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(54) **SYSTEM AND METHOD FOR BRIDGE INSPECTION AND MAINTENANCE**

BRÜCKENINSPEKTIONS- UND WARTUNGSSYSTEM UND VERFAHREN

SYSTÈME ET PROCÉDÉ D’INSPECTION ET DE MAINTENANCE DE PONT

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Description

[0001] The present invention relates to a bridge inspection and maintenance system, comprising a mounted sliding platform below the bridge to be inspected.

[0002] The platform further comprises one or more sensors for acquiring images of said bridge.

[0003] The inspection of bridges generally takes place by monitoring the condition of the bridge parts, especially the parts below the bridge, using visual investigation methods and non-destructive testing, imaging means, such as cameras or the like, so that the processing of the acquired images allows to identify any structural defects or to predict breakages or damage to the bridge structure.

[0004] It is evident that this inspection cannot be carried out by an operator supported by vehicles placed on the ground below the bridge, as most defects would not be detected due to the operator's distance.

[0005] For this reason, the inspection of bridges currently requires the installation of solid structures which allow positioning the support means of the operator at the lower parts of the bridge, or requires the use of structures which can be fixed to the upper parts of the bridge, which however, at least temporarily require blocking the traffic of vehicles in transit on the bridge.

[0006] Alternatively, it is possible to envisage the use of aerial systems, but their use is generally subject to too many restrictions to allow for constant and effective monitoring, in order to detect the occurrence of problems.

[0007] As anticipated, the inspection of the bridge by visual inspection means is of great help for highlighting any damage in the initial phases of construction and during normal use of the bridge, but also for verifying the conformity of welds and geometry with respect to the project designs, immediately after construction.

[0008] Some current systems provide for automated monitoring and inspection, using robotic means, presenting different solutions related to small or large systems.

[0009] However, besides being particularly expensive, these solutions do not allow continuous monitoring of the status of the bridge.

[0010] Some state-of-the-art robotic solutions include the development of a mobile and autonomous manipulator for the maintenance of steel bridges, which allows the removal of paint and rust. This system consists of a platform adapted to support the manipulator, a computer, a laser scanner and several sensors. In this way the system can inspect the bridge and detect any defects.

[0011] However, this system is still ineffective.

[0012] Firstly, the rails on which the platform moves are part of the system and not of the bridge, which has negative repercussions on portability. Furthermore, since the platform is connected to the ground and not to the bridge to be monitored, the vibrations due to the vehicle traffic transiting on the bridge generate incorrect images, which do not correspond to the actual situation of the bridge and which cannot be reprocessed for proper inspection and possible intervention.

[0013] The presence of dust in the air, due to maintenance, also causes false detection by the sensors.

[0014] Lightweight and portable robots are also present in the state of the art, designed to allow the inspection of bridges.

[0015] Such systems are designed so that operators can easily carry such robots and use them through the use of a lifting system, such as for example a ladder, a crane, at the point to be monitored. These systems, equipped with a high-resolution camera, provide the operator with rapid information that can be immediately used to assess the condition of the bridge. However, since the presence of the operator is of fundamental importance for the connection of the robot to the bridge, this type of solution cannot be used on very high bridges or those which are not easily accessible. In addition, the robotic system, although capable of overcoming minimal obstacles, cannot bypass the bridge piers and, if necessary, must be moved manually.

[0016] There are several types of robotic bridge inspection systems, which move below the bridge surface, designed to carry out inspections and maintenance at specific points, but these systems are not currently able to collect data on the entire bridge in a continuous and systematic manner. The document CN 105507145 B discloses a known bridge inspection system.

[0017] A continuous and systematic scan not only allows to plan maintenance when a problem is detected, but also to predict the formation of defects in the bridge structure, thanks to the analysis of the data collected.

[0018] There is therefore an unmet need for state-of-the-art systems to solve the problems outlined above, in particular to create an inspection and maintenance system for bridges which allows continuous monitoring and accurate image acquisition, not influenced by the bridge type or structure or by the traffic of vehicles crossing the bridge, avoiding the presence of operators at the bridge parts to be monitored.

[0019] The present invention achieves the above aims by realizing a system as defined in claim 1, in which the platform is formed by two structures positioned symmetrically with respect to the longitudinal axis of the bridge.

[0020] Furthermore, each structure comprises a first part configured to translate along a longitudinal axis of the bridge on a corresponding longitudinal guide integral with the bridge and a second part configured to transversely translate with respect to said longitudinal axis on the first part on a corresponding transverse guide.

[0021] Thanks to this configuration, the two structures can be moved from a closed configuration, in which the corresponding second parts are coupled to each other at the central longitudinal axis of the bridge, to an open configuration, in which the two second parts are separated from each other in the opposite direction with respect to the centre of the central longitudinal axis of the bridge, until they are decoupled from each other, by a transverse translational movement.

[0022] The system object of the present invention allows carrying out inspections of the areas below the bridges in a continuous and rapid manner.

[0023] The fact that the structures are fixed directly to the bridge, through the first parts, so as to be integral with the bridge structure, allows the system object of the present invention to acquire images which are not affected by the vibrations of the bridge.

[0024] Imaging sensors, such as cameras, therefore detect precise images of the bridge structure, so as not only to obtain constant and effective monitoring, but also to identify the current state of maintenance and obtain a prediction about future interventions, necessary to prevent possible damage.

[0025] In addition, the possibility of reconfiguring the structure from open to closed configuration and vice versa allows different functions to be performed.

[0026] By operating the structure in open configuration, it is possible to scan the underlying parts of the bridge quickly.

[0027] Thanks to its unique configuration and the presence of sensors for the acquisition of images in each of the second parts of each individual structure, the system object of the present invention does not require any type of support structures for the mounting on the bridge or for the operation thereof: it is therefore possible to carry out continuous monitoring, also during normal use conditions of the bridge by vehicles.

[0028] Furthermore, as will be described in detail below, in closed configuration the two second parts form a single platform, capable of supporting further robotic means for the cleaning, thorough inspection and/or maintenance of the bridge.

[0029] Sliding along the bridge, the two structures can switch from the closed configuration to the open configuration whenever they are located at a bridge pier or whenever necessary, so that the first parts can slide independently without the obstruction of the piers and without interrupting the monitoring of the bridge.

[0030] It is also apparent that the system object of the present invention is preferably realized for automatic operation, possibly under the supervision of a user who controls the system remotely.

[0031] As anticipated, the system is integral with the bridge, so in combination with the latter, it allows the realization of a sort of "smart bridge", that is, a bridge which comprises sensors aimed at detecting structural anomalies and which can process structural information to allow the real-time monitoring of the bridge status and predict future damage.

[0032] According to a preferred embodiment, each second part has an upper guide adapted to support robotic inspection and/or maintenance and/or cleaning means.

[0033] When the second parts are in coupled configuration, the upper guides identify a single upper guide.

[0034] The system object of the present invention is therefore able to collect data from the sensors incorporated into the structure on a very rapid regular basis when in open configuration, at the same time, it is able to offer support to other robotic devices which perform dedicated and more accurate inspections, maintenance and cleaning, when in closed configuration.

