagement with the core element and the final core bolt, makes it possible to comparatively easily remove the core element and perform inspection and/or additional work via the unblocked tapped portion of the passage, before installing the final core bolt by re-installing the core element as the final core bolt or by installing a core bolt being an element different from the core element that is temporarily used to form the deformed sleeve zone.

[0043] In various developments of the invention, the sleeve or blind nut element and/or the core bolt may be of a type that as such is/are currently available and suitable for installing a blind fastening device in a two-step process, in particular using a separate, removable installation pin. Hence, the invention may be applied in connection with a wide variety of types of blind fastening devices.

[0044] In a development, the inspection of the sleeve or of at least a portion thereof and/or the additional work on the sleeve and/or in the vicinity thereof on the second side of the structure is or are performed at least partially within a space between a containment cap arranged on the second side of the structure and the portion of the installed sleeve protruding from the structure on the second side. In particular, the inspection device(s) and/or the working device(s) may be partially inserted into the space between the containment cap and the protruding portion of the installed sleeve. The containment cap may in particular be a containment cap for lightning protection. In particular, the containment cap is attached to a component of the structure, in a region where the bore is or will be formed, before the structure is closed. The invention thus advantageously can enable or facilitate inspection and/or additional work which otherwise would be very difficult or would not be possible due to the presence of the containment cap.

[0045] According to a development, the structure is a closed-box structure. The method and use of the invention can be particularly useful for installing blind fastening devices in closed-box structures, in which access for performing inspection or re-work otherwise is difficult.

[0046] Further, the structure in particular is a structure of an aircraft or spacecraft. Specifically, in various developments of the invention, the structure can be a wing or a part of a wing, a wing box or a part of a wing box, a center-wing box or a part of a center-wing box, or a stabilizer or a part of a stabilizer. Moreover, in further developments, the structure may be a rudder or a part thereof, an elevator or a part thereof, an aileron or a part thereof, a flap or a part thereof, or a slat or a part thereof. In this way, the invention can be useful for producing in an efficient and reliable manner a great variety of different, large or small box-like structures. In particular, the invention may be applied in wide variety of structural assembly processes in aircraft or spacecraft production.

[0047] In further developments, additional quality control may be performed during forming the deformed sleeve zone for installing the sleeve in the structure, for example by monitoring force and/or torque applied to the core element and/or by monitoring axial and/or rotational displacement of the core element, during forming the deformed sleeve zone. Hence, reliability can additionally be increased further.

[0048] Moreover, in further developments, additional quality control may be performed during tightening the core bolt for installation thereof, for example by monitoring torque applied to the core bolt and/or by monitoring an angle through which the core bolt is rotated during tightening and/or by inspecting a final head projection of the core bolt. Thus, quality control can also be performed to make sure that the final core bolt is correctly set and tightened.

[0049] The improvements, enhancements and developments of the present invention may be arbitrarily com-

bined with each other whenever this makes sense. Moreover, other possible enhancements, developments and implementations of the present invention comprise combinations of features of the invention which have been described above or will be described in the following in relation to the detailed description of embodiments, even where such a combination has not been expressly mentioned.

[0050] In particular, the improvements, developments and enhancements of the invention described above may be applied in analogous manner to each of the method and use proposed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051] The invention will be explained in the following with reference to the schematic figures of the drawings which illustrate embodiments of the invention. Herein:

Fig. 1 displays a perspective view of an exemplary aircraft in the production of which embodiments of the invention can be applied;

Fig. 2 displays an exemplary structure of "closed-box" type in a perspective, schematic view;

Fig. 3 illustrates steps of methods and uses according to embodiments of the present invention;

Fig. 4 illustrates methods and uses according to further embodiments of the present invention; and

Fig. 5 illustrates an exemplary step of further embodiment.

[0052] The enclosed drawings are intended to illustrate embodiments of the invention so that the invention may be further understood. The drawings, in conjunction with the description, are intended to explain principles and concepts of the invention. Other embodiments and many of the advantages described may be inferred from the drawings. Elements of the drawings are not necessarily drawn to scale.

[0053] Elements, features and components which are identical or which have the same function or effect have been labeled in the drawings using the same reference signs, except where explicitely stated otherwise.

DETAILED DESCRIPTION OF EMBODIMENTS

[0054] Fig. 1 shows an airplane 1, e.g. a commercial passenger airplane, as an example of an aircraft or spacecraft in which embodiments of the invention may be used in exemplary and advantageous manner. The aircraft 1 comprises a fuselage 3, wings 4, an empennage 6 including a vertical stabilizer 10 and a horizontal stabilizer 15, as well as engines 8 attached to the wings 4. The wings 4 each have a trailing edge 5, the vertical stabilizer 10 has a trailing edge 11, and the horizontal stabilizer 15 has a trailing edge 16. Reference sign 19 schematically indicates the location of a center wing-box.

[0055] The structure or airframe of the aircraft 1 may be formed, for example, from light metal components, such as from components made from one or more aluminum alloys, or may be formed from fibre-reinforced composite components including a synthetic matrix and reinforcing fibres embedded therein, or from a combination of metal and fibre-reinforced composite components.

[0056] Furthermore, the structure or airframe of the aircraft 1 includes various box-like structures, at least some of which can be designed as truly closed boxes. For the example, the wings 4 or parts thereof, for instance the wing-box, the center wing-box 19 and/or the stabilizers 15, 16 or a part of these may form such closed-box structures. Further, a rudder in the region of the trailing edge 11 of the vertical stabilizer 10, an elevator in the region of the trailing edge 16 of the horizontal stabilizer 15, ailerons in the region of the trailing edge 5 of the wings 4, and/or a flap or slat provided on the wing 4, or part thereof, may form a closed-box structure.

[0057] In Fig. 2, a fully closed box-type structure 200 is schematically illustrated. The structure 200 has a bottom and top wall, a front and back wall, as well as side walls. The walls are substantially closed without any significant opening that would allow access to an interior of the structure 200. The geometry of the structure 200 in Fig. 2 is merely exemplary and shown for purposes of illustration, but it should be understood that the invention can be applied to a wide variety of structures, and in particular to a wide variety of closed-box structures, in particular in an aircraft or spacecraft, for example to any one of the closed-box structures of the aircraft 1 described herein above.

[0058] Fig. 2 also schematically illustrates, in exemplary manner, two connection regions 201 and 202, in which fastening devices are installed for connecting components to the structure 200 and/or for connecting another element to a component of the structure 200. It should be understood that the structure 200 may include only one of the regions 201, 202, or may be provided with a plurality of regions 201 and/or 202.

[0059] In the connection region 201, two overlapping components of the structure 200, which are not illustrated in more detail in Fig. 2, are connected to each other using a plurality of blind fastening devices 100. Furthermore, in the connection region 202, a further element has been attached to a component of the structure 200 using a plurality of blind fastening devices 100a.

