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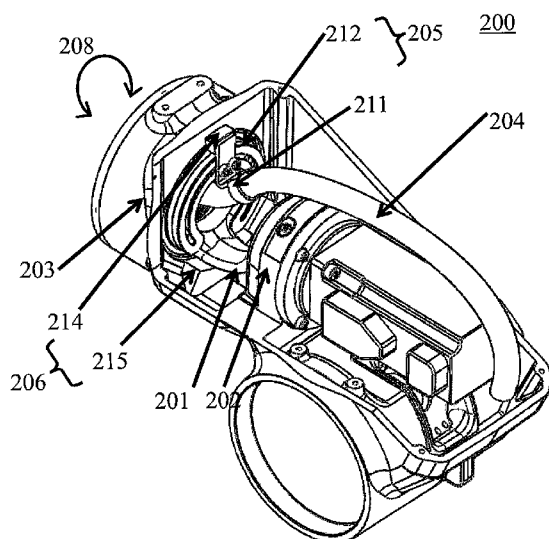


Fig. 2

(57) Abstract: A routing structure (200, 300, 400, 500) for a robot is provided. The routing structure (200, 300, 400, 500) comprises a rotary shaft (201) adapted to be rotatable around an axis; and a guide member (205) arranged to support cables (204) or hoses, such that the cables (204) or hoses are separated from the rotary shaft (201). By means of the guide member (205), the direction and shape of bending and twisting of the cables (204) or hoses would be predictable and unnecessary friction may be avoided. A rotary joint comprising the routing structure (200, 300, 400, 500) and a robot comprising the rotary joint are also provided.



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ROUTING STRUCTURES FOR ROBOT

FIELD OF INVENTION

- 5 [0001] Embodiments of the present invention generally relate to the field of industry robots, particularly relate to routing structures for robots, and more particularly relate to routing structures for a large rotation range.

BACKGROUND OF INVENTION

- 10 [0002] Nowadays, for industrial robots, especially the ones designed to work in limited and complex workspaces, flexibility and compactness are becoming major design requirements.

- [0003] A robot typically comprises one or more rotary joints in order to achieve flexible positioning of robot arms. Generally, the larger the rotation ranges of the rotary joints are, the more flexible a robot is. The robots with flexible joints can achieve user-assigned positions without big changes of the main axes.
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- [0004] Also, there is a trend to route all the cables, including the custom cables, inside the robot arms. With this feature, better protection for the cables can be provided, and the Mean Time Between Failures (MTBF) of robots increases significantly. This feature also enables users to program the robot without considering the possibility of cables interfering with the surroundings, which has simplified the processes of programming and debugging.
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- [0005] However, both of these two requirements lead to a big challenge to the design of cable routing: cables and hoses must be routed in narrow spaces inside robot arms, and go through joints with big rotation ranges. As we know, improper structures will cause cables and hoses bending in a small radius, twisting in a small length, or sliding on coarse surfaces. All of these will reduce the lifetime of cables and hoses and cause unwanted shutdown.
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- 30 SUMMARY OF THE INVENTION

[0006] In view of the foregoing, there is a need in the art for a routing structure which can reduce or eliminate the interference between a rotary shaft and cables. Further, there is a need for a routing structure which enables a large rotation range. In addition, there is a need for a routing structure which is compact.

5 [0007] To better address one or more of the above concerns, in a first aspect of the invention, a routing structure for a robot is provided. The routing structure comprises: a rotary shaft adapted to be rotatable around an axis; and a guide member arranged to support cables or hoses, such that the cables or hoses are separated from the rotary shaft.

10 [0008] In an exemplary embodiment, the rotary shaft can be shaped as an arc to allow the cables or hoses going through a hollow axle coupled with the rotary shaft.

[0009] In an exemplary embodiment, a first end of the rotary shaft is coupled with a driving unit and a second end of the shaft is coupled with the hollow axle.

15 [0010] In an exemplary embodiment, the guide member can comprise a supporter for supporting the cables or hoses; a runner arranged to be coaxial with the rotary shaft; and a slider arranged to be slidable along the runner. A first end of the supporter is shaped for clamping the cables or hoses and a second end of the supporter is coupled with the slider.

[0011] In exemplary embodiments, the runner may be fixed on the rotary shaft or on a housing of the robot.

20 [0012] In an exemplary embodiment, the runner may be replaced with a rotary bearing. The rotary bearing is arranged coaxially with the rotary shaft. The rotary bearing may comprise two portions being rotatable with respect to each other. One portion of the rotary bearing is fixed with the slider, and the other portion is fixed on the rotary shaft or on a housing of the robot.

25 [0013] In an exemplary embodiment, the routing structure can further comprise a mechanical stopper for preventing the rotary shaft from moving out of its working range.

[0014] In an exemplary embodiment, the mechanical stopper comprises a projection fixed to the second end of the supporter; and a boss located on a housing of the robot for blocking the projection and thereby the rotary shaft from forwarding.

[0015] In an exemplary embodiment, when the rotary shaft rotates within a first range,

the supporter remains substantially quiescent, and when the rotary shaft rotates within a second range, the rotary shaft pushes the supporter to rotate together.

[0016] In an exemplary embodiment, the first end of the supporter has a ring for guiding the cables or hoses, and the cables or hoses are rotatable with respect to the ring.

5 [0017] In a second aspect of the invention, embodiments of the present invention provide a rotary joint comprising the routing structure as described above.

[0018] In a third aspect of the invention, embodiments of the present invention provide a robot comprising the rotary joint as described above.

10 [0019] Particular embodiments of the subject matter described in this specification can be implemented so as to realize one or more of the following advantages.

[0020] With particular embodiments of the techniques described in this specification, a simple routing structure is provided, which reduces or eliminates the interference between the cables and the rotary shaft. Due to its simple structure, it is easy for adoption and possible to achieve a bigger hole to let cable go through in a compact design. Further,
15 without using special drivetrain components, the risk of component failure is reduced and the cost of the routing structure would be more competitive.

[0021] Other features and advantages of the embodiments of the present invention will also be understood from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the
20 principles of embodiments of the present invention.

BRIEF DESCRIPTION OF DRAWINGS

[0022] Embodiments of the present invention will be described in the sense of examples and their advantages are explained in greater detail below, with reference to the
25 accompanying drawings, wherein:

[0023] FIG. 1 shows a routing structure 100 in the prior art;

[0024] FIG. 2 shows a routing structure 200 at a home position according to a first embodiment of the present invention;

[0025] FIG. 3 shows a section view of the routing structure 200 as shown in Fig. 2;

[0026] FIG. 4 shows the routing structure 200 at an in-between position according to the first embodiment of the present invention;

[0027] FIG. 5 shows the routing structure 200 at a max positive position according to the first embodiment of the present invention;

5 [0028] FIG. 6 shows the routing structure 200 at a max negative position according to the first embodiment of the present invention;

[0029] FIG. 7 shows a detailed view of a mechanical stopper according to the first embodiment of the present invention;

10 [0030] FIGS. 8A-8B shows a routing structure 300 according to a second embodiment of the present invention;

[0031] FIGS. 9A-9B shows a routing structure 400 according to a third embodiment of the present invention; and

[0032] FIGS. 10A-10B shows a routing structure 500 according to a fourth embodiment of the present invention.

15 [0033] Throughout the figures, same or similar reference numbers indicate same or similar elements.

DETAILED DESCRIPTION OF EMBODIMENTS

20 [0034] Hereinafter, the principle and spirit of the present invention will be described with reference to the illustrative embodiments. It should be understood, all these embodiments are given merely for the skilled in the art to better understand and further practice the present invention, but not for limiting the scope of the present invention. For example, features illustrated or described as part of one embodiment may be used with another embodiment to yield still a further embodiment. In the interest of clarity, not all
25 features of an actual implementation are described in this specification.