[0035] Robotic vehicles can, of course, offer a wide range of machining which can be carried out on the bridge, depending on the tools which are provided on these robotic vehicles.

[0036] In addition, the creation of a single platform, consisting of the coupling of the two second parts, allows to obtain a weight support structure of these robotic means, which therefore do not have to support their own weight, resulting in a more agile handling of the same during the machining.

[0037] According to one embodiment, the ends of said second parts facing the central longitudinal axis of the bridge have complementary profiles, so that in a coupled configuration of the two second parts, the profiles of the corresponding ends are in contact by shape coupling.

[0038] An innovative system of joining the parts is obtained, which allows quick and easy couplings and decouplings.

[0039] To improve the coupling, a mechanical, shape coupling system is used, simple from a constructive point of view and particularly solid without the need to use electronic devices, which can be damaged during the movement of the parts or increase the risk of breakages or malfunctions of the entire system.

[0040] Advantageously, to improve the coupling of the first and the second part, it is possible to provide a sensor system adapted to check that the first part and the second part are aligned with respect to the longitudinal axis of the bridge.

[0041] According to a refinement of the variant just described, one end has a convex profile along a vertical section plane in the direction of the centre of the bridge, while the other end has a concave profile along a vertical section plane in the direction of the centre of the bridge.

[0042] As will be more apparent from the illustration of some embodiments, the convex, or pointed, end encompasses the other as one second portion approaches the other.

[0043] The interpenetration of one end with the other allows to obtain a perfect coupling of the parts, in order to achieve a precise alignment of the upper guides, for an easy transition from one part of the robotic means to the other.

[0044] Advantageously, the longitudinal guides are arranged at the sides of the bridge.

[0045] In this way, a slim, lightweight and easy-to-install construction of the system of the present invention is obtained.

[0046] To pursue the same objects, according to a possible embodiment, the second portions are arranged lower than the first portions.

[0047] This configuration also facilitates the movement of the second parts, as their dimensions do not create obstacles to the movement of the same with respect to the first parts.

[0048] As anticipated, the possibility of switching from the open configuration to the closed configuration not only has advantages aimed at overcoming the bridge piers, but also has advantages from the functional point of view.

[0049] In fact, in closed configuration, the system is able to use robotic means to perform specific machining and to obtain more accurate images.

[0050] For this reason, the present invention also relates to a method of bridge inspection and maintenance, as defined in claim 6 and which provides for the use of the system described above.

[0051] The method object of the present invention comprises the following steps:

a) translation of at least one of the two structures along the bridge and acquisition of images of the bridge, through scanning by the second part belonging to the translating structure: the two structures are in open configuration,
b) image processing,
c) positioning the second parts in open or closed configuration based on the processing of the previous step.

[0052] The two structures, which move separately in open configuration, can scan the parts below the bridge at high speed, collect these images and process them.

[0053] Thanks to the independent movement, the two structures can perform translations and imaging of the bridge at different times and/or in different bridge areas.

[0054] Preferably, in fact, the step a) of translation takes place so that the two structures can move independently and non-aligned, so as to monitor different sections of the bridge positioned along the longitudinal axis thereof.

[0055] The first parts can therefore only deal with the movement of the structures, while the second parts deal with the detection of images, thanks to the presence of the sensors.

[0056] The processing means may be provided integrated within the first or second portions, or may be provided remotely, connected to the structures via wireless communication.

[0057] If the image processing requires more accurate maintenance or analysis in one or more specific areas, both structures may be positioned at said areas and the second parts may be coupled, so as to form a single platform.

[0058] Once the second parts are in coupled configuration, it is possible to provide, if necessary, the intervention of the robotic means described above, to obtain greater accuracy in the images acquired, or to carry out any type of machining.

[0059] Increasing the accuracy of the images captured not only allows to identify any problems or damage to the bridge in a timely manner, but also to predict future wear or decay of bridge parts.

[0060] It is evident that the method object of the present invention is a method of controlling the inspection system described above, whereby, according to this method, the transition from the open configuration to the closed configuration and vice versa is carried out not only to allow the formation of a single support platform for further robotic means operating on the parts below the bridge, but whenever the two structures are located at a pier.

[0061] These and other features and advantages of the present invention will become clearer from the following description of some non-limiting exemplary embodiments illustrated in the attached drawings in which:

figures 1a and 1b illustrate the system object of the present invention according to a possible embodiment, in open configuration;
figures 2a and 2b illustrate the system object of the present invention according to a possible embodiment, in closed configuration;
figure 3 illustrates a possible implementation variant of the guides for handling the first and second parts belonging to the system object of the present invention;
figure 4 illustrates, through a flow chart, the method of the present invention in accordance with a possible embodiment;
figures 5a and 5b illustrate two perspective views of a detail relative to the second part belonging to the system object of the present invention.

[0062] It is specified that the figures annexed to the present patent application indicate some preferred embodiments of the system and method object of the present invention to better understand their advantages and characteristi cs.

[0063] Such embodiments are therefore for illustrative purposes only and not limited to the inventive concept of the present invention, that is, of realizing a bridge inspection system, which allows a continuous monitoring of the bridge conditions and which allows an acquisition of images of the bridge to be inspected which are not affected by the traffic of vehicles transiting on the bridge, ensuring a rapid and effective acquisition.

[0064] With particular reference to figures 1a to 2b, the bridge inspection and maintenance system 10 comprises two structures 1, 2 positioned symmetrically with respect to the longitudinal axis A of the bridge 10 which are slidably mounted below the bridge 10.

[0065] The two structures 1, 2 further comprise one or more sensors for acquiring images of the bridge 10.

[0066] Such sensors are not illustrated in the figure, but may consist of common imaging sensors, such as video cameras, photo cameras or the like, and are integrated within the two structures 1 and 2.

[0067] Such sensors thus allow images of the bridge 10 to be acquired, in particular of the areas below the roadway of the bridge 10, which can be more easily damaged.

[0068] The translation of the two structures 1 and 2 along the direction of the longitudinal axis A of the bridge 10 therefore allows to acquire images of the entire area below the roadway of the bridge 10.

[0069] As anticipated, the two structures 1 and 2 are symmetrical with respect to the longitudinal axis A of the bridge, and each structure comprises a first part, respectively 11 and 21, and a second part, respectively 12 and 22.

[0070] The first parts 11 and 21 are configured to move along a longitudinal axis of the bridge 10 on a corresponding longitudinal guide 13, 23, integral with the bridge 10.

[0071] In particular, the longitudinal guides 13 and 23 are positioned at the sides of the bridge 10, as clearly illustrated in figures 1b and 2b.

[0072] Furthermore, each second part 12 and 22 is configured to translate transversely with respect to the longitudinal axis A, on the corresponding first part 11, 21 through a transverse guide, illustrated and described below in figure 3.

[0073] The combination of the longitudinal guides and the transverse guides allows each structure 1 and 2 to move in the directions indicated by arrows B and C of figures 1b and 2b.

[0074] In particular, the first parts 11 and 21 move along the entire length of the bridge 10, arrow B, while the second parts 12 and 22 provide for a mutual approach/-distancing movement, arrow C.