[0060] The blind fastening devices 100 and 100a and operations carried out during installation thereof will be explained in the following with reference to Figs. 3 to 5. The explanations will refer, regarding Figs. 3 and 5, to a structure 20, and regarding Fig. 4, to a structure 20a. The structures 20, 20a each can correspond to the box-type structure 200 shown in exemplary manner in Fig. 2, or to a structure of another type. In particular, the structures

20, 20a can be box-type structures of the aircraft 1 such as a wing, wing box, center-wing box, stabilizer, rudder, elevator, aileron, flap or slat, or part thereof.

[0061] Fig. 3 schematically illustrates steps of embodiments of a method for installing a blind fastening device or blind fastener 100, which is formed as a blind rivet, in a bore 28 provided in a structure 20. Only a portion of the structure 20 is shown in Fig. 3. The structure 20 comprises two at least partially overlapping first and second components 21, 22, which can each be formed from a sheet-type material. The components 21, 22 may be metal sheets or sheets made from a fibre-reinforced synthetic material, or a combination thereof, but the components 21, 22 could be made from other material and/or be shaped in a different manner. Fig. 3 shows two components 21, 22 in exemplary manner, but it should be understood that the structure 20 can in variants of the embodiment comprise more than two components 21, 22, for example more than two overlapping sheets.

[0062] The structure 20 has a first side A and a second side B. As explained above, the structure 20 may, in advantageous embodiments, be a closed-box structure of the aircraft 1, with the first side A being an outer, accessible side, and the second side B being an inner, "blind" side of the structure 20 that can be accessed only with difficulty or not at all. The bore 28 is provided in the form of a through-hole extending through both components 21, 22 along a center axis C of the bore 28. The bore 28 preferably is substantially circular in cross-section and can be obtained by drilling through the arrangement of the first component 21 and the second component 22, or, if more than two components 21, 22 are provided, through the plurality of components.

[0063] In Fig. 3, reference sign S1 indicates a situation in which a sleeve 31, which may be substantially rotationally symmetric, has been inserted into the bore 28 along the center axis C, from the first, accessible side A. The sleeve 31 comprises a longitudinal internal passage 32 along a longitudinal axis of the sleeve 31, which coincides with the centerline C when the sleeve 31 has been inserted into the bore 28 as shown for situation S1. On one end thereof, oriented towards the first side A, the sleeve 31 is provided with a collar 34. In Fig. 3, the bore 28 has been countersunk from the first side A in order to accommodate the collar 34. In this way, an abutment for the sleeve 31 is provided.

[0064] In the state S1, when the collar 34 is fittingly arranged within the countersunk portion of the bore 28 and abuts on the first component 21 of the structure 20, a section 35 of the sleeve 31 protrudes from the structure 20 on the second, blind side B thereof. In the vicinity of an end that is distal relative to the collar 34, and within a part of the section 35, the longitudinal passage 32 of the sleeve 31 is provided with an internal thread 46. Along the center axis C, the thread 46 is spaced from a surface of the structure 20 by an unthreaded part of the section 35.

[0065] Before the sleeve 31 is inserted into the bore 28, a temporary core element 36 in the form of a temporary core bolt, is inserted into the passage 32 and may be screwed into the sleeve 31. For this purpose, the temporary core bolt 36 comprises an external thread 45 engageable with the internal thread 46 of the sleeve 31.

[0066] After inserting the sleeve 31 into the bore 28, the temporary core bolt 36 can be accessed from the first side A. In order to securely install the sleeve 31 in the structure 20, the sleeve 31 is maintained in its position and orientation relative to the bore 28, for example restrained against being pulled out of the bore 28 and against being rotated, by a suitable tool, not shown in Fig. 3.

[0067] Then, using the tool, the temporary core bolt 36 is axially pulled along the center axis C toward the first side A, in such a way that axial traction 55 acts on that portion of the sleeve 31 having the internal thread 46. In this way, within the unthreaded part of the section 35, a deformed sleeve zone 33 of the sleeve 31, or "bulb" 33, is formed, which engages a surface of the second component 22 of the structure 20 on the second side B to firmly attach the sleeve 31 to the structure 20 and firmly connect the first and second components 21, 22.

[0068] Alternatively, instead of pulling, the temporary core bolt 36 can be rotated about a longitudinal axis thereof parallel to the centerline C. By rotating the temporary core bolt 36 while applying sufficient torque, axial traction 55 can be applied to the portion of the sleeve 31 having the internal thread 46, whereby the unthreaded part of the section 35 can be deformed to form the deformed sleeve zone 33 or "bulb".

[0069] In further variants, the actions of pulling and rotating the temporary core bolt 36 might be used in combination.

[0070] The head of the temporary core element 36 and the threads 45 thereof can be accordingly adapted for a "pull-type" or "threaded-type" installation of the sleeve 31 or a combination thereof.

[0071] After the sleeve 31 has been securely installed by forming the deformed zone 33, the temporary core element 36 is removed from the longitudinal passage 32. For this purpose, the threads 45, 46 are disengaged by unscrewing the temporary core element 36, which is then taken out of the passage 32 from the first side A. In the resulting state, the internal, longitudinal passage 32 is unblocked. The installed sleeve, comprising the deformed sleeve zone 33, will be denoted by reference numeral 31' in the following.

[0072] In the following, it will be described how in accordance with embodiments of the invention access within and through the unblocked passage 32, in particular past the open thread 46, is used to perform different tasks of quality control and re-work of the seated sleeve 31'.

[0073] An inner diameter of the passage 32 may, for example, be within a range of about 4 mm to about 10 mm, although passages 32 having smaller or larger inner diameters are conceivable, too.

[0074] When the sleeve 31, which may also be termed

a "nut element", is deformed in order to securely connect the components 21, 22 to each other, or more than two components if the bore 28 extends through more than two of such components, and at the same time to secure the sleeve 31 within the bore 28, it may be desirable that an appropriate target deformation mode of the circumferential wall of the sleeve 31 be obtained. Also, it may be desirable that cracks in the sleeve 31 and more specifically in the deformed sleeve zone 33 or "bulb" be detected. Checking the final properties of the seated sleeve 31 or nut element is hence desirable, and performing these checks before installing a final core bolt element offers the advantage of being able to access the inside of the passage 32 as well as the second or back side B.

[0075] In order to perform quality control on the installed sleeve 31' in order to ensure that it is correctly installed, the longitudinal passage 32 of the installed sleeve 31' is used for inspecting the sleeve 31' and accessing the backside B.

[0076] In the state S2 shown in Fig. 3, electromagnetic non-destructive testing of the installed sleeve 31' or portions thereof is performed, in particular eddy-current testing, which makes use of induction. In order to perform the non-destructive testing, an inspecting device 64 is partly inserted from the first, accessible side A of the structure 20 into the longitudinal passage 32.