[0035] In the prior art, the most common routing solution is using a hollow joint. All the cables go through the joint by the hole coincident with the joint axis, and twist when the joint rotate.

[0036] FIG. 1 shows a routing structure 100 in the prior art. In the routing structure

100, a rotary shaft 101 is coupled between two members. One end of the rotary shaft 101 is directly or indirectly coupled with a driving unit 102, e.g. a motor, and the other end of the rotary shaft 101 is coupled with a driven axle 103, e.g. a robot arm.

[0037] In order to transmit power and various signals to and from robot arms, one or more cables typically go through each rotary joint. The rotary shaft 101 is shaped as an arc, such that the arc shaft 101 can be used to form a hole and let the cables 104 go through.

[0038] During operation, the driving unit 102 may drive the rotary shaft 101 to rotate in directions as indicated by the arrow 108. Then, the rotary shaft 101 may drive the driven axle 103, e.g. a robot arm, to rotate accordingly. In this way, the robot arm can achieve desired positions.

[0039] The routing structure 100 as shown in FIG. 1 is very simple and can work well under a situation that relative small rotation ranges, e.g., no more than $\pm 170^\circ$, are required. Specifically, when the rotation range is small, e.g. $\pm 170^\circ$, generally, the cables 104 going through the robot joint would not contact with the rotary shaft 101 and no bending or twisting will happen. However, when the rotation ranges increase, for example $\pm 270^\circ$, the rotary shaft 101 would contact with the free cables 104 going through the hollow (not shown) and drive the free cables 104 to rotate together. Such rotation will cause the cables 104 bending in a small radius, twisting around the driving unit 102 in a small length, and sliding on coarse surfaces, e.g. the surface of the driving unit 102. All of these will reduce the lifetime of the cables.

[0040] Some other routing structures in the prior art need special components, e.g., a drive unit including hollow motors and/or hollow reducers, which increases risk of component failure and the cost of the routing structures.

[0041] Thus, to better address one or more of the above concerns, in general, embodiments of the present invention provide a routing structure for a robot. The routing structure comprises a rotary shaft adapted to be rotatable around an axis; and a guide member arranged to support cables or hoses, such that the cables or hoses are separated from the rotary shaft. In some implementations, the rotary shaft is shaped as an arc to allow the cables or hoses going through a hollow axle coupled with the rotary shaft. In some implementations, a first end of the rotary shaft is coupled with a driving

unit, and a second end of the rotary shaft is coupled with the hollow axle.

[0042] The proposed routing structure is very simple and easy to adopt even in a compact design. By means of the guide member, the direction and shape of bending and twisting of the cables or hoses would be predictable, and thus unwanted contact and friction between the shaft and the cables or hoses may be avoided as possible. In further embodiments, such routing structure is easy to introduce an additional safety assurance mechanism, which is important during robot applications. In addition, without using special drivetrain components, the risk of component failure is reduced and the cost of the routing structure would be more competitive.

[0043] With reference to the accompanying drawings, some embodiments of the present invention will be described hereinafter. Throughout the descriptions of various embodiments of the present invention, repeated descriptions of similar elements will be omitted. Although the following description will be described with respect to a robot joint, the skilled in the art could understand that the proposed routing structure may be used in any apparatus where interference between a rotary shaft and cables or hoses should be reduced or eliminated.

Embodiment 1

[0044] Referring to FIGS. 2-7, hereinafter will be described a first embodiment of the present invention.

[0045] FIG. 2 shows a routing structure 200 at a home position according to the first embodiment of the present invention.

[0046] As shown in FIG. 2, a rotary shaft 201 is coupled between two members. A first end of the rotary shaft 201 is coupled with a driving unit 202, for example, a motor. A second end of the rotary shaft 201 is coupled with a driven axle 203, for example, a robot arm. During operation, the driving unit 202 may drive the rotary shaft 201 to rotate around an axis, i.e., rotating in directions as indicated by the arrow 208. Then, the rotary shaft 201 may drive the driven axle 203, e.g. a robot arm, to rotate accordingly. In this way, the robot arm can achieve desired positions.

[0047] The rotary shaft 201 is shaped to allow cables 204 or hoses traveling within the

robot. In one implementation, the rotary shaft 201 may be shaped as an arc to allow the cables 204 or hoses going through a hollow axle (e.g., the driven axle 203) coupled with the rotary shaft, which is similar to that in FIG. 1. In other implementations, the rotary shaft 201 may have other shapes to form a hole and let the cables 204 or hoses go through.

5 [0048] Different from the solution as shown in FIG. 1 where the cables are free, in embodiments of the present invention, a guide member 205 is provided to support the cables 204 or hoses so as to provide a fixture point for the cables 204 or hoses. The guide member 205 has separated the cables 204 or hoses from the rotary shaft 201, such that unnecessary friction between the cables and the rotary shaft may be avoided. Further,
10 by fixing the cables or hoses partly, the direction and shape of bending and twisting of the cables may be predictable.

[0049] The guide member 205 may be constructed in various ways. In this embodiment, the guide member 205 comprises a supporter 211 for supporting the cables 204 or hoses; a runner 212 arranged to be coaxial with the rotary shaft 201; and a slider
15 213 (shown in FIG. 3) arranged to be slidable along the runner 212.

[0050] A first end of the supporter 211 is shaped for guiding the cables 204 or hoses. In one implementation, the first end of the supporter 211 may have a ring, e.g. a C-shaped ring, for clamping the cables 204 or hoses, and the cables or hoses may be rotatable with respect to the C-shaped ring.

20 [0051] A second end of the supporter 211 is coupled with the slider 213. The coupling may be implemented by one or more screws as shown in FIGS. 2-3. In other implementation, the second end of the supporter 211 and the slider 213 may be coupled in other ways, including but not limited to riveting, moulding, welding, etc. Alternatively, the second end of the supporter 211 and the slider 213 may be formed integrally.

25 [0052] By such arrangement, the slider 213 and the supporter 211 may slide along the runner 212 and drive the clamped cables 204 or hoses to move (e.g., bend and twist) together.

[0053] The runner 212 may have a C-shaped ring. In the first embodiment, the runner 212 is fixed on the rotary shaft 201 and is concentric with the rotary shaft 201.
30 Depending on the manufacture method, the runner 212 and the rotary shaft 201 may be formed integrally or separately.

[0054] In some implementations, rollers may be adopted to smooth the sliding in the runner 212.

[0055] In a prefer implementation, the routing structure 200 may further comprise a mechanical stopper 206 for preventing the rotary shaft 201 from moving out of its working range. The mechanical stopper 206 is an important safety assurance during robot applications.

[0056] As shown in FIG. 2, the mechanical stopper 206 may comprise a projection 214 and a boss 215. The projection 214 may be fixed to the second end of the supporter 211 and project out of the runner 212 in the radial direction. Depending on the manufacture method, the projection 214 and the supporter 211 may be formed integrally or separately. When formed separately, the projection 214 and the supporter 211 may be coupled by riveting, moulding, welding, etc.

[0057] The boss 215 is located on a housing of the robot, e.g., the housing of the driving unit 202, for blocking the projection 214 and thereby blocking the rotary shaft 201 from forwarding. Similarly, the boss 215 may be formed integrally with the housing of the driving unit 202. Alternatively, the boss 215 may be formed separately and coupled with the housing by riveting, moulding, welding, etc.

[0058] The nature-born safety structure is integrated in this routing solution without any additional cost, which has provided more safety assurance for operators and equipments. The operation of the mechanical stopper 206 will be described later with respect to FIGS. 5-7.

[0059] For better illustrating, FIG. 3 shows a section view of the routing structure 200 of the first embodiment. As shown in FIG. 3, a rotary shaft 201 is coupled between a driving unit 202 and a driven axle 203. The rotary shaft 201 is shaped as an arc to allow cables 204 or hoses going through.