[0075] The movement of the second parts 12 and 22 allows to identify a closed configuration, in which the second parts 12 and 22 are in a configuration coupled to each other, to an open configuration, in which the two second parts 12 and 22, sliding transversely in the opposite direction with respect to the axis A, are decoupled from each other.

[0076] Figures 1a and 1b illustrate the open configuration, while figures 2a and 2b illustrate the closed configuration.

[0077] The transition from the closed configuration to the open configuration and vice versa will be described below, through a flow chart relating to the method object of the present invention.

[0078] However, it may be noted that one of the criteria for switching from the closed configuration to the open configuration is the presence of a pier 100 of the bridge 10.

[0079] As illustrated in figures 1a and 1b, the two structures 1 and 2 are located at a pier 100: in order to allow the two structures to slide longitudinally, the two second parts 12 and 22 slide transversely towards the sides of the bridge 10, so that the two structures 1 and 2 can translate laterally with respect to the pier 100.

[0080] From the figures it can be seen that in the open configuration, the two structures 1 and 2 move along the bridge 10 in parallel, that is, side by side with each other.

[0081] However, it is possible to provide that the two structures 1 and 2 can be independently controlled, to monitor different parts of the bridge 10, positioned in a different longitudinal direction.

[0082] Furthermore, the first parts 11 and 21 preferably are small compared to the second parts 12 and 22.

[0083] According to a refinement, in fact, the first parts 11 and 21 act as a support for the second parts 12 and 22, with the sole purpose of allowing the latter to be dragged in the direction of the longitudinal axis A of the bridge 10.

[0084] The second parts 12 and 22 instead comprise the imaging sensors and, according to a preferred embodiment, each second part 12, 22 has an upper guide adapted to support robotic means of inspection, and/or maintenance and/or cleaning.

[0085] In coupled configuration of the second parts 12 and 22, the upper guides identify a single upper guide.

[0086] The longitudinal guides of the first parts 11, 21, the transverse guides of the second parts 12, 22 and the upper guides may be realized in any of the ways known in the state of the art.

[0087] All these guides must allow the various parts to be moved as previously described.

[0088] Figure 3 illustrates a possible embodiment of such guides.

[0089] Referring to figure 3, a view of one of the two structures is illustrated, e.g., of the structure 1, in which the first part 11 and the second part 12 are provided.

[0090] The second part 12 has two transverse guides 122 adapted to allow the movement of the second part 12 with respect to the first part 11 (arrow C) and an upper guide 123 adapted to support robotic means of inspection, and/or maintenance and/or cleaning, not illustrated in the figure.

[0091] In coupled configuration of the second parts 12 and 22, the latter form a single platform, so that the robotic means can move from one second part to the other, using the upper guides 123.

[0092] The sliding of the first parts 11, 21 on the longitudinal guides positioned along the sides of the bridge 10 can take place thanks to standard means such as wheels or cables. The longitudinal guides can simply be realized with standard steel profiles.

[0093] The sliding of the second parts 12, 22 on the first parts 11, 21 takes place thanks to the racks 122 fixed to the second parts 12, 22, moving thanks to the sprockets 124 fixed to the first parts 11, 21.

[0094] In addition, the robotic means slide through another rack 123 fixed to the second parts 12, 22, on which a sprocket connected to said robotic means is fixed.

[0095] The robotic means can be of different nature: they can be dedicated to inspection tests, for example by providing additional cameras with respect to the sensors of the second parts, cleaning or other maintenance work.

[0096] The robotic means are moved from one side to the other of the bridge 10 (i.e., the second parts 12, 22) in a standard manner, thanks to the perfect continuity of the upper guides 123 positioned on the second parts.

[0097] The system object of the present invention is generally fully automatic, but is also manually operable, through specific tools, if the emergency recovery of the system is necessary.

[0098] During normal operation, therefore, the system object of the present invention is fully automatic and/or operated remotely, and the remote supervision of one or more operators can be provided.

[0099] An embodiment of the bridge inspection method of the present invention is illustrated in figure 4.

[0100] This method involves the use of the system described above.

[0101] Assuming to start with the two structures 1 and 2 in open configuration, step 40, these structures are moved, separately or in combination, in the area below the main roadway of the bridge to be inspected.

[0102] Once in position, the scan takes place, step 41, through the sensors positioned on the structures 1 and 2.

[0103] The scan performed by the structures 1 and 2 in open configuration is carried out quickly, thanks to the speed of movement of the two structures 1 and 2.

[0104] The data acquired during the scan, step 41, is collected and can be processed through artificial intelligence algorithms, which can be used both to identify the bridge status and to predict future interventions.

[0105] Subsequently, step 42, an analysis of the data collected in step 41 is performed to verify the presence of problems which require more accurate maintenance or investigation. In the absence of these problems, the scanning continues on another area of the bridge always in open configuration.

[0106] If the two structures 1 and 2 move independently, two different areas of the bridge can be inspected, speeding up the monitoring of the same, concentrating the inspection of both structures only at points identified as particularly deteriorated, or requiring maintenance.

[0107] Regardless of the combined or independent movement of the two structures, if problems are detected, the second parts 12 and 22 are moved transversely, until they reach the coupled configuration and the corresponding closed configuration, step 45, of the structures 1 and 2.

[0108] Obviously, during the independent movement of the two structures 1 and 2, the two structures 1 and 2 must first be aligned, to allow the second parts to be configured in closed condition.

[0109] Such configuration allows a single platform to be formed capable of supporting further robotic means, step 46, which perform more accurate inspections, maintenance and/or cleaning depending on the problems detected in step 42.

[0110] The presence of problems, i.e. the discriminant, which allows to assess whether it is necessary to intervene with dedicated robotic devices, can be established either through specific image processing algorithms, or manually, through the judgement of an operator, also in real time.

[0111] According to the embodiment illustrated in figure 4, before reaching the closed configuration, step 45, the system detects if it is located at a pier, which would not allow the movement of the second parts towards the central longitudinal axis of the bridge.

[0112] The detection of a pier may, for example, be carried out with proximity sensors.

[0113] If a pier is detected, the two structures 1 and 2 are moved, step 44, up to a distance from the pier such that the second parts 12 and 22, step 45, can be coupled and then operated with robotic means, step 46.

[0114] Step 48 relating to the use of robotic means is carried out not only to increase the accuracy of the images, but also if the previous scans of steps 41 and 46 have detected certain processes to be carried out on the bridge.

[0115] In such case the area on which to intervene is identified and the robotic means are controlled to remedy the damage detected.

[0116] It is evident that the method just described, operating in automatic mode, allows constant and continuous monitoring of the bridge, able to detect any damage and see to its repair.

[0117] Figures 5a and 5b illustrate two views of the second parts 12 and 22 in coupled configuration, with the detail of the ends of each second part facing the centre of the bridge.

[0118] As anticipated in fact, the second part 12 is realized in a manner completely similar to the second part 22, except for the contact ends in coupling configuration, which identify the interface 220.

[0119] According to the variant illustrated in the figures, such ends of the said second parts have complementary profiles, so that in coupled configuration of the second parts 12 and 22, the profiles of the corresponding ends are in contact by shape coupling.