[0077] The inspection device 64 is an electromagnetic testing device for inspection using the eddy current testing method and may, for example, be rotated, as indicated by reference numeral 65, during testing. Electromagnetic, non-contact inspection of the sleeve 31' using eddy current is performed in situation S2 to verify that the geometry of the installed sleeve 31', corresponds, e.g. within a specified range of permissible deviation, to a predefined target geometry. Further, the electromagnetic inspection indicated by S2 can be used to verify that a target mode of deformation is present in the deformed sleeve zone 33, i.e. that this zone has been formed as desired. Further, the electromagnetic inspection in situation S2 is used to verify that the sleeve 31', in particular in the deformed sleeve zone 33, is free from cracks or other flaws.

[0078] In variants, in situation S2, the inspection device 64 may be a laser-based testing device for performing non-destructive testing based on laser technology, for example using laser scanning of the sleeve 31', in order to verify the correctness of the geometry and deformation mode of the sleeve 31' and detect any cracks or anomalies introduced when the deformed sleeve zone 33 is formed, if cracks or anomalies are present. In this manner, it is possible to detect e.g. cracks or the presence of undesirable deformation modes or incorrect geometry even in case the fastener 100 is to be installed in a truly blind structure 20.

[0079] The inspection device 64 is not shown in Fig. 3 in its entirety. Instead, a forward portion configured as a probe for performing the electromagnetic or laser-based testing is schematically displayed. The forward portion is inserted into the longitudinal passage 32 from the first, accessible side A. The corresponding forward movement of insertion is indicated in Fig. 3 by an arrow 66. In this manner, using the inspection device 64, intrusive inspection involving intrusion of the forward portion into the passage 32 is performed.

[0080] After inspection by means of the inspection device 64 is terminated, the inspection device 64 is removed from the passage 32 towards the first side A.

[0081] In situation S3, a tip portion of a borescope 76 as an inspection device has been inserted from the first side A into and through the longitudinal passage 32. Arrow 77 indicates in schematic manner a movement of inserting the borescope 76 along the center axis C, which approximately corresponds to a central axis of the internal passage 32.

[0082] As indicated in Fig. 3 at S3, the tip of the borescope 76 has been guided past the thread 46 and out of an end of the sleeve 31' on the second side B. Using the borescope 76, visual inspection in particular of the portion of the installed sleeve 31' protruding from the component 22 on the second side B of the structure 20 is carried out, for quality control of the installed sleeve 31'. In this way, an operator can visually inspect the installed sleeve 31', and an area surrounding it if desired, on the inaccessible, blind side B of the structure 20. The tip portion of the borescope 76 is moveable, e.g. to perform a pivoting movement 78. Also, the borescope 76 can be rotated substantially about the center line C, the rotational movement being indicated by reference numeral 79.

[0083] The visual inspection may include visual inspection of the portion of the sleeve 31 projecting from the structure 20 on the second side B for any visually apparent irregularities, for example within the deformed zone 33.

[0084] Also, while the eddy-current-based or laser-based non-destructive testing as explained above with reference to S2 may be used to inspect the geometry of the sleeve 31', in particular actually obtained geometrical dimensions such as an axial length L of the portion of the installed sleeve 31' protruding on the second side B from the structure 20 and/or a width or outer diameter D of the deformed sleeve zone 33, the visual inspection as explained above with reference to S3 may be used, too, for checking the dimensional properties of the deformed sleeve 31', e.g. by verifying that L and/or D is/are within respective permissible ranges. D may also be designated a "bulb diameter".

[0085] In situation S3 shown in Fig. 3, access through the passage or through-hole 32 in the installed sleeve 31' is thus used for visual inspection of the backside B.

[0086] After the visual inspection SV has been performed, the borescope 76 is removed again from the longitudinal passage 32 towards the first side A.

[0087] In the situations denoted by S4 and S5 in Fig. 3, the longitudinal passage 32 of the installed sleeve 31' is used for performing additional work on the sleeve 31' and/or in the vicinity thereof on the second side B, via

the passage 32.

[0088] Fig. 3 shows that in the state S4, a coating applying device 84 as a working device has been inserted from the first side A with a forward portion thereof, in a direction 85 substantially parallel to the center axis C of the bore 28, into and through the longitudinal passage 32 of the sleeve 31'. Reference sign 85 indicates the insertion movement. At a tip of the coating applying device 84, the coating applying device 84 comprises a coating material outlet region formed as a nozzle 87 for ejecting or spraying coating material onto a target region. The tip of the coating applying device 84 including the nozzle 87 is inserted through the passage 32 and past the thread 46, out of the passage 32 on the second side B. Further, the tip of the coating applying device 84 including the nozzle 87 may be moved, for example, in the manner of a pivoting movement 88, and at least the forward portion of the coating applying device 84 extending within and through the passage 32 can be rotated. Fig. 4 shows a corresponding turning movement 89 of the coating applying device 84.The pivoting movement 88 may also be omitted.

[0089] Using the coating applying device 84, a portion of the installed sleeve 31' extending beyond the structure 20 on the second side B can be coated or re-coated with coating material ejected or sprayed from the nozzle 87 in order to enhance protection of the blind fastener 100 against corrosion and/or in order to enhance electrical conductivity and lightning strike compatibility. In an exemplary embodiment illustrated in Fig. 4, painting or repainting of the deformed sleeve zone 33 or "bulb" is performed using the access through the passage 32. Fig. 3 shows a coating 86 on the bulb 33 applied in this manner.

[0090] After the coating or re-coating operation using the device 84 has been completed, the device 84 is removed again from the passage 32 towards the first side A.

[0091] Situation S5 shows that the longitudinal passage 32 of the installed sleeve 31' can be used for further additional work such as applying a sealant.

[0092] In the state S5, a sealant applying device 91 has been inserted from the first side A with a forward portion thereof, using an insertion movement 92 substantially parallel to the center axis C of the bore 28, into and through the longitudinal passage 32 of the sleeve 31'. At a tip of the sealant applying device 91, the sealant applying device 91 comprises a sealant outlet region formed as a nozzle 94 for ejecting the sealant towards a target region. The tip of the sealant applying device 91 including the nozzle 94 is inserted through the passage 32 and past the thread 46, out of the passage 32 on the second side B. Further, the tip of the sealant applying device 91 including the nozzle 94 may or may not be movable, for example pivotable, relative to other portions of the sealant applying device 91, analogous to the movement 88 illustrated for situation S4. Further, at least the forward portion of the sealant applying device 91 which extends within and through the passage 32 can be rotated in a manner analogous to movement 89 illustrated for situation S4.

[0093] Fig. 3 illustrates that in embodiments of the invention, sealant 93 is applied using the device 91 along an interface between the deformed bulb 33 and a surface of the second component 22 on the second side B. The sealant may be a paste or viscous liquid ejected from the nozzle 94. Using the device 91, sealant may be applied to other locations on or in the vicinity of the sleeve 31' if required.