[0060] A guide member 205 is shown to include a supporter 211 for supporting the cables 204 or hoses; a runner 212 arranged to be coaxial with the rotary shaft 201; and a slider 213 arranged to be slidable along the runner 212.

[0061] The first end of the supporter 211 is shaped for clamping the cables 204 or hoses, and the cables or hoses may be rotatable with respect to the C-shaped ring. The

second end of the supporter 211 is coupled with the slider 213 by one or more screws, such that the slider 213 and the supporter 211 may slide along the runner 212 and drive the clamped cables 204 or hoses to move (e.g., bend and twist) together.

[0062] The runner 212 may have a C-shaped ring and be fixed on one end of the rotary shaft 201.

[0063] A mechanical stopper 206 is provided for preventing the rotary shaft 201 from moving out of its working range. The mechanical stopper 206 comprises a projection 214 and a boss 215. The projection 214 may be fixed to the second end of the supporter 211 and project out of the runner 212 in the radial direction. The projection 214 and the supporter 211 may be formed integrally and take the shape of Z. The head of Z is the projection 214, and the tail of Z is the first end of the supporter 211, which has a C-shaped ring for clamping the cables 204 or hoses. The boss 215 is located on a housing of the robot for blocking the projection 214 and thereby blocking the rotary shaft 201 from forwarding.

[0064] The routing structure 200 is very simple and easy to adopt even in a compact design. By means of the guide member 205, the movement of the cables 204 or hoses may be restricted, and thus unwanted contact and friction between the rotary shaft 201 and the cables 204 or hoses may be avoided as possible. In further implementations, a mechanical stopper 206 may be introduced to assure safety.

[0065] Hereinafter the operation of the routing structure 200 will be described with respect to FIGS. 1 and 4-6, which respectively show the routing structure 200 at different positions during operation.

[0066] FIG. 1 shows the routing structure 200 at a home position according to the first embodiment of the present invention. As shown in FIG. 1, at the home position, the rotary shaft 201 is opposite to the supporter 211. Although the routing structure 200 is illustrated to be symmetrical, the routing structure 200 may be asymmetrical as required and the relative positional relation may vary. Starting from the home position, the rotary shaft 201 may rotate in two directions, clockwise (+) or anticlockwise (-), as indicated by the arrow 208.

[0067] When the rotary shaft 201 rotates within a first small range, e.g., about $\pm$

100deg, the rotary shaft 201 will drive the coupled runner 212 to rotate together. Then, the runner 212 will move with respect to the slider 213 mounted in the runner 212. In this way, the supporter 211 coupled with the slider 213 remains almost quiescent or merely has little movement. When rotating within the first range, the rotary shaft 201 would not
5 contact with the cables 204 supported by the supporter 211 and no bending or twisting of the cables 204 will happen.

[0068] When the rotary shaft 201 goes on rotating, e.g., exceeding about $\pm 100\text{deg}$, the rotary shaft 201 will contact with the supporter 211 first and push it to rotate together. FIG. 4 shows the routing structure 200 at an in-between position according to the first
10 embodiment of the present invention.

[0069] As shown in FIG. 4, the rotary shaft 201 has rotated about 100deg from the home position in the clockwise direction. The rotary shaft 201 contacts with the supporter 211 instead of hitting the cables 204 directly. If the rotary shaft 201 goes on rotating within a second range, e.g., about $+100\sim+270\text{deg}$ or $-100\sim-270\text{deg}$, it will push
15 the supporter 211 to rotate together. Then, the clamped cables 204 will bend and twist as the supporter 211 rotates.

[0070] By means of the guide member 205, the direction and the shape of bending and twisting of the cables 204 would be predictable (for example see FIGS. 5-6). Under this situation, the lifetime of the cables 204 could be guaranteed because the minimum
20 bending radius of the cables is predictable and unnecessary friction could be eliminated.

[0071] FIG. 5 shows the routing structure 200 at a max positive (clockwise) position according to the first embodiment of the present invention.

[0072] As shown in FIG. 5, the rotary shaft 201 has rotated about 270deg from the home position in the clockwise direction. The rotary shaft 201 contacts with the
25 supporter 211 and pushes the supporter 211 to rotate together. Then, the clamped cables 204 are bent and twisted as the supporter 211 rotates.

[0073] When the rotary shaft 201 has arrived at its max positive position, the mechanical stopper 206 will function to prevent the rotary shaft 201 from moving out of its working range, e.g., $+270\text{deg}$. The projection 214 extruding out of the runner 212 in
30 the radial direction will hit on the boss 215 and be blocked from forwarding. Thereby,

the rotary shaft 201 will be blocked from forwarding. Such mechanical stopper 206 provides an additional safety assurance not only for the cables themselves, but also for operators and surrounding equipments.

[0074] Similarly, FIG. 6 shows the routing structure 200 at a max negative (anticlockwise) position according to the first embodiment of the present invention.

[0075] As shown in FIG. 6, the rotary shaft 201 has rotated about 270deg from the home position in the anticlockwise direction. The rotary shaft 201 contacts with the supporter 211 and pushes the supporter 211 to rotate together. Then, the clamped cables 204 are bent and twisted as the supporter 211 rotates.

[0076] When the rotary shaft 201 has arrived at its max negative position, the mechanical stopper 206 will function to prevent the rotary shaft 201 from moving out of its working range, e.g., -270deg. The projection 214 extruding out of the runner 212 in the radial direction will hit on the boss 215 and be blocked from forwarding. Thereby, the rotary shaft 201 will be blocked from forwarding.

[0077] FIG. 7 shows a detailed view of a mechanical stopper 206 when the routing structure 200 is at its max negative position as shown in FIG. 6. As shown in FIG. 7, the projection 214 is blocked by the boss 215 from forwarding in the anticlockwise direction.

[0078] The working range of the rotary shaft 201 may be designed according to the practical requirements, which may be symmetrical or asymmetrical. Thus, the runner and the boss may be adapted accordingly.

[0079] The above description has thus described the structure and operation of the routing structure 200 according to the first embodiment of the present invention. The skilled in the art could appreciate that, various modifications and changes may be made to the illustrated routing structure. The following description has illustrated some of the modifications, and other variants are possible.

Embodiment 2

[0080] Referring now to FIGS. 8A-8B, hereinafter will be described a second embodiment of the present invention. In the second and subsequent embodiments, the

components identical with or similar to those in the first embodiment are given the same reference numerals for the sake of omitting explanation.

[0081] FIG. 8A shows a routing structure 300 according to the second embodiment of the present invention. As shown in FIG. 8A, similar to the first embodiment, a rotary shaft 201 is coupled between a driving unit 202 and a driven axle 203. The rotary shaft 201 is shaped as an arc to allow cables 204 or hoses going through. A guide member 205 is shown to include a supporter 211 for supporting the cables 204 or hoses; a runner 212 arranged to be coaxial with the rotary shaft 201; and a slider 213 (shown in FIG. 8B) arranged to be slidable along the runner 212.

[0082] The difference is in that the runner 212 is fixed on a housing of the driving unit 202, e.g., the housing of the motor, instead of on the rotary shaft 201. The runner 212 may have a C-shaped ring, e.g., a broken ring of 270deg. Compared with the routing structure 200 in FIG. 2, the runner 212 in the routing structure 300 as illustrated in FIG. 8A is bigger than that in the routing structure 200. The rotary shaft 201 is coaxial with the runner 212 and can rotate along the inner ring of the runner 212.

[0083] Because the runner 212 is fixed on the housing of the driving unit 202 and has a broken ring, a nature-born mechanical stopper is formed by the two end faces of the runner 212.

[0084] For better illustration, FIG. 8B shows a detailed section view of the routing structure 300.