[0120] In particular, the end of the second part 12 has a convex profile 222, along a vertical section plane, in the direction of the central longitudinal axis of the bridge 10, while the other end has a concave profile 221, along a vertical section plane, in the direction of the centre of the bridge 10.

[0121] The profiles 221 and 222 therefore have a wedge-shaped section, such that, in the transition from the decoupled configuration to the coupled configuration, the outer walls of the profile 222 slide against the outer walls of the profile 221, up to the interpenetration of the vertex of the profile 222 into the seat formed by the concave profile 221.

[0122] The variant just described makes it possible to realize a system which has a particularly slim structure and easy handling.

[0123] Several factors make it possible to obtain these benefits.

[0124] First, the second parts 12 and 22 can slide on the first parts 11 and 21, which are hung on the guides 13 and 23 and do not require additional components for the correct maintenance in position of the second or first parts.

[0125] Furthermore, according to the illustrated embodiment, the curved shape of the second parts 12 and 22 allows to limit the dimensions of the latter, also in open condition, when the second parts are more spaced apart from each other

[0126] Finally, the curved shape of the second parts 21 and 22 also has advantageous aspects with respect to the translation, especially in combination with the presence of complementary surfaces as described with regard to figures 5a and 5b, as it facilitates the coupling of the two second parts 12 and 22.

[0127] The translation along a curve, and not along a straight line, of the two second parts, facilitates the sliding of the surface 222 on the surface 221, ensuring a solid coupling of the two second parts, even in the event of jolts in one or the other part, during the transition from the open condition to the closed condition.

Claims

1. A bridge inspection and maintenance system comprising a platform slidably mounted below said bridge (10),

    said platform consisting of two structures (1, 2) positioned symmetrically with respect to the longitudinal axis (A) of the bridge (10),
    each structure (1, 2) comprising a first part (11, 21) configured to move along a longitudinal axis of the bridge on a corresponding longitudinal guide integral with said bridge (10) and a second part (12, 22) configured to translate transversely with respect to said longitudinal axis on said first part (11, 21) on a corresponding transverse guide,
    the two said structures (1, 2) being movable from a closed configuration, wherein the corresponding second parts (12, 22) are coupled to each other at the central longitudinal axis of the bridge (10), to an open configuration, wherein the two said second parts (12, 22) are separated from each other in the opposite direction with respect to the central longitudinal axis of the bridge (10), until they are decoupled from each other, by a transverse translational movement,
    characterized in that said platform comprises one or more sensors for acquiring images of said bridge (10) and **in that**
    said one or more sensors are provided on each of said second parts (12, 22),
    Said two structures being configured to be independently moved along the bridge.

2. The system of claim 1, wherein each second part (12, 22) has an upper guide adapted to support robotic inspection and/or maintenance and/or cleaning means, the upper guides identifying a single upper guide in coupled configuration of said second parts (12, 22).

3. The system according to claim 1, wherein the ends of said second parts (12, 22) facing the central longitudinal axis of the bridge (10) have complementary profiles, such that in a coupled configuration of the two second parts (12, 22), the profiles of the corresponding ends are in contact by shape coupling.

4. The system according to claim 3, wherein one end has a convex profile (222) along a vertical section plane in the direction of the central longitudinal axis of the bridge (10), while the other end has a concave profile (221) along a vertical section plane in the direction of the central longitudinal axis of the bridge (10).

5. The system according to claim 1, wherein the said longitudinal guides are arranged at the sides of the bridge (10), the said second parts (12, 22) being arranged lower than said first parts (11, 21).

6. A bridge inspection and maintenance method, which method involves using the system according to one or more of claims 1 to 5,
    characterized in that it comprises the following steps:

    a) translating at least one structure (1, 2) along the bridge (10) and acquiring images of the bridge (10), through scanning by the second part of said at least one structure, the two said structures (1, 2) being provided in open configuration
    b) processing said images,
    c) positioning the second parts (12, 22) in open or closed configuration based on the processing of step b).

7. The method according to claim 6, wherein step c) involves the following sub-steps:

    - identifying at least one point on the bridge where a more accurate acquisition can be made than in step a),
    - translating the two structures (1, 2) at said point,
    - positioning the second parts (12, 22) in closed configuration,
    - acquiring one or more images at said point.

8. The method according to claim 7, wherein step c) comprises using dedicated robotic inspection, maintenance and cleaning means.

9. The method according to claim 6, wherein step c) involves the positioning of the second parts (12, 22) in open configuration when the two said structures

(1, 2) are located at a pier (100) of said bridge (10).

Patentansprüche

1. Brückeninspektions- und -wartungssystem, umfassend eine Plattform, die verschiebbar unter der Brücke (10) montiert ist,

   wobei die Plattform aus zwei Strukturen (1, 2) besteht, die symmetrisch in Bezug auf die Längsachse (A) der Brücke (10) positioniert sind,
   wobei jede Struktur (1, 2) einen ersten Teil (11, 21) umfasst, der dazu konfiguriert ist, sich entlang einer Längsachse der Brücke auf einer entsprechenden mit der Brücke (10) integrierten Längsführung zu bewegen, und einen zweiten Teil (12, 22), der dazu konfiguriert ist, sich quer in Bezug auf die Längsachse auf dem ersten Teil (11, 21) auf einer entsprechenden Querführung zu bewegen,
   wobei die zwei Strukturen (1, 2) von einer geschlossenen Konfiguration, in der die entsprechenden zweiten Teile (12, 22) an der zentralen Längsachse der Brücke (10) miteinander gekoppelt sind, in eine offene Konfiguration bewegbar sind, wobei die beiden zweiten Teile (12, 22) voneinander in entgegengesetzter Richtung in Bezug auf die zentrale Längsachse der Brücke (10) getrennt sind, bis sie durch eine transversale Translationsbewegung voneinander entkoppelt werden,
   dadurch gekennzeichnet, dass die Plattform einen oder mehrere Sensoren zum Erfassen von Bildern der Brücke (10) umfasst und dass der eine oder die mehreren Sensoren auf jedem der zweiten Teile (12, 22) bereitgestellt sind,
   wobei die zwei Strukturen dazu konfiguriert sind, unabhängig voneinander entlang der Brücke bewegt zu werden.

2. System nach Anspruch 1, wobei jedes zweite Teil (12, 22) eine obere Führung aufweist, die dazu angepasst ist, robotische Inspektions- und/oder Wartungs- und/oder Reinigungsmittel zu tragen, wobei die oberen Führungen eine einzelne obere Führung in gekoppelter Konfiguration der zweiten Teile (12, 22) identifizieren.

3. System nach Anspruch 1, wobei die Enden der zweiten Teile (12, 22), die der zentralen Längsachse der Brücke (10) zugewandt sind, komplementäre Profile aufweisen, sodass in einer gekoppelten Konfiguration der beiden zweiten Teile (12, 22) die Profile der entsprechenden Enden durch Formkopplung in Kontakt stehen.

4. System nach Anspruch 3, wobei ein Ende ein konvexes Profil (222) entlang einer vertikalen Schnittebene in der Richtung der zentralen Längsachse der Brücke (10) aufweist, während das andere Ende ein konkaves Profil (221) entlang einer vertikalen Schnittebene in der Richtung der zentralen Längsachse der Brücke (10) aufweist.