[0094] After the sealant application has been completed, the device 91 is removed from the longitudinal passage 32 of the sleeve 31' towards the first side A.

[0095] After the steps S2, S3, S4, S5 of inspecting and performing additional work have been terminated, a final core bolt 105 is inserted from the first side A into the longitudinal passage 32 of the installed, checked, coated and sealed sleeve 31'. This is shown in Fig. 3 by situation S6. The final core bolt 105 comprises a head adapted to an internal geometry of the collar 34, and an external thread 106 that can be threaded into the internal thread 46 of the installed sleeve 31'. The core bolt 105 is screwed into the installed sleeve 31' and tightened with respect to the sleeve 31' therein, preferably by means of a tool not illustrated in Fig. 3. In this manner, the core bolt 105 is finally installed and the connection obtained using the blind fastener 100 is provided with its desired final strength. The tightening of the core bolt 105 is accomplished from the first side A.

[0096] In the description provided above regarding the embodiments illustrated in Fig. 3, the final core bolt 105 is an element that is distinct from the temporary core element 36. Accordingly, the core element 36, which is temporarily inserted into the passage 32, is a separate element not identical with the final core bolt 105.

[0097] However, in variants of the embodiments illustrated in Fig. 3, the core element 36 used to form the deformed sleeve zone 33 can correspond to the final core bolt 105. In other words, in such variants, a core element which will form the final core bolt 105 is temporarily arranged, in the state S1, in the passage 32 as a core element 36 in order to perform the deformation and creation of the deformed sleeve zone 33. The deformed sleeve zone 33 is in this case formed in the same manner as described above in detail with reference to the use of the temporary core element 36 in Fig. 3. The core element which will also be used as the final core bolt 105 is then removed from the passage 32, the steps S2, S3, S4, S5 or a selection thereof are performed, and after completion of inspection and/or additional work, the core bolt 105 is installed again as the final core bolt 105.

[0098] The steps S2, S3, S4, S5 are, in an exemplary embodiment explained above, performed in this order between the installation of the sleeve 31 as indicated by situation S1 and the insertion of the final core bolt 105 illustrated at reference sign S6. However, it should be understood that one or more of the steps or actions S2, S3, S4, S5 can be omitted e.g. if unnecessary in a particular application. Also, the order of the steps S2, S3,

S4, S5 or of the selected subset thereof can be changed according to the requirements of the particular application. Further, one or more of the steps S2, S3, S4, S5 could also be performed more than once for the same fastener 100. For instance, an action of coating or of sealing, or both, as indicated by reference numerals S4 and/or S5, could be followed by another visual inspection, as in situation S3, to verify that the coating and/or sealant has/have been correctly applied.

[0099] Fig. 4 schematically illustrates some steps of embodiments of a method for installing another blind fastening device 100a, which comprises a sleeve 31a, 31a' that is formed as a blind rivet nut, in a structure 20a. In the same manner as in Fig. 3, the structure 20a has a first, accessible side A and a second, "blind" side B that is difficult to access. The structure 20a can be a closed-box structure of the aircraft 1 as described above.

[0100] In Fig. 4, the undeformed sleeve 31a is inserted into a bore 28a extending through a single component 22a, which e.g. may be formed as a metal sheet or a sheet of a fibre-reinforced synthetic material. The bore 28a preferably is circular in cross-section and may be drilled, for example, through the component 22a.

[0101] The sleeve 31a comprises a collar 34a which abuts flat against an outer surface of the component 22a on the first side A. Different from Fig. 3, the bore 28a does not comprise a countersunk portion, but countersinking may be performed in variants if desired. Fig. 4 also illustrates a temporary core element 36a analogous to the temporary core element 36 of Fig. 3, but comprising a head that is formed differently, in order to cooperate with the collar 34a.

[0102] Besides, in the embodiments illustrated by Fig. 4, the sleeve 31a is installed in the situation S1a in the same manner as explained above with reference to Fig. 3. The sleeve 31a is securely attached to the component 22a by forming a deformed sleeve zone 33a on the second side B that engages the component 22a. The temporary core bolt 36a comprises an external thread 45a analogous to the thread 45 in Fig. 3, the sleeve 31a comprises an internal thread 46a analogous to the thread 46 in Fig. 3, and using the engagement of the threads, axial traction is applied to an end portion of the sleeve 31a on the second side B to form the deformed sleeve zone 33a, as explained above.

[0103] After installing the sleeve 31a' and removal of the temporary core bolt 36a, one or more than one or all of the steps S2, S3, S4, S5, in this sequence or in a different order, are performed in the same manner as explained above with reference to Fig. 3, in particular for quality control on the installed sleeve or blind nut 31a' and/or for performing additional work like coating or sealing, for example.

[0104] After the steps of inspection and additional work S2-S5, or a desired subset thereof, have been completed as described above, a further component 21a having another bore is provided, a final core bolt 105a is inserted through the bore of the component 21a and into the passage 32 of the attached sleeve 31a', and the core bolt 105a is screwed into the sleeve 31a' and firmly tightened in order to attach the further component 21a to the component 22a. This is illustrated by situation S6a in Fig. 4. The sleeve 31a' has a function of a blind rivet nut for the purpose of attaching the component 21a to component 22a. The core bolt 105a has an external thread 106a cooperating with the internal thread 46a.

[0105] In some variants of the embodiments illustrated by Fig. 4, the temporary core element 36a and the final core bolt 105a may be separate and distinct elements, while in other variants, the core element which will form the final core bolt 105a may be used in the situation S1a to form the deformed sleeve zone 33, as described above in relation to elements 36, 105. In the latter case, the core bolt 105a, used to create the "bulb" 33, is re-used, after completion of the inspection and/or additional work, as a final core bolt 105a in the completed connection.

[0106] With regard to temporary core elements 36, 36a, or core elements used for forming the bulb 33 and then in particular re-used as the core bolt 105 or 105a, as described above, such core elements may in some variants comprise a portion that may be separated from the core element e.g. when forming the bulb 33, for example at a predetermined breaking point. Also, a separately provided final core bolt 105, 105a may for example in some variants comprise a predetermined breaking point where a portion of the core bolt 105, 105a may separate when finally tightening the core bolt 105, 105a.

[0107] In a further embodiment, for example in case the structure 20, 20a is part of a wing, an interior space of the closed-box structure 20, 20a may accommodate fuel. For improved protection in case of lightning strike and to prevent any spark due to lightning from reaching an interior of a fuel tank, a nut cap or containment cap 150 may be arranged on the second side B of the structure 20, or 20a, enclosing the protruding portions of the blind fastener 100, 100a. Such a situation is schematically illustrated in Fig. 5. The cap 150 is, for example, made from a synthetic material.

[0108] Fig. 5 shows the visual inspection using the inspection device 76, already described above with reference to Fig. 3, in case the containment cap 150 is provided. The cap 150 has been attached to the second component 22 on the second, blind side B of the structure 20 before closing the structure 20.