[0085] During operation, when the rotary shaft 201 rotates within a first range, e.g., about $\pm 100\text{deg}$, the runner 212 fixed on the housing of the driving unit 202 would not rotate. In turn, the supporter 211 coupled with the slider 213 remains substantially quiescent. When the rotary shaft 201 goes on rotating within a second range, e.g., about $+100\sim+270\text{deg}$ or $-100\sim-270\text{deg}$, it will contact with the supporter 211 first and push it to rotate together, i.e., sliding along the runner 212. Then, the clamped cables 204 will bend and twist as the supporter 211 slides. The positional relation between the rotary shaft 201 and the supporter 211 during the operation is same with that in the first embodiment as explained with respect to FIGS. 1 and 4-6, and the detail description thereof is omitted herein.

[0086] When the slider 213 and the supporter 211 arrives at the end of the runner 212, the slider 213 stops due to the end of the runner 212, and in turn the rotary shaft stops. In this way, safety assurance is provided for both cables and operators.

[0087] Alternatively, an additional mechanical stopper 206 may be provided for preventing the rotary shaft 201 from moving out of its working range. As shown, the mechanical stopper 206 may comprise a projection 214 fixed on the second end of the supporter 211. The operation of the mechanical stopper 206 is similar to that in the first embodiment except that in the second embodiment, the projection 214 is blocked by the end of the runner 212. When the rotary shaft 201 rotates a certain degree, e.g., 100deg, it will push the projection 214 along the runner 212. When the projection 214 collides with the end face of the runner 212, the rotary shaft 201 will stop.

Embodiment 3

[0088] FIG. 9A shows a routing structure 400 according to a third embodiment of the present invention.

[0089] As shown in FIG. 9A, similar to the first embodiment, a rotary shaft 201 is coupled between a driving unit 202 and a driven axle 203. The rotary shaft 201 is shaped as an arc to allow cables 204 or hoses going through. A guide member 205 is also provided to support the cables 204 or hoses.

[0090] The difference is in that the runner 212 of the guide member 205 in the first embodiment is replaced with a rotary bearing 216 in the third embodiment. The rotary bearing 216 comprises two portions, i.e., an inner ring and an outer ring, being rotatable with respect to each other. The inner ring of the rotary bearing 216 is fixed on the rotary shaft 201. The slider 213 of the guide member 205 is fixed to the outer ring and the supporter 211 of the guide member 205 is coupled with the slider 213.

[0091] Also, a mechanical stopper 206 may be provided for preventing the rotary shaft 201 from moving out of its working range. A projection 214 of the mechanical stopper 206 may be fixed on the outer ring of the rotary bearing 216, and a boss 215 of the mechanical stopper 206 may be located on the housing of the robot. When the rotary shaft 201 is rotating a certain degree, e.g., 100deg, it will push the supporter 211 and the

projection 214 along the outer ring of the bearing 216. When the projection 214 collides with the boss 215, the rotary shaft 201 will stop.

[0092] For better illustration, FIG. 9B shows a detailed section view of the routing structure 400.

5 [0093] The positional relation between the rotary shaft 201, the rotary bearing 216 and the supporter 211 during the operation is same with that in the first embodiment and the detail description thereof is omitted herein.

Embodiment 4

10 [0094] FIG. 10A shows a routing structure 500 according to a fourth embodiment of the present invention.

[0095] The routing structure 500 of the fourth embodiment is similar to the routing structure 400 of the third embodiment. The difference is in that the rotary bearing 216 is fixed on a housing of the driving unit 202, e.g., the housing of the motor, just like the
15 second embodiment.

[0096] Specifically, the outer ring of the rotary bearing 216 is fixed on the housing of the driving unit 202. The slider 213 of the guide member 205 is fixed to the inner ring and the supporter 211 of the guide member 205 is coupled with the slider 213.

[0097] Also, a mechanical stopper 206 may be provided for preventing the rotary shaft
20 201 from moving out of its working range. A projection 214 of the mechanical stopper 206 may be fixed on the inner ring of the rotary bearing 216, and a boss 215 of the mechanical stopper 206 may be located on the housing of the robot. When the rotary shaft 201 is rotating a certain degree, e.g., 100deg, it will push the supporter 211 and the projection 214 along the inner ring of the bearing 216. When the projection 214 collides
25 with the boss 215, the rotary shaft 201 will stop.

[0098] For better illustration, FIG. 10B shows a detailed section view of the routing structure 500.

[0099] The positional relation between the rotary shaft 201, the rotary bearing 216 and the supporter 211 during the operation is same with that in the second embodiment and the

detail description thereof is omitted herein.

Embodiment 5

[00100] In a fifth embodiment of the present invention (not shown), the routing structure comprises a rotary shaft and a simple guide member. Similar to other embodiments, a first end of the rotary shaft is coupled with a driving unit and a second end of the rotary shaft is coupled with a driven axle. The rotary shaft is shaped to allow cables or hoses traveling within the robot.

[00101] In the fifth embodiment, however, the guide member has only one supporter for supporting the cables or hoses. A first end of the supporter is shaped for clamping the cables or hoses. A second end of the supporter is fixed relatively to the rotary shaft.

[00102] In one implementation, the second end of the supporter may be fixed directly on the rotary shaft. During operation, when the rotary shaft rotates, the supporter and in turn the clamped cables will rotate accordingly. However, by means of the guide member (e.g., the supporter), the direction and shape of bending and twisting of the cables may be predefined, and thus unwanted contact and friction between the shaft and the cables may be avoided as possible.

[00103] In another implementation, the second end of the support may be fixed on the housing of the driving unit. In such implementation, depending on the relative position relation between the rotary shaft and the guide member, the rotary shaft will contact with the guide member at different positions. For example, at a home position, the supporter may be arranged to be opposite to the rotary shaft.

[00104] In another aspect of the present invention, there is provided a rotary joint comprising the routing structure as described above.

[00105] In another aspect of the present invention, there is provided a robot comprising the rotary joint as described above.

[00106] It is believed that the disclosure set forth herein encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are

not to be considered in a limiting sense as numerous variations are possible. The subject matter of the disclosure includes all novel and non-obvious combinations and sub-combinations of the various elements, features, functions and/or properties disclosed herein. Similarly, recitation in the disclosure and/or the claims of “a” or “a first” element, or the equivalent thereof, should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

[00107] It is believed that the following claims particularly point out certain combinations and sub-combinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and sub-combinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

[00108] Therefore, it is to be understood that the embodiments of the invention are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are used herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

WHAT IS CLAIMED IS:

1. A routing structure for a robot, comprising:

a rotary shaft (201) adapted to be rotatable around an axis; and

5 a guide member (205) arranged to support cables or hoses, such that the cables or hoses are separated from the rotary shaft.

2. The routing structure of claim 1, wherein the rotary shaft is shaped as an arc to allow the cables or hoses going through a hollow axle coupled with the rotary shaft.

10 3. The routing structure of claim 2, wherein a first end of the rotary shaft is coupled with a driving unit and a second end of the rotary shaft is coupled with the hollow axle.

4. The routing structure of any of claims 1-3, wherein the guide member comprises:

a supporter (211) for supporting the cables or hoses;

15 a runner (212) arranged to be coaxial with the rotary shaft; and

a slider (213) arranged to be slidable along the runner;

wherein a first end of the supporter is shaped for clamping the cables or hoses, and a second end of the supporter is coupled with the slider.

20 5. The routing structure of claim 4, wherein the runner is fixed on the rotary shaft or on a housing of the robot.

6. The routing structure of any of claims 1-3, wherein the guide member comprises:

a supporter (211) for supporting the cables or hoses;

25 a rotary bearing (216) arranged to be coaxial with the rotary shaft, wherein the rotary bearing comprises two portions being rotatable with respect to each other; and

a slider (213) arranged to be fixed to one portion of the rotary bearing;

wherein a first end of the supporter is for clamping the cables or hoses, and a second

end of the supporter is coupled with the slider.