5. System nach Anspruch 1, wobei die Längsführungen an den Seiten der Brücke (10) angeordnet sind, wobei die zweiten Teile (12, 22) tiefer angeordnet sind als die ersten Teile (11, 21).

6. Verfahren zur Inspektion und Wartung von Brücken, wobei das Verfahren die Verwendung des Systems nach einem oder mehreren der Ansprüche 1 bis 5 umfasst,
   dadurch gekennzeichnet, dass es die folgenden Schritte umfasst:

   a) Verschieben mindestens einer Struktur (1, 2) entlang der Brücke (10) und Erfassen von Bildern der Brücke (10) durch Abtasten durch den zweiten Teil der mindestens einen Struktur, wobei die zwei Strukturen (1, 2) in offener Konfiguration bereitgestellt sind
   b) Verarbeiten der Bilder,
   c) Positionieren der zweiten Teile (12, 22) in offener oder geschlossener Konfiguration basierend auf der Verarbeitung von Schritt b).

7. Verfahren nach Anspruch 6, wobei Schritt c) die folgenden Teilschritte umfasst:

   - Identifizieren mindestens eines Punktes auf der Brücke, an dem eine genauere Erfassung als in Schritt a) vorgenommen werden kann,
   - Verschieben der zwei Strukturen (1, 2) an diesem Punkt,
   - Positionieren der zweiten Teile (12, 22) in geschlossener Konfiguration,
   - Erfassen eines oder mehrerer Bilder an diesem Punkt.

8. Verfahren nach Anspruch 7, wobei Schritt c) das Verwenden dedizierter robotischer Inspektions-, Wartungs- und Reinigungsmittel umfasst.

9. Verfahren nach Anspruch 6, wobei Schritt c) das Positionieren der zweiten Teile (12, 22) in offener Konfiguration umfasst, wenn sich die zwei Strukturen (1, 2) an einem Pfeiler (100) der Brücke (10) befinden.

Revendications

1. Système d’inspection et d’entretien de pont compre-

nant une plate-forme montée coulissante sous ledit pont (10),

ladite plate-forme étant constituée de deux structures (1, 2) positionnées symétriquement par rapport à l'axe longitudinal (A) du pont (10), chaque structure (1, 2) comprenant une première partie (11, 21) configurée pour se déplacer le long d'un axe longitudinal du pont sur un guide longitudinal correspondant solidaire dudit pont (10) et une seconde partie (12, 22) configurée pour se translater transversalement par rapport audit axe longitudinal sur ladite première partie (11, 21) sur un guide transversal correspondant,
les deux dites structures (1, 2) étant mobiles d'une configuration fermée, dans laquelle les secondes parties correspondantes (12, 22) sont couplées l'une à l'autre au niveau de l'axe longitudinal central du pont (10), à une configuration ouverte, dans laquelle les deux dites secondes parties (12, 22) sont séparées l'une de l'autre dans la direction opposée par rapport à l'axe longitudinal central du pont (10), jusqu'à ce qu'elles soient découplées l'une de l'autre, par un mouvement de translation transversale,
caractérisé en ce que ladite plate-forme comprend un ou plusieurs capteurs pour acquérir des images dudit pont (10) et **en ce que** lesdits un ou plusieurs capteurs sont prévus sur chacune desdites secondes parties (12, 22),
lesdites deux structures étant configurées pour être déplacées indépendamment le long du pont.

2. Système selon la revendication 1, dans lequel chaque seconde partie (12, 22) présente un guide supérieur adapté pour supporter des moyens d'inspection et/ou d'entretien et/ou de nettoyage robotisés, les guides supérieurs identifiant un seul guide supérieur dans une configuration couplée desdites secondes parties (12, 22).

3. Système selon la revendication 1, dans lequel les extrémités desdites secondes parties (12, 22) faisant face à l'axe longitudinal central du pont (10) ont des profils complémentaires, de sorte que dans une configuration couplée des deux secondes parties (12, 22), les profils des extrémités correspondantes sont en contact par couplage de forme.

4. Système selon la revendication 3, dans lequel une extrémité a un profil convexe (222) le long d'un plan de section verticale dans la direction de l'axe longitudinal central du pont (10), tandis que l'autre extrémité a un profil concave (221) le long d'un plan de section verticale dans la direction de l'axe longitudinal central du pont (10).

5. Système selon la revendication 1, dans lequel lesdits guides longitudinaux sont disposés sur les côtés du pont (10), lesdites secondes parties (12, 22) étant disposées plus bas que lesdites premières parties (11, 21).

6. Procédé d'inspection et d'entretien de pont, lequel procédé implique l'utilisation du système selon une ou plusieurs des revendications 1 à 5,
caractérisé en ce qu'il comprend les étapes suivantes consistant à :

a) traduire au moins une structure (1, 2) le long du pont (10) et acquérir des images du pont (10), par balayage par la seconde partie de ladite au moins une structure, les deux dites structures (1, 2) étant fournies en configuration ouverte
b) traiter lesdites images,
c) positionner les secondes parties (12, 22) dans une configuration ouverte ou fermée sur la base du traitement de l'étape b).

7. Procédé selon la revendication 6, dans lequel l'étape c) implique les sous-étapes suivantes consistant à :

- identifier au moins un point sur le pont où une acquisition plus précise peut être faite qu'à l'étape a),
- translater les deux structures (1, 2) audit point,
- positionner les secondes parties (12, 22) en configuration fermée,
- acquérir une ou plusieurs images audit point.

8. Procédé selon la revendication 7, dans lequel l'étape c) comprend l'utilisation de moyens d'inspection, d'entretien et de nettoyage robotisés dédiés.

9. Procédé selon la revendication 6, dans lequel l'étape c) implique le positionnement des secondes parties (12, 22) dans une configuration ouverte lorsque les deux dites structures (1, 2) sont situées au niveau d'une pile (100) dudit pont (10).