[0109] Fig. 5 illustrates that even in case the cap 150 is provided, an inspection of the blind side of the sleeve 31' is made possible, using the inspection device 76 and inspecting via the longitudinal passage 32. A tip of the device 76 is inserted through the passage 32 into a space between the cap 150 and the installed sleeve 31'.

[0110] In an analogous manner, the steps S2, S4 and/or S5 may be carried out as well also in case the containment cap 150 is provided. Specifically, in the case of steps S4 or S5, the tip comprising the nozzle 87 or 94, respectively, of the device 84 or 91, is inserted into the space between the cap 150 and the sleeve 31' for per-

forming additional work within this space.

[0111] In the embodiments described above with reference to Figs. 1-5, axial force and/or torque that is/are externally applied by a tool to the core element 36, 36a, as well as axial displacement and/or angle of rotation of the core element 36, 36a, may be additionally detected and monitored during forming the bulb 33 for additional quality control. Such detection and monitoring may be performed in analogous manner if the core bolt 105 or 105a is temporarily used as the core element 36 or 36a.

[0112] Moreover, during tightening the final core bolt 105, 105a, the torque applied to the core bolt 105, 105a as well as the angle through which the core bolt 105, 105a is rotated during the tightening may be detected and monitored for further improved quality control of the finally assembled fastening device 100, 100a. In addition to this, or alternatively, a distance by which the head of the core bolt 105 or 105a projects from a reference surface of the structure 20, 20a at the end of the tightening step may be detected and compared with a target value.

[0113] Using access through the longitudinal passage 32 or 32a to the second, blind side B, efficient quality control can be carried out in economical manner on up to 100 percent of all blind fastening devices 100, 100a installed in a structure 20, 20a, even if the structure 20, 20a is a truly blind, closed-box structure. The performance of each one of the entire set of blind fastening devices 100, 100a installed in the structure 20, 20a, not only with regard to the mechanical properties thereof, but also e.g. with regard to corrosion resistance and lightning strike compatibility, can be ensured in efficient manner, for example by additionally performing sealing or painting operations on the blind side as described above with reference to S4, S5. Hence, by performing steps S2 to S5 or a desired subset thereof between situations S1, S6 or S1a, S6a, closed-box structures 20, 20a, 200, in particular for the aircraft 1, are made possible which can be "truly blind" with substantially no or strongly limited access to the second side B for inspection or re-work, after finally installing the fastening devices 100, 100a. Also, being able to check substantially 100 percent of the blind fastening devices 100, 100a in blind applications may contribute to saving weight, parts and workload, as a smaller number of blind fastening devices 100, 100a may be appropriate to obtain a reliable structure 20, 20a or the dimensions of the fastening devices 100, 100a may be varied.

[0114] Although the invention has been completely described above with reference to preferred embodiments, the invention is not limited to these embodiments but may be modified in many ways.

List of reference signs

[0115]

1	airplane
3	fuselage
4	wing
5	trailing edge
6	empennage
8	engine
10	vertical stabilizer
11	trailing edge
15	horizontal stabilizer
16	trailing edge
19	center wing-box
20, 20a	structure
21	first component
21a	component
22	second component
22a	component
28, 28a	bore
31, 31a	sleeve (initial state)
31', 31a'	sleeve (deformed state)
32, 32a	longitudinal passage
33, 33a	deformed sleeve zone
34, 34a	collar
35	section (sleeve)
36, 36a	core element
45, 45a	thread (core element)
46, 46a	thread (sleeve)
55	traction
64	inspection device
65	rotation
66	forward movement
76	inspection device
77	insertion movement
78	pivoting movement
79	rotation
84	coating applying device
85	insertion movement
86	coating
87	nozzle
88	pivoting movement
89	turning movement
91	sealant applying device
92	insertion movement
93	sealant
94	nozzle
100	blind fastening device
100a	blind fastening device
105	final core bolt
105a	final core bolt
106	thread (final core bolt)
106a	thread (final core bolt)
150	containment cap
200	box-type structure
201	connection region
202	connection region
A	first, accessible side
B	second, blind side
C	center axis
D	diameter
L	length
S1	state

S1a state
S2 state
S3 state
S4 state
S5 state
S6 state
S6a state
SV visual inspection substep

Claims

1. Method for installing a blind fastening device (100; 100a) in a bore (28; 28a) provided in a structure (20; 20a), the structure (20; 20a) having a first side (A) and a second side (B), wherein the method comprises steps of:

   - inserting a sleeve (31; 31a) into the bore (28; 28a) from the first side (A) of the structure (20; 20a);
   - using a core element (36; 105; 36a; 105a) arranged in a longitudinal passage (32; 32a) of the sleeve (31; 31a) and accessible from the first side (A), forming a deformed sleeve zone (33; 33a) engaging the structure (20; 20a) on the second side (B) thereof to install the sleeve (31; 31a) in the structure (20; 20a);
   - removing the core element (36; 105; 36a; 105a) from the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a');
   - inserting at least one inspection device (64; 76) at least partly into or through the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a'), performing inspection of the installed sleeve (31'; 31a') or of at least a portion thereof using the inspection device (64; 76), and removing the inspection device (64; 76) from the longitudinal passage (32; 32a); and/or inserting a working device (84; 91) at least partly through the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a'), performing additional work, on the second side (B) of the structure (20; 20a), on the installed sleeve (31'; 31a') and/or in the vicinity thereof using the working device (84; 91), and removing the working device (84; 91) from the longitudinal passage (32; 32a); and
   - inserting a core bolt (105; 105a) into the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a') and tightening the core bolt (105; 105a) with respect to the installed sleeve (31'; 31a'), wherein the core bolt (105; 105a) in particular is or corresponds to the core element or is another element.

2. Method according to at least one of the preceding claims,
characterized in that the inspection of the installed sleeve (31'; 31a') comprises non-destructive testing of the installed sleeve (31'; 31a') or of at least a portion thereof, in particular using an electromagnetic non-destructive testing procedure, for example using eddy-current testing, or using a laser-based non-destructive testing procedure, for example a non-destructive testing procedure including laser scanning.

3. Method according to at least one of the preceding claims,
characterized in that the method comprises inserting, using and removing, as the inspection device (64), a non-destructive testing device, in particular an electromagnetic testing device or a laser-based testing device, in particular comprising at least a forward portion insertable into the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a').

4. Method according to at least one of the preceding claims,
characterized in that the inspection of the installed sleeve (31'; 31a') comprises visual inspection of the installed sleeve (31'; 31a') or of at least a portion thereof on the second side (B) of the structure (20; 20a), in particular visual inspection of the deformed sleeve zone (33; 33a) or of a portion thereof.

5. Method according to at least one of the preceding claims,
characterized in that the method comprises inserting, using and removing, as the inspection device (76), a borescope comprising a forward portion that is insertable into and through the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a').