7. The routing structure of claim 6, wherein the other portion of the rotary bearing is fixed on the rotary shaft or on a housing of the robot.

5

8. The routing structure of claim 5, further comprising:

a mechanical stopper (206) for preventing the rotary shaft from moving out of its working range.

10

9. The routing structure of claim 8, wherein the mechanical stopper comprises:

a projection (214) fixed to the second end of the supporter; and

a boss (215) located on a housing of the robot for blocking the projection and thereby the rotary shaft from forwarding.

15

10. The routing structure of claim 7, further comprising:

a mechanical stopper (206) for preventing the rotary shaft from moving out of its working range.

20

11. The routing structure of claim 10, wherein the mechanical stopper comprises:

a projection (214) fixed to the second end of the supporter; and

a boss (215) located on a housing of the robot for blocking the projection and thereby the rotary shaft from forwarding.

25

12. The routing structure of any of claims 4-7, wherein when the rotary shaft rotates within a first range, the supporter remains substantially quiescent, and when the rotary shaft rotates within a second range, the rotary shaft pushes the supporter to rotate together.

13. The routing structure of any of claims 4-7, wherein the first end of the supporter

has a ring for guiding the cables or hoses, and the cables or hoses are rotatable with respect to the ring.

14. A rotary joint comprising the routing structure according to any of claims 1 to 13.

5

15. A robot comprising the rotary joint according to claim 14.

AMENDED CLAIMS

received by the International Bureau on 30 October 2013 (30.10.2013)

WHAT IS CLAIMED IS:

1. A routing structure for a robot, comprising:
a rotary shaft (201) adapted to be rotatable around an axis; and
5 a guide member (205) arranged to support cables or hoses, and configured to be rotatable with respect to the rotary shaft (201).
2. The routing structure of claim 1, wherein the rotary shaft is shaped as an arc to allow the cables or hoses going through a hollow axle coupled with the rotary shaft.
10
3. The routing structure of claim 2, wherein a first end of the rotary shaft is coupled with a driving unit and a second end of the rotary shaft is coupled with the hollow axle.
4. The routing structure of any of claims 1-3, wherein the guide member comprises:
15 a supporter (211) for supporting the cables or hoses;
a runner (212) arranged to be coaxial with the rotary shaft; and
a slider (213) arranged to be slidable along the runner;
wherein a first end of the supporter is shaped for clamping the cables or hoses, and a second end of the supporter is coupled with the slider.
20
5. The routing structure of claim 4, wherein the runner is fixed on the rotary shaft or on a housing of the robot.
6. The routing structure of any of claims 1-3, wherein the guide member comprises:
25 a supporter (211) for supporting the cables or hoses;
a rotary bearing (216) arranged to be coaxial with the rotary shaft, wherein the rotary bearing comprises two portions being rotatable with respect to each other; and
a slider (213) arranged to be fixed to one portion of the rotary bearing;

wherein a first end of the supporter is for clamping the cables or hoses, and a second end of the supporter is coupled with the slider.

7. The routing structure of claim 6, wherein the other portion of the rotary bearing is
5 fixed on the rotary shaft or on a housing of the robot.

8. The routing structure of claim 5, further comprising:
a mechanical stopper (206) for preventing the rotary shaft from moving out of its
working range.

10

9. The routing structure of claim 8, wherein the mechanical stopper comprises:
a projection (214) fixed to the second end of the supporter; and
a boss (215) located on a housing of the robot for blocking the projection and thereby
the rotary shaft from forwarding.

15

10. The routing structure of claim 7, further comprising:
a mechanical stopper (206) for preventing the rotary shaft from moving out of its
working range.

20

11. The routing structure of claim 10, wherein the mechanical stopper comprises:
a projection (214) fixed to the second end of the supporter; and
a boss (215) located on a housing of the robot for blocking the projection and thereby
the rotary shaft from forwarding.

25

12. The routing structure of any of claims 4-7, wherein when the rotary shaft rotates
within a first range, the supporter remains substantially quiescent, and when the rotary
shaft rotates within a second range, the rotary shaft pushes the supporter to rotate together.

13. The routing structure of any of claims 4-7, wherein the first end of the supporter has a ring for guiding the cables or hoses, and the cables or hoses are rotatable with respect to the ring.

5 14. A rotary joint comprising the routing structure according to any of claims 1 to 13.