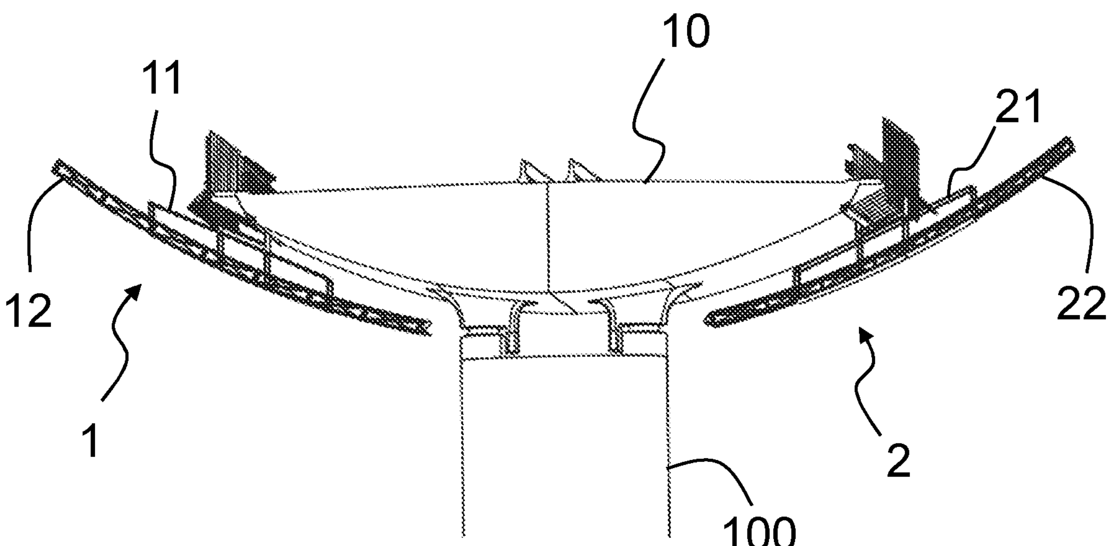

Fig. 1a

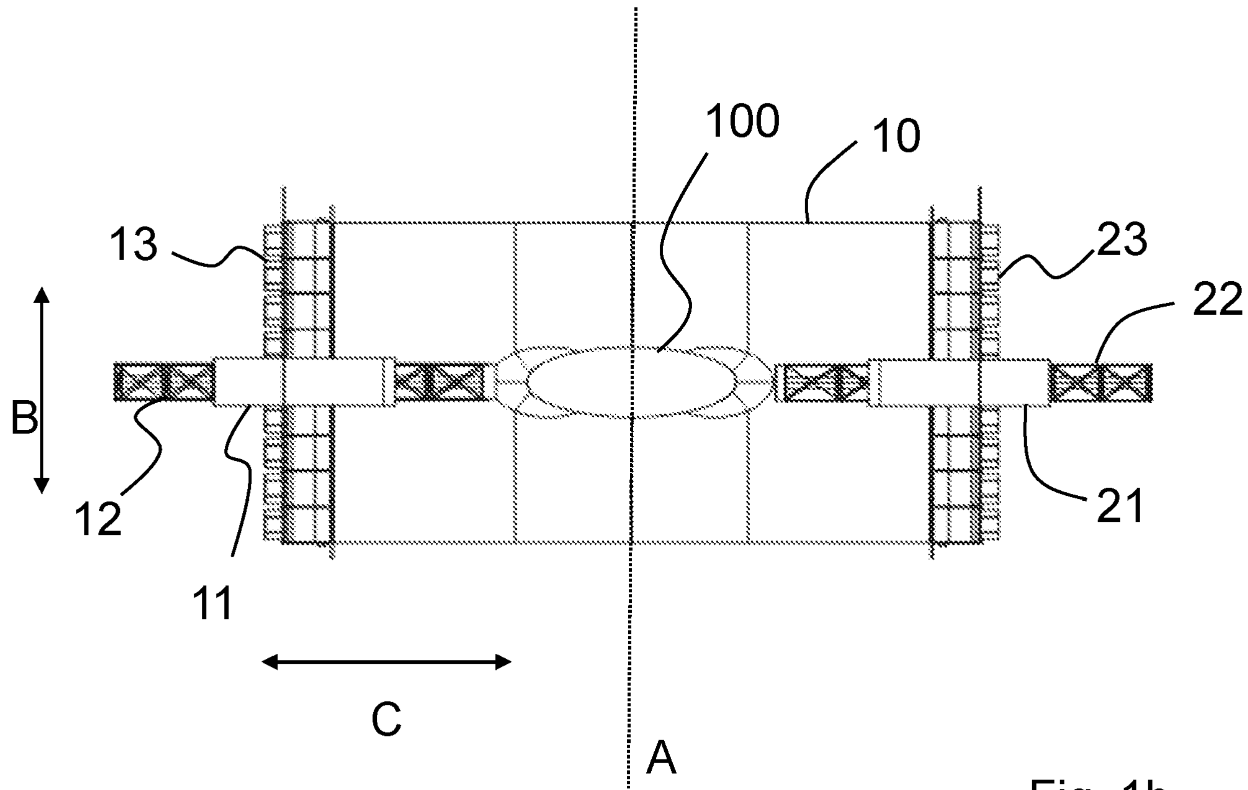

Fig. 1b

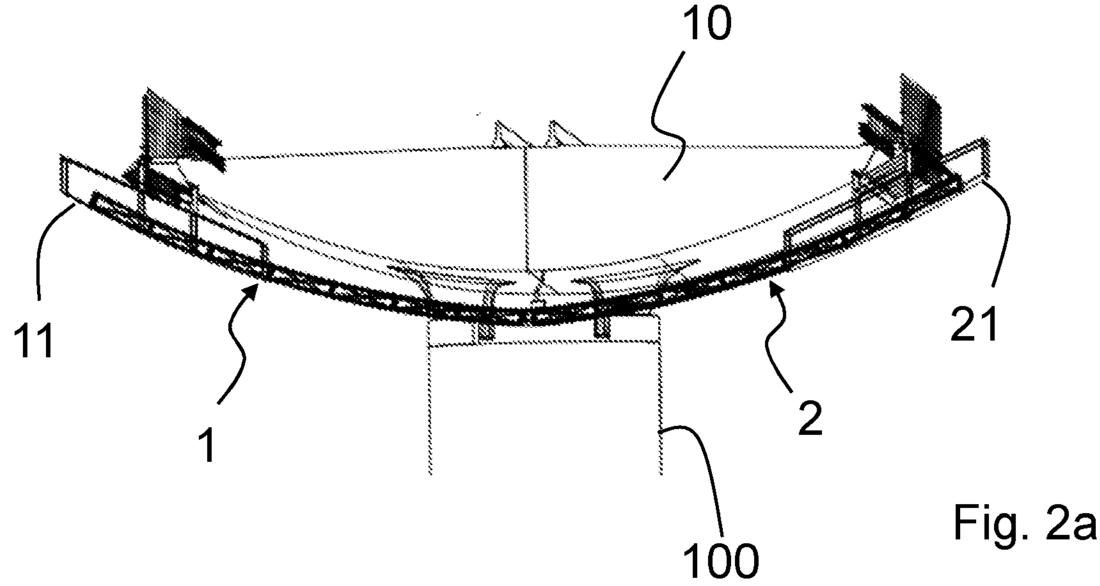

Fig. 2a

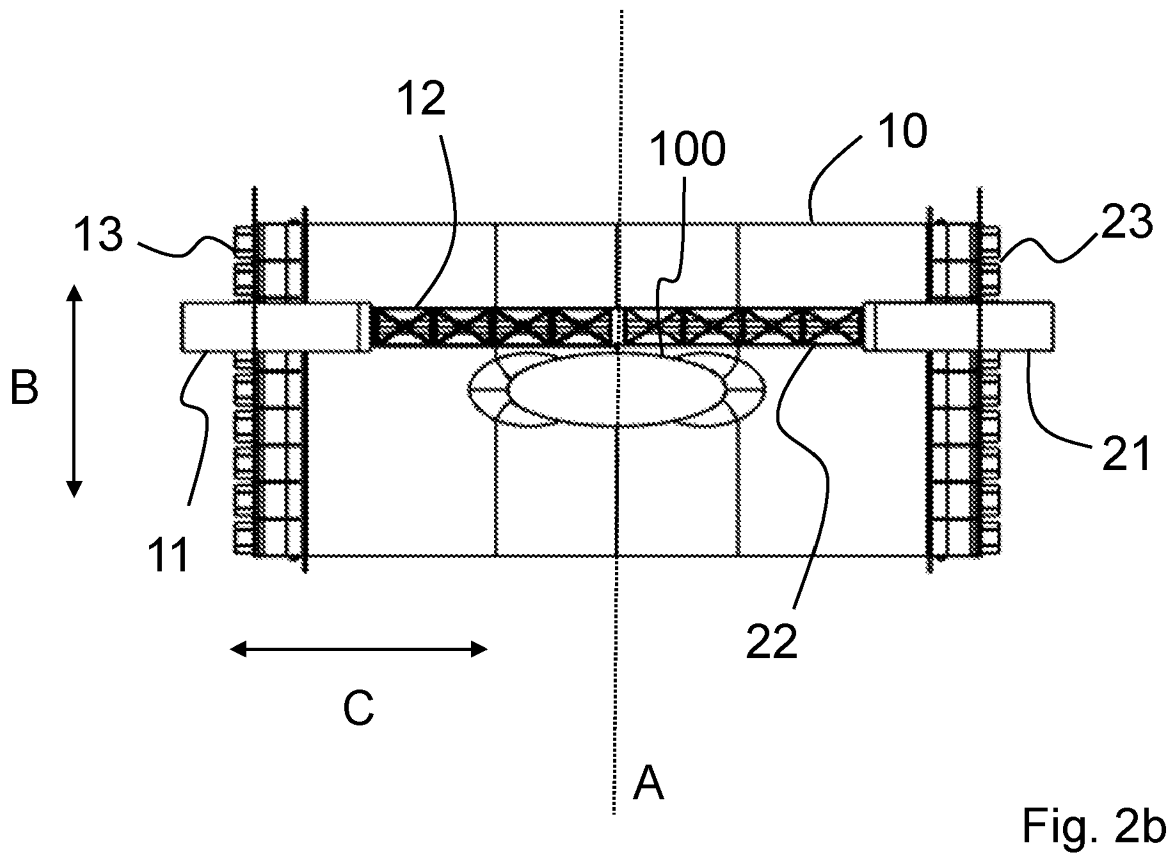

Fig. 2b