6. Method according to at least one of the preceding claims,
characterized in that the inspection of the installed sleeve (31'; 31a') includes inspecting a geometry of the installed sleeve (31'; 31a'), in particular includes inspecting actual geometrical dimensions of a portion of the installed sleeve (31'; 31a') protruding from the second side (B) of the structure (20; 20a), more particularly includes inspecting an axial length (L) of the portion of the installed sleeve (31'; 31a') protruding from the second side (B) of the structure (20; 20a) and/or a width or outer diameter (D) of the deformed sleeve zone (33; 33a).

7. Method according to at least one of the preceding claims,
characterized in that the inspection of the installed sleeve (31'; 31a') includes testing the installed sleeve (31'; 31a') or at least a portion thereof for the presence of cracks and/or includes inspecting the deformed sleeve zone (33; 33a) for the presence of a target mode of deformation or for the presence of

an undesired mode of deformation or both.

8. Method according to at least one of the preceding claims,
characterized in that performing the additional work on the installed sleeve (31'; 31a') includes coating or re-coating at least a portion of the installed sleeve (31'; 31a'), in particular by coating or re-coating the deformed sleeve zone (33; 33a) or at least a portion thereof.

9. Method according to at least one of the preceding claims,
characterized in that the method comprises inserting, using and removing, as the working device, a coating applying device (84) comprising a forward portion that is insertable into and through the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a') and is formed with a coating material outlet region (87).

10. Method according to at least one of the preceding claims,
characterized in that performing the additional work on the installed sleeve (31'; 31a') includes applying a sealant (93) along a contact region between the deformed sleeve zone (33; 33a) and the structure (20; 20a) on the second side (B) thereof, wherein the sealant (93) in particular is applied as a liquid or as a paste-like material.

11. Method according to at least one of the preceding claims,
characterized in that the method comprises inserting, using and removing, as the working device, a sealant applying device (91) comprising a forward portion that is insertable into and through the longitudinal passage (32; 32a) of the installed sleeve (31'; 31a') and is formed with a sealant outlet region (94).

12. Method according to at least one of the preceding claims,
characterized in that the blind fastening device (100) is a blind rivet or **in that** the blind fastening device (100a) comprises a blind rivet nut (31a).

13. Method according to at least one of the preceding claims,
characterized in that for forming the deformed sleeve zone (33; 33a), the core element (36; 105; 36a; 105a) is axially moved while the sleeve (31; 31a) is maintained in its position relative to the bore (28; 28a) and/or **in that** for forming the deformed sleeve zone (33; 33a), the core element (36; 105; 36a; 105a) is rotated while the sleeve (31; 31a) is maintained in its position and orientation relative to the bore (28; 28a).

14. Method according to at least one of the preceding claims,
characterized in that the sleeve (31; 31a) is provided, within a part of a section of the sleeve (31; 31a) that protrudes from the second side (B) of the structure (20; 20a) after insertion of the sleeve (31; 31a) into the bore (28; 28a), with an internal thread (46; 46a) engageable with an external thread (45; 45a) of the core element (36; 105; 36a; 105a), and in particular **in that** the core bolt (105; 105a) comprises an external thread (106; 106a) engageable with the internal thread (46; 46a) of the installed sleeve (31'; 31a') and the step of inserting and tightening the core bolt (105; 105a) comprises screwing the core bolt (105; 105a) into the installed sleeve (31'; 31a').

15. Use of a longitudinal passage (32; 32a) of a sleeve (31'; 31a'), provided for forming part of a blind fastening device (100; 100a) and installed in a structure (20; 20a) having a first side (A) and a second side (B), for performing an inspection of the sleeve (31'; 31a') or of at least a portion thereof via the longitudinal passage (32; 32a) or for performing additional work on the sleeve (31'; 31a') and/or in the vicinity thereof on the second side (B) of the structure (20; 20a) via the longitudinal passage (32; 32a) or for performing both of the inspection and the additional work; wherein the sleeve (31'; 31a') is partially arranged within a bore (28; 28a) provided in the structure (20; 20a);

wherein the sleeve (31'; 31a') comprises a deformed sleeve zone (33; 33a) engaging the structure (20; 20a) on the second side (B) thereof; and
wherein the longitudinal passage (32; 32a) of the sleeve (31'; 31a') is configured for at least partially receiving a core bolt (105; 105a) in such a manner that the core bolt (105; 105a) can be accessed from the first side (A) and can be tightened with respect to the installed sleeve (31'; 31a').