15. A robot comprising the rotary joint according to claim 14.

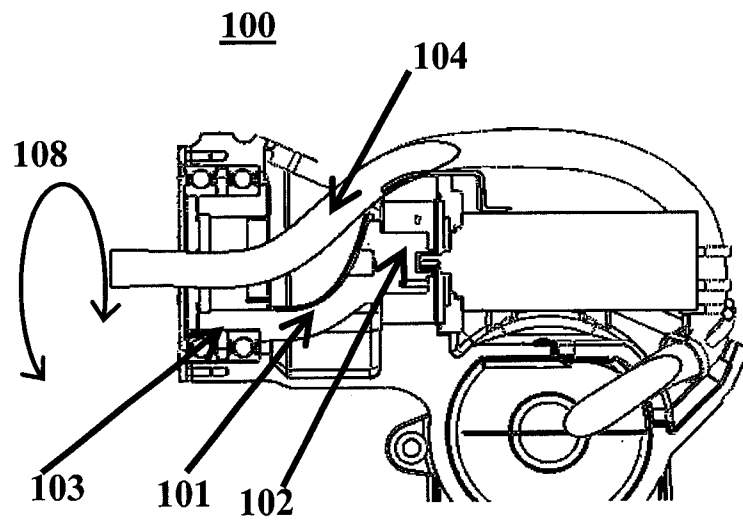


Fig. 1

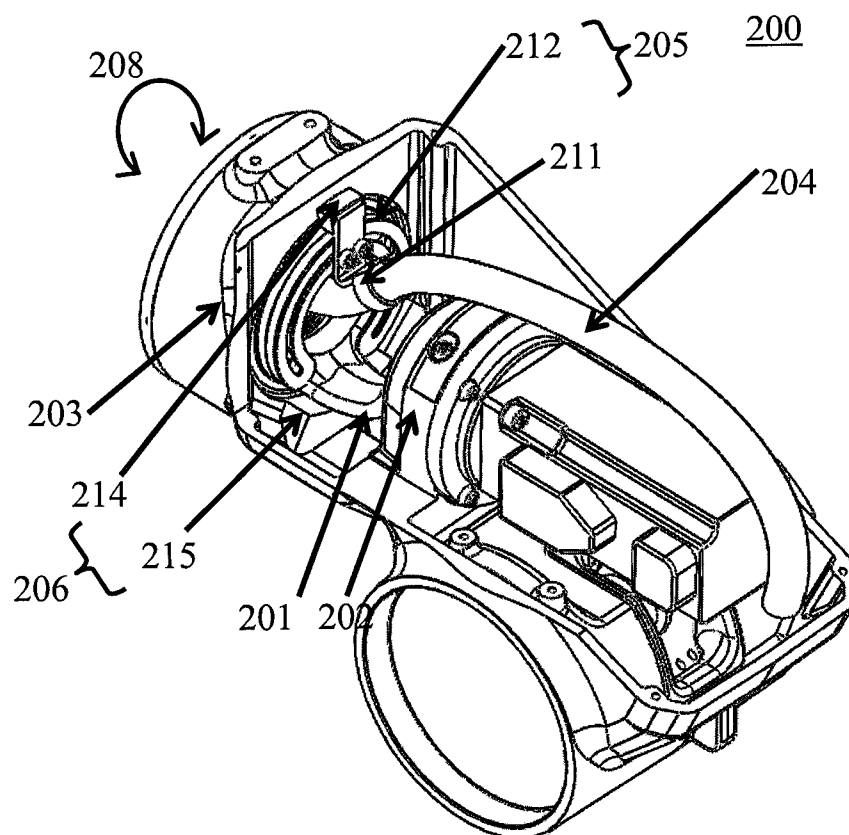


Fig. 2

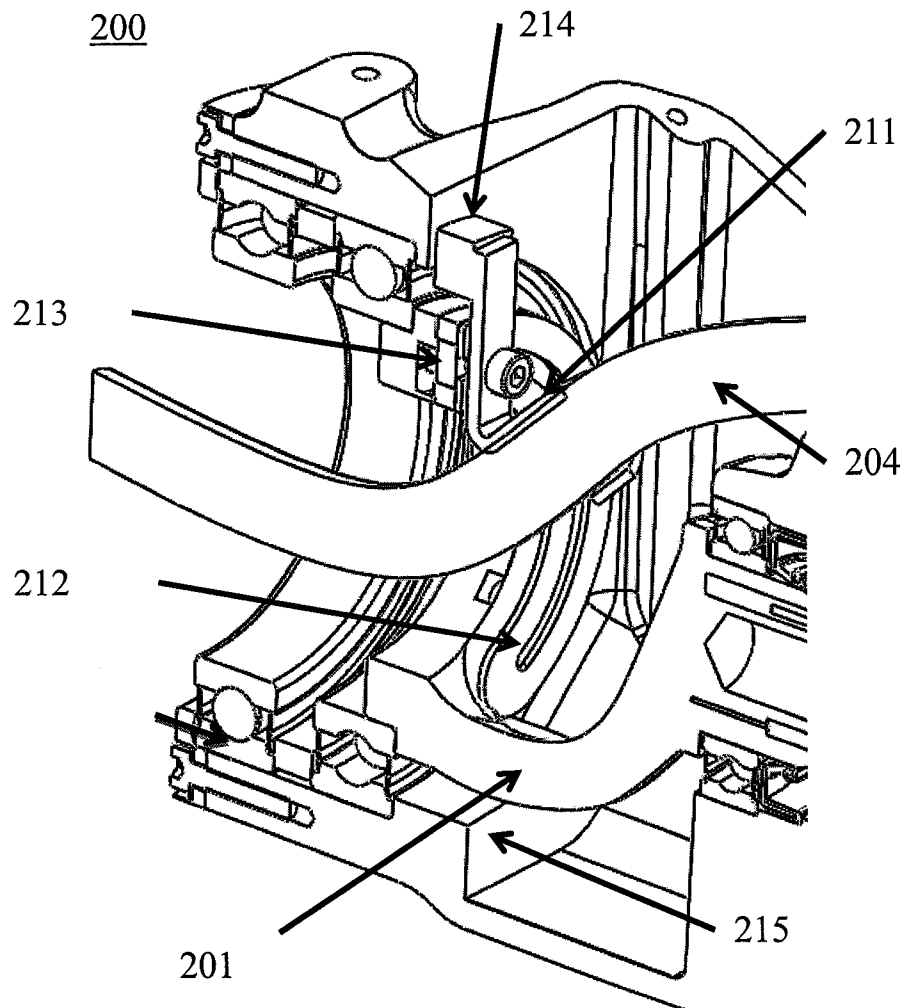


Fig. 3

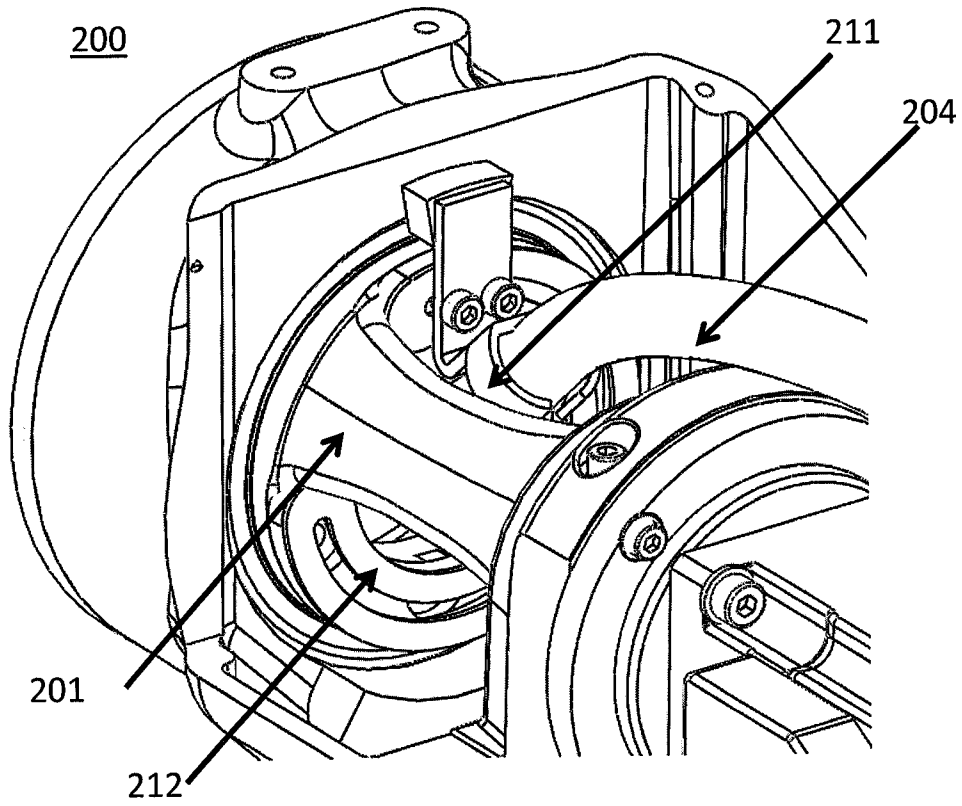


Fig. 4

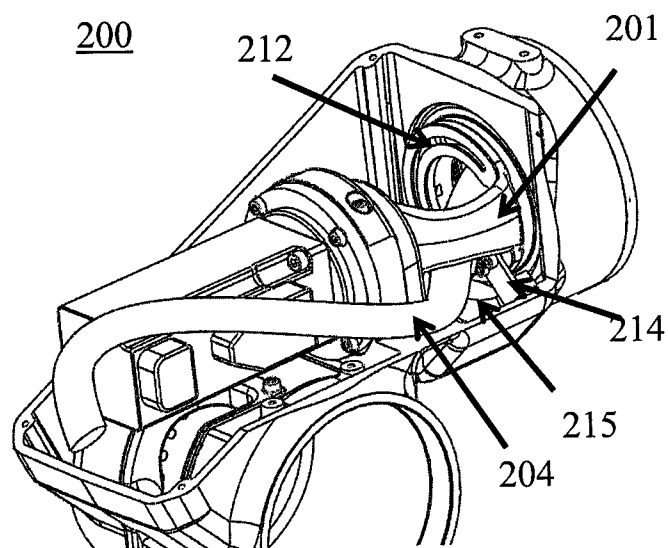


Fig. 5

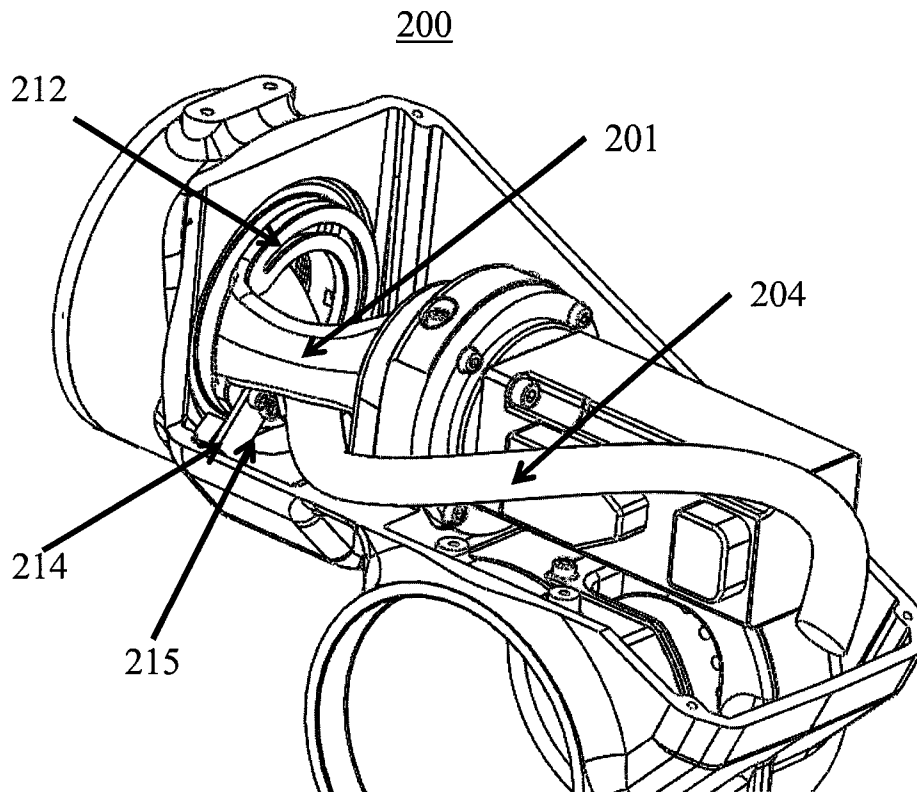


Fig. 6

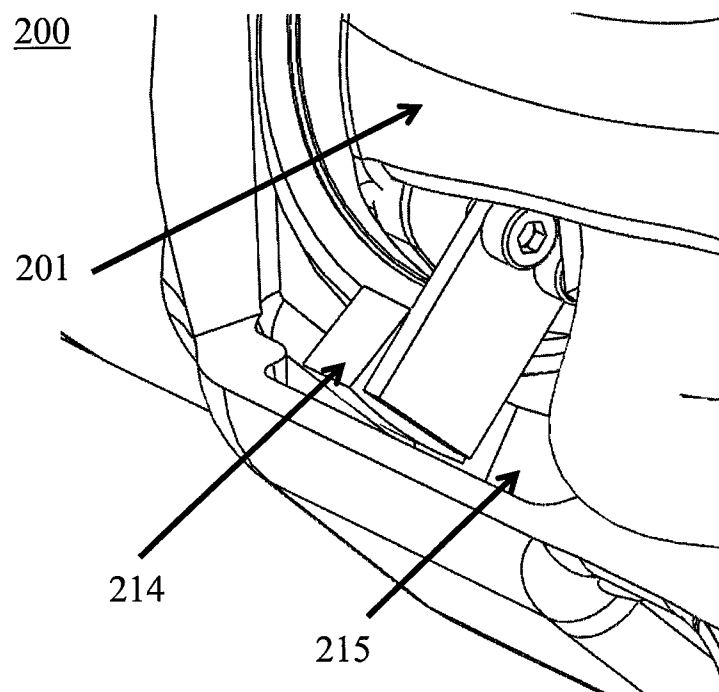


Fig. 7

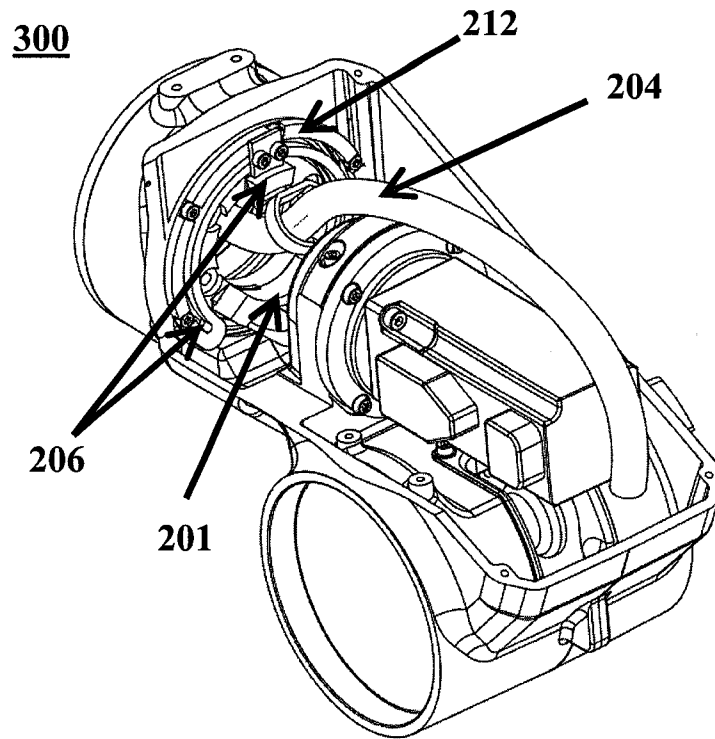


Fig. 8A

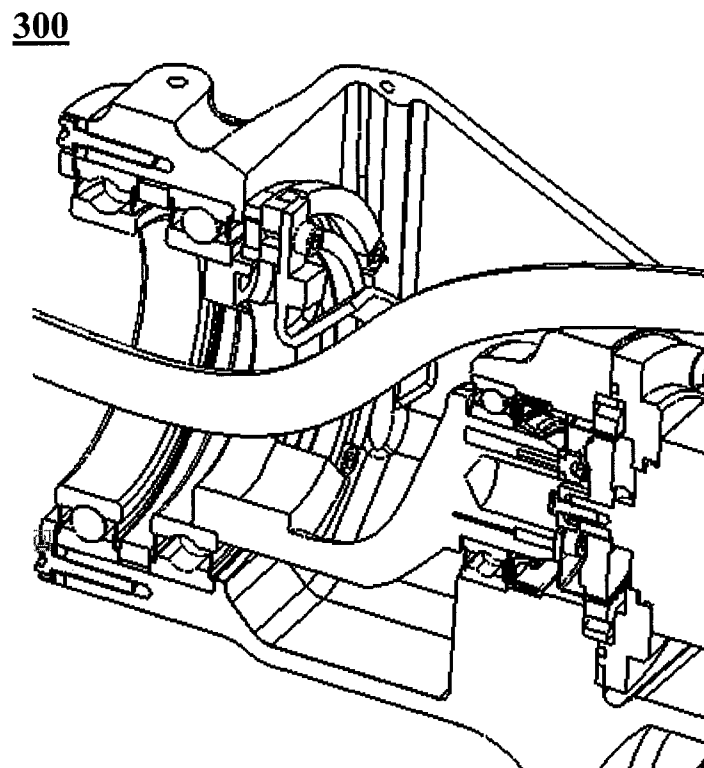


Fig. 8B

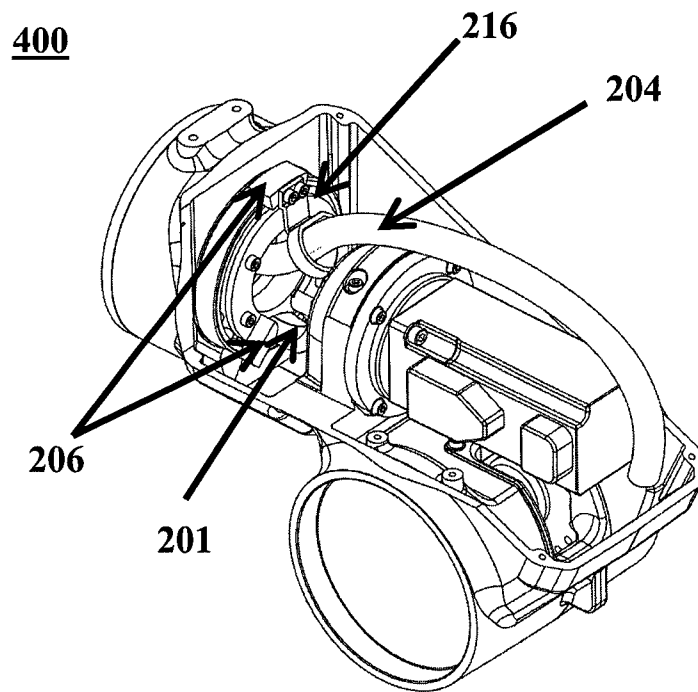


Fig. 9A

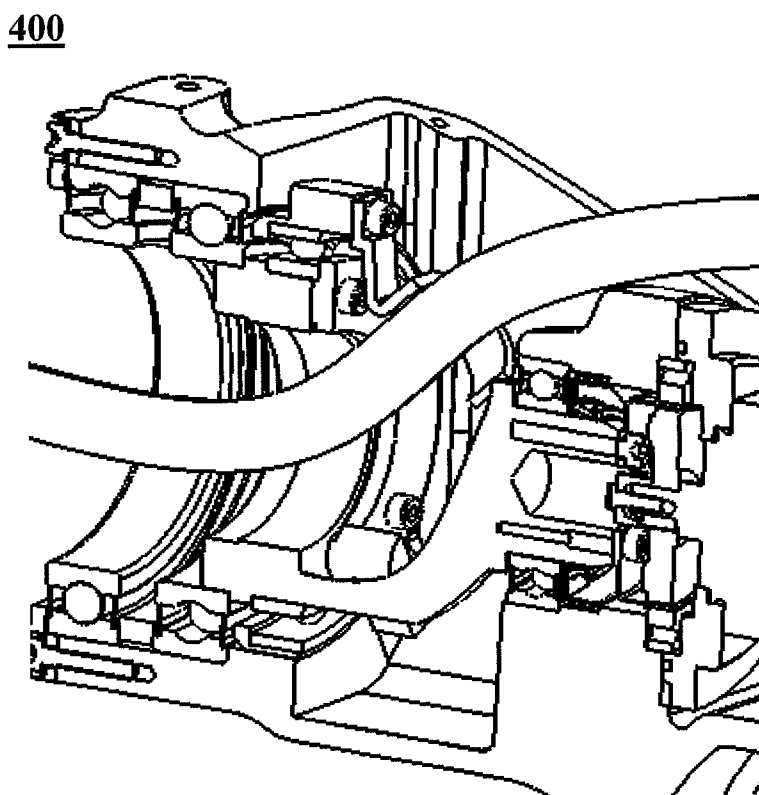


Fig. 9B

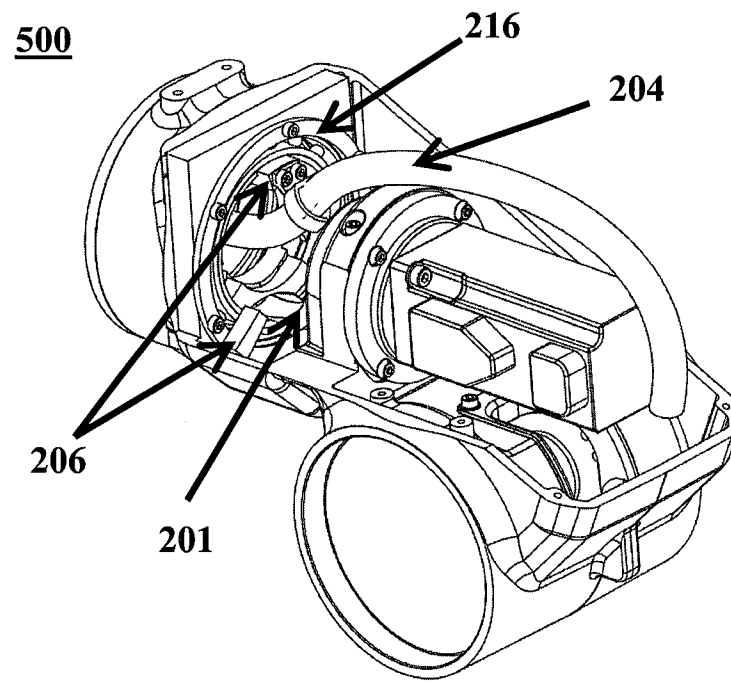


Fig. 10A

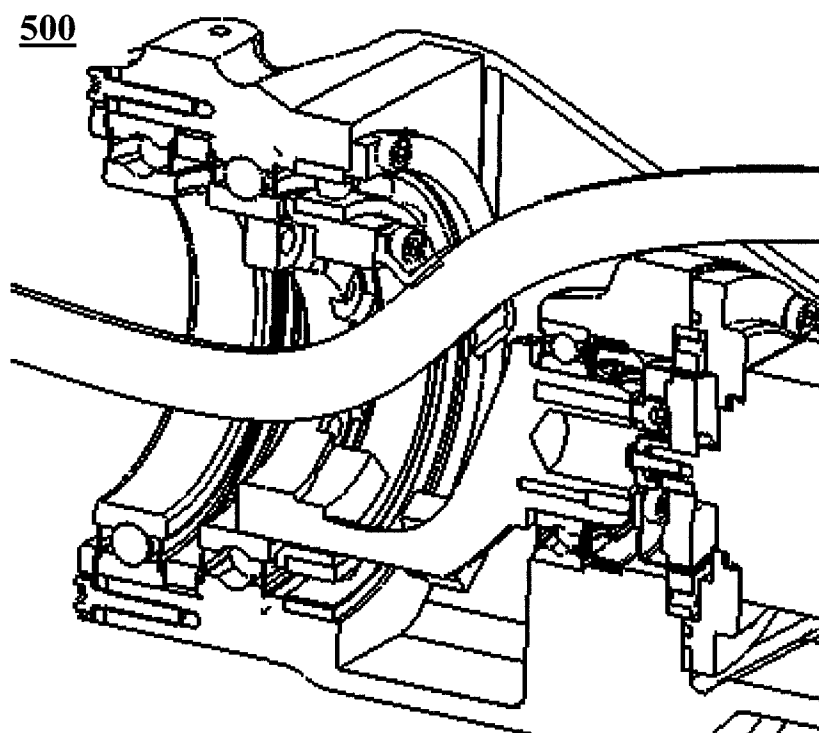