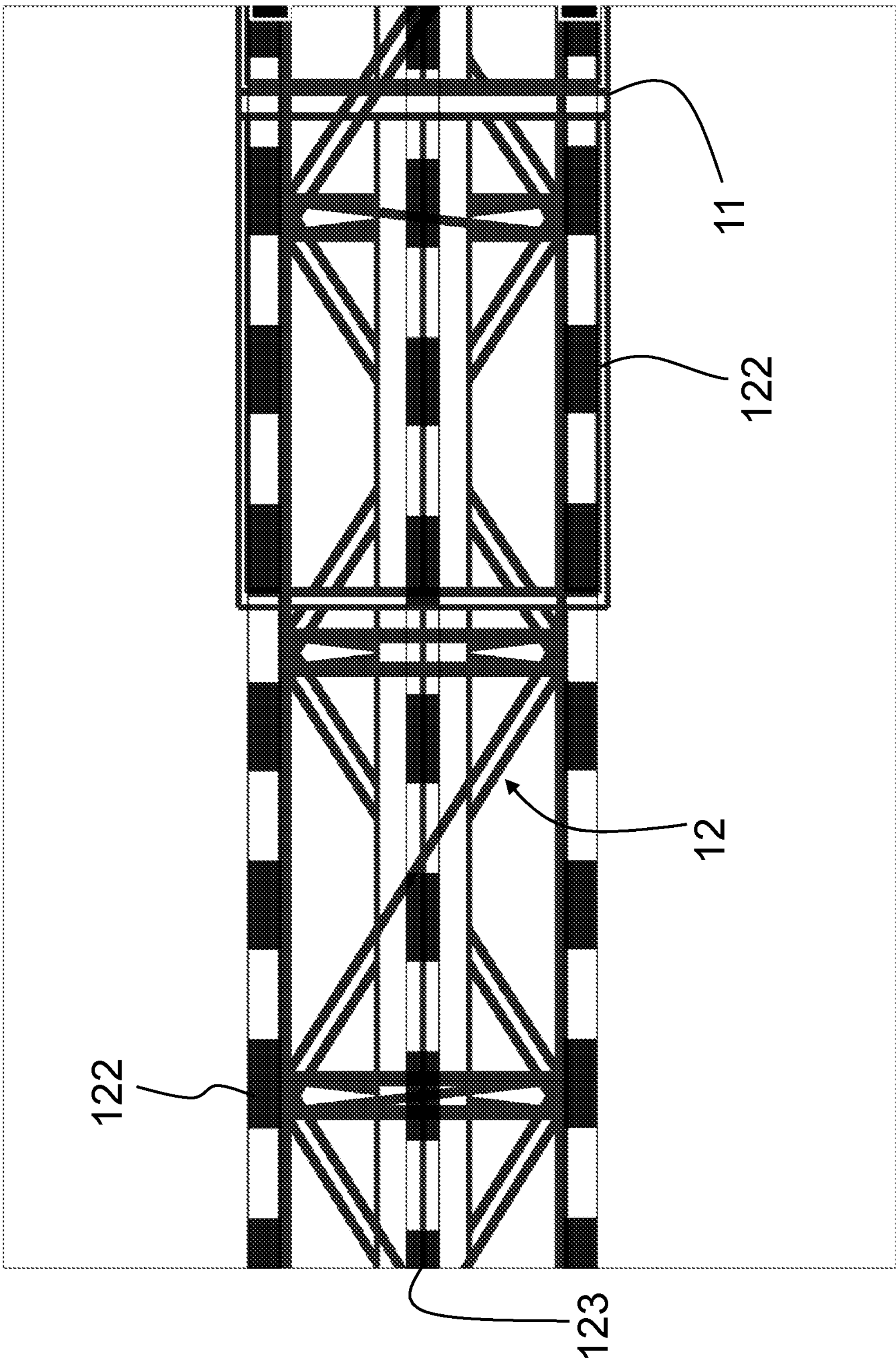

Fig. 3

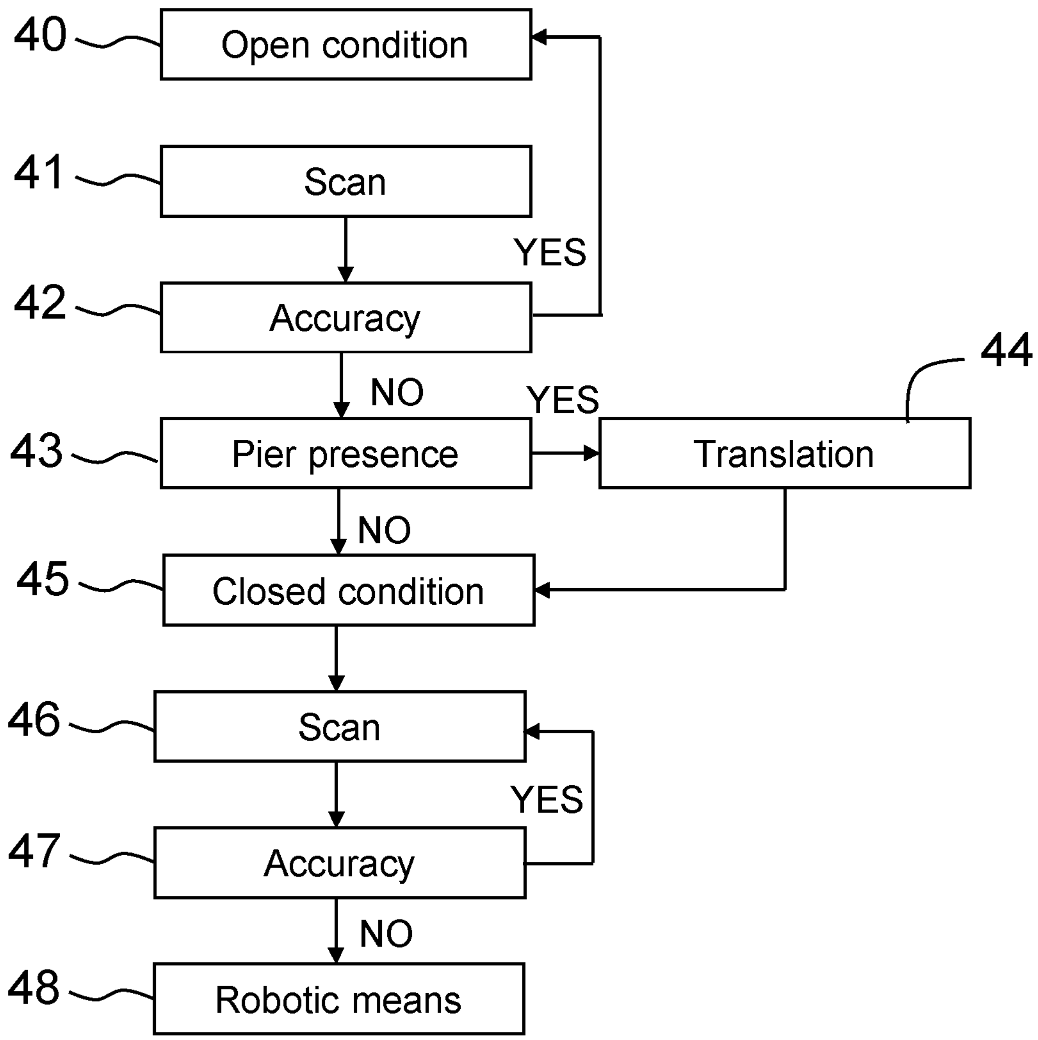
40
Open condition
41
Scan
YES
42
Accuracy
NO
YES
44
43
Pier presence
Translation
NO
45
Closed condition
46
Scan
YES
47
Accuracy