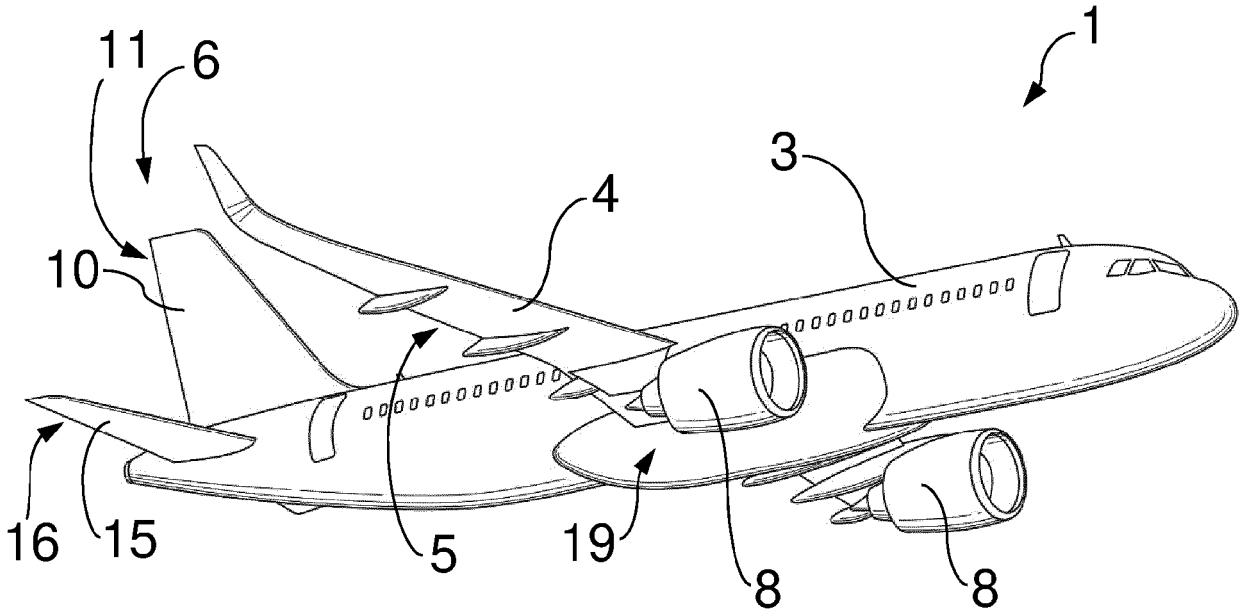

Fig. 1

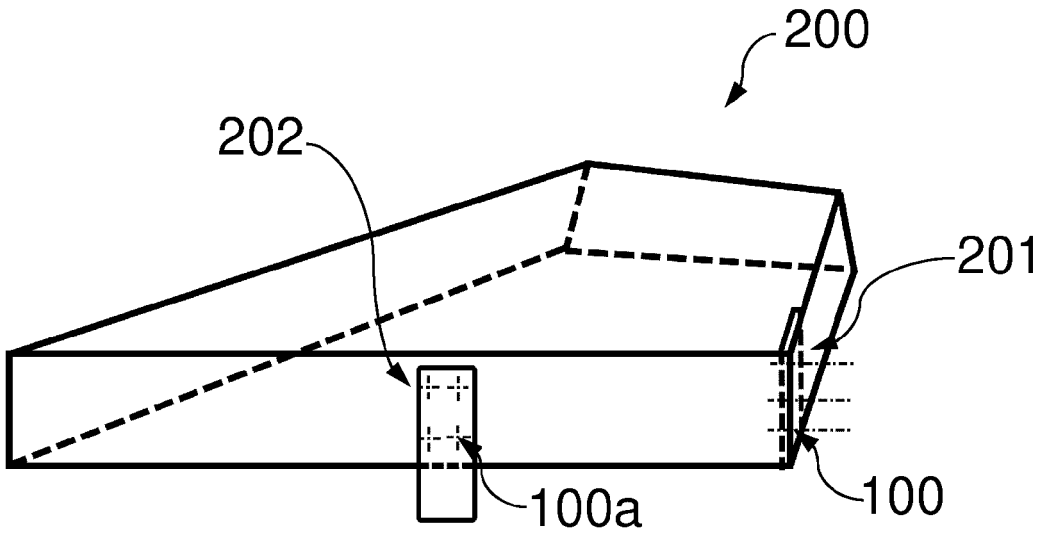

Fig. 2

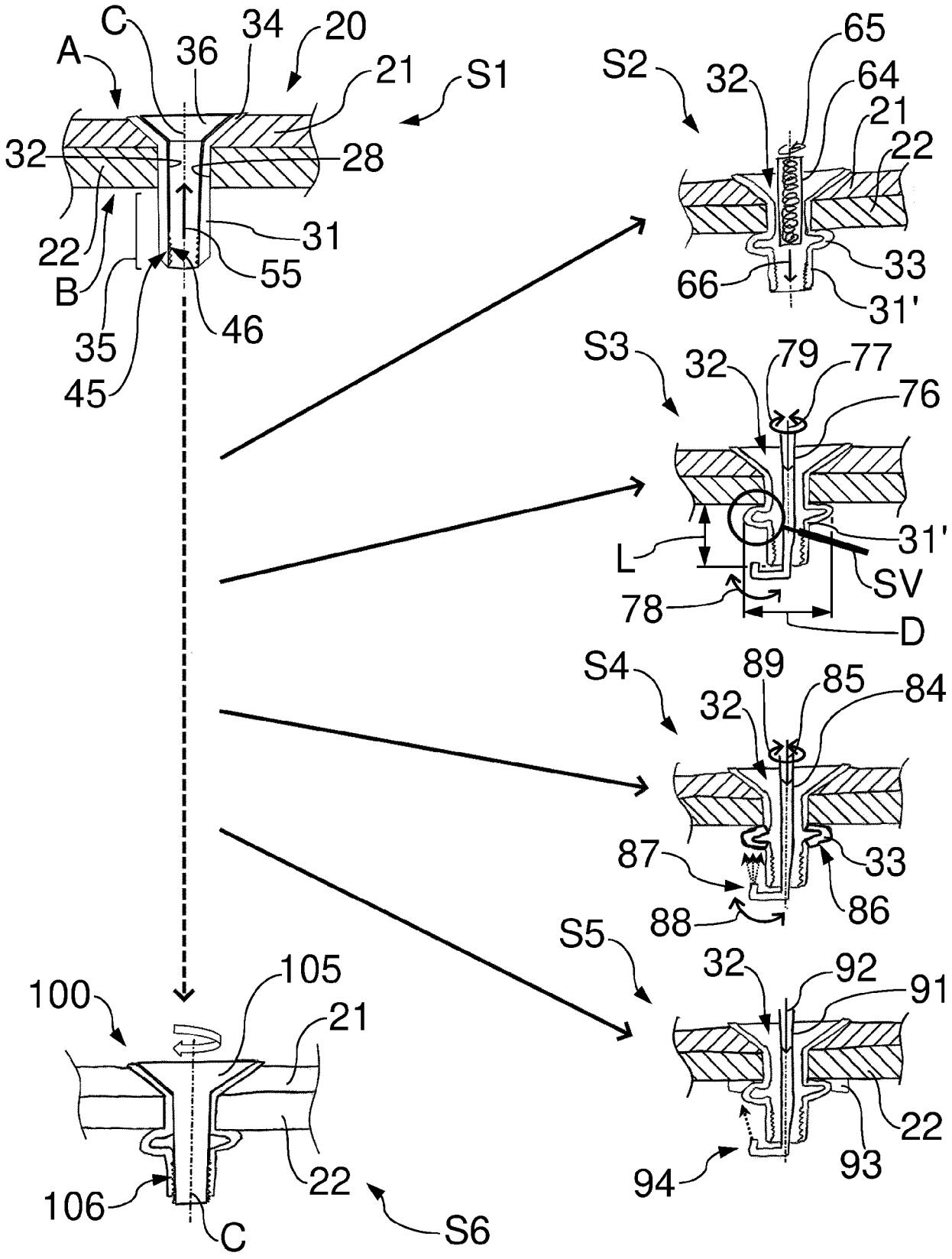
C
A
36
34
20
21
S1
32
28
22
B
31
55
35
46
45
S2
65
32
64
21
22
33
66
31'
S3
32
79
77
76
31'
L
SV
78
D
S4
89
85
84
32
87
33
88
86
S5
32
92
91
22
93
94
100
105
21
22
106
C
S6