Fig. 10B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/078611

A. CLASSIFICATION OF SUBJECT MATTER

B25J19/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B25J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI; CNPAT; WPI; EPODOC: shaft, axis, rotary, rotatable, guide, cable, hose, routing, robot

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN1733436A(FANUC LTD.) 15 Feb. 2006 (15.02.2006) page 4 line 3 to page 9 line 9 of the description and figures 1-7	1-3, 14-15
A	CN101450485A(CUI, Guangshu) 10 Jun. 2009 (10.06.2009) the whole document	1-15
A	CN201325058Y(ABB TECHNOLOGIES INC.) 14 Oct. 2009 (14.10.2009) the whole document	1-15
A	JP2010-264525A(OSAKA TRANSFORMER CO. LTD.) 25 Nov. 2010 (25.11.2010) the whole document	1-15
A	DE102007008985A1(KUKA ROBOTER GMBH.) 28 Aug. 2008 (28.08.2008) the whole document	1-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

20 Mar. 2013(20.03.2013)

Date of mailing of the international search report

18 Apr. 2013 (18.04.2013)

Name and mailing address of the ISA/CN
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Telephone No. (86-10)62412854

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/078611

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN1733436A	15.02.2006	EP1625920A1	15.02.2006
		JP2006-51581A	23.02.2006
		US2006/0101936A1	18.05.2006
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JP2010-264525A	25.11.2010	NONE	
DE102007008985A1	28.08.2008	NONE	