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(54) **CUTTER DEVICE, TUNNELING MACHINE, AND CUTTER CHANGING METHOD**

(57) Disclosed is a cutter device. The cutter device comprises a sleeve (2), a rotating sleeve (3), and a cutter assembly (1); the sleeve is provided with an inner cavity; the rotating sleeve is disposed in the inner cavity of the sleeve and is rotatably disposed relative to the sleeve around a first rotating shaft extending in a first direction (Z), and the rotating sleeve comprises a channel passing through in a second direction (X); the cutter assembly comprises a cutter holder (11) and a cutter (12) disposed in the cutter holder; the cutter is rotatably disposed relative to the cutter holder around a second rotating shaft extending in a third direction (Y); the first direction, the second direction, and the third direction are perpendicular to one another; and the outer wall of the cutter holder is in sealing fit with the inner wall of the channel, and the cutter holder is movably disposed in the channel in the second direction. According to the cutter device, the sealing performance is guaranteed by means of the sealing

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fit of the outer wall of the cutter holder and the inner wall of the channel, and compared with gate sealing in the prior art, the sealing saves gate space, thus the arrangement of a smaller cutter distance can be achieved, and the space of a cutterhead is fully utilized. Further disclosed are a tunneling machine and a cutter changing method.

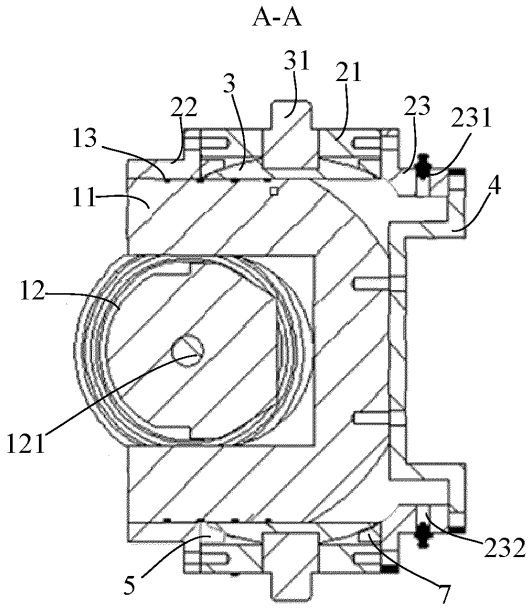

FIG.5

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This disclosure is based on and claims priority to the application with Application No. CN202111682045.8 filed on Dec. 28, 2021, the disclosure of which is hereby incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The disclosure relates to the technical field of tunneling, in particular to a cutter device, a tunneling machine and a cutter changing method.

BACKGROUND

[0003] With the rapid development of transportation infrastructure construction, shield construction, with its characteristics of safety, rapidness and high efficiency, has been increasingly applied in the construction of underground engineering such as urban subways, tunnels across rivers and underground oil transport pipelines. In the river crossing engineering, a slurry shield is usually used due to the large buried depth of the tunnel, the strong permeability of the stratum and the high water pressure. As the river bottom and the seabed are mostly sandy gravel strata formed by flood wash and interbedded strata with uneven hardness, the cutter bearing the function of tunneling in the shield machine wears out quickly, and needs to be frequently inspected, repaired and maintained as well as changed during the construction engineering.

[0004] Existing conventional tunneling machines with the normal pressure cutter changing function all depend on a cutter gate valve to block the pressure of a tunnel face, so that the cutter changing at normal pressure is realized. However, the valve seal is easily corroded by the influx of slurry, and damage to the seal causes the gate to be not tightly closed, which in turn results in a greater influx of slurry. Therefore, how to realize the seal in the process of cutter change at normal pressure is a problem to be solved urgently.

[0005] It should be noted that the statements in this background art potion only provide the disclosure related background art, and may not necessarily constitute prior art.

SUMMARY

[0006] The disclosure provides a cutter device, a tunneling machine and a cutter changing method, which aims to improve the sealing problem in the cutter changing process at normal pressure.

[0007] A first aspect of the disclosure provides a cutter device comprising a sleeve, a rotating sleeve, and a cutter assembly; the sleeve has an inner cavity, the rotating sleeve is disposed in the inner cavity of the sleeve and is rotatable relative to the sleeve around a first rotating shaft extending in a first direction, and the rotating sleeve comprises a channel passing through