Fig. 3

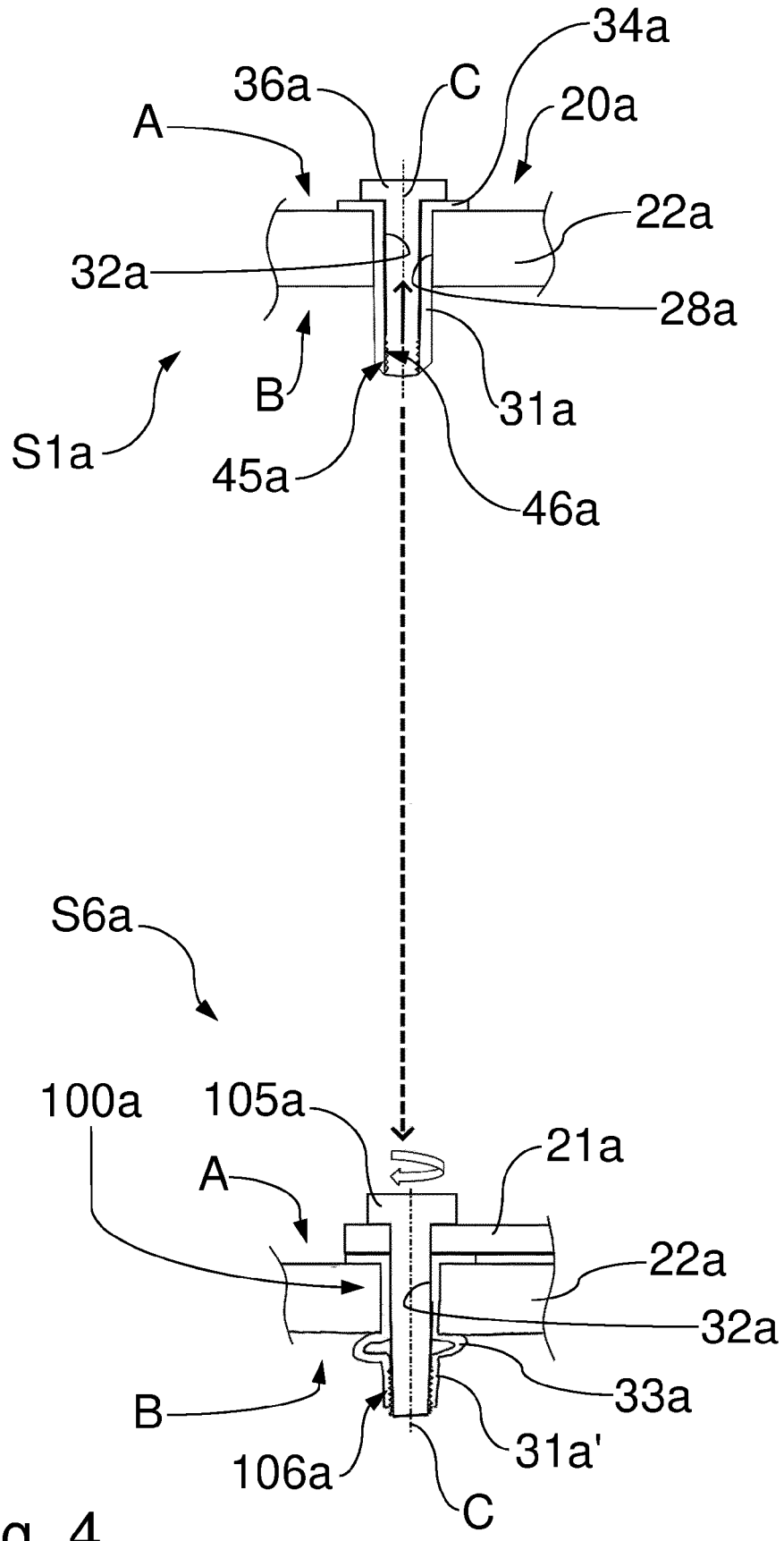
34a
36a
C
20a
A
22a
32a
28a
B
31a
S1a
45a
46a
S6a
100a
105a
21a
A
22a
32a
33a
B
31a'
106a
C

Fig. 4

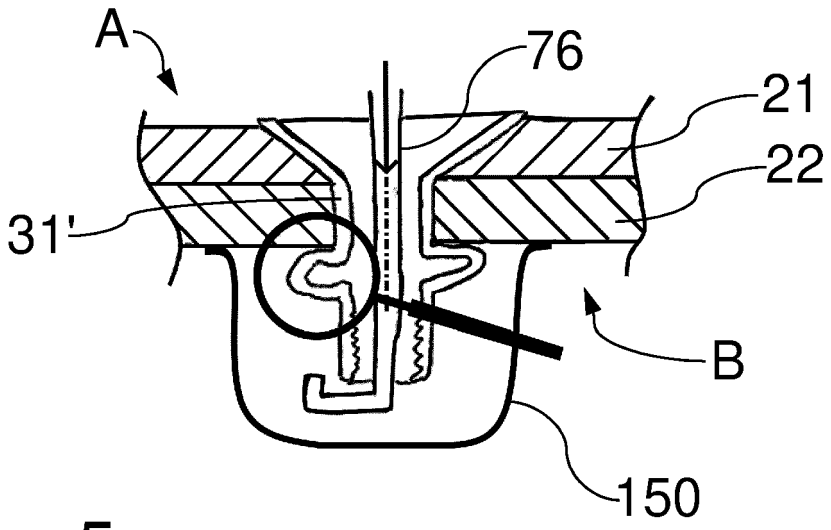

Fig. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 19 2693

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2018/178186 A1 (FRAUNHOFER GES FORSCHUNG [DE]) 4 October 2018 (2018-10-04) * page 11, line 21 - page 14, line 18; figures 1-4 *	1-15	INV. B21J15/04 B21J15/14 B21J15/28
A	US 2018/238372 A1 (VILLET ANTOINE [FR] ET AL) 23 August 2018 (2018-08-23) * paragraph [0007] - paragraph [0008] * * paragraph [0039] - paragraph [0051]; figures 1-4 *	1-15	
A,D	WO 2018/007324 A1 (LISI AEROSPACE [FR]) 11 January 2018 (2018-01-11) * claim 10; figures 1-4 *	1-15	
A,D	FR 2 999 707 A1 (AIRBUS OPERATIONS SAS [FR]) 20 June 2014 (2014-06-20) * claim 1; figures 1-3 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC) B21J F16B

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 February 2022	Ritter, Florian

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 21 19 2693

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.

02-02-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018178186 A1	04-10-2018	DE 102017205464 A1	04-10-2018
		EP 3600715 A1	05-02-2020
		WO 2018178186 A1	04-10-2018
US 2018238372 A1	23-08-2018	BR 112017026673 A2	14-08-2018
		CA 2987870 A1	15-12-2016
		CN 107810338 A	16-03-2018
		EP 3308040 A1	18-04-2018
		ES 2784934 T3	02-10-2020
		FR 3037369 A1	16-12-2016
		JP 6885879 B2	16-06-2021
		JP 2018517105 A	28-06-2018
		KR 20180017002 A	20-02-2018
		RU 2018100399 A	11-07-2019
		US 2018238372 A1	23-08-2018
		WO 2016198600 A1	15-12-2016
WO 2018007324 A1	11-01-2018	CN 109477506 A	15-03-2019
		EP 3482088 A1	15-05-2019
		FR 3053745 A1	12-01-2018
		US 2019186522 A1	20-06-2019
		WO 2018007324 A1	11-01-2018
FR 2999707 A1	20-06-2014	NONE	

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

- FR 2999707 A1 **[0006]**
- WO 2018007324 A1 **[0007]**
- US 20190186522 A1 **[0007]**