NO
48
Robotic means

Fig. 4

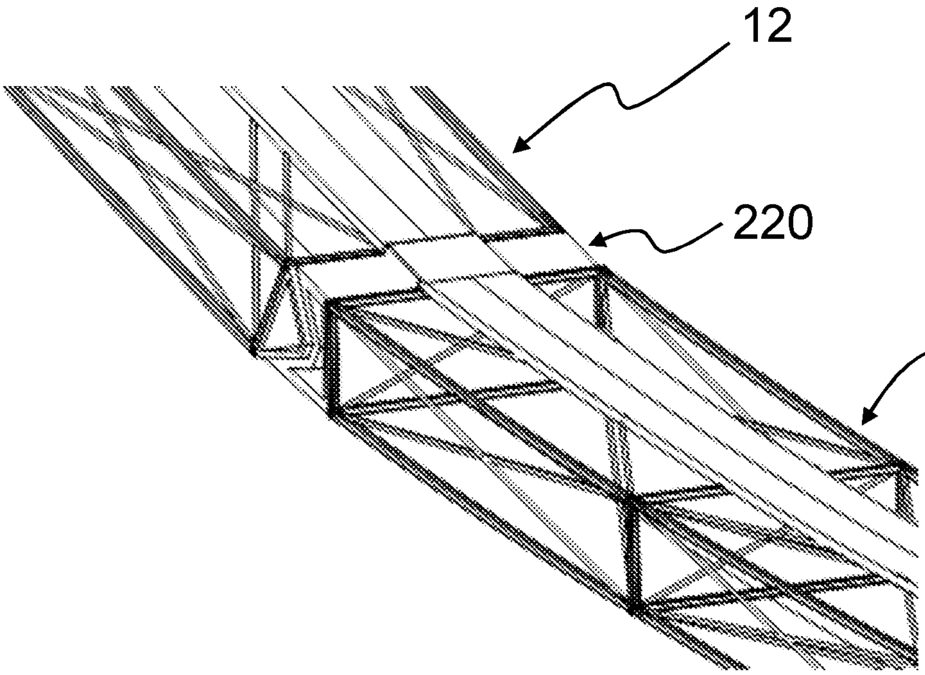

Fig. 5a

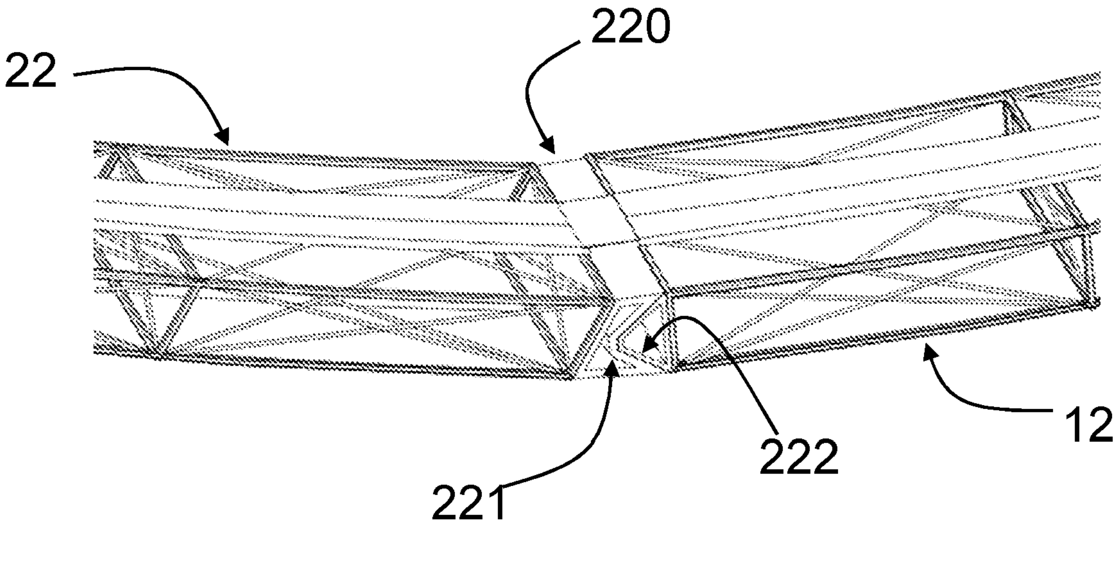

Fig. 5b

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 105507145 B **[0016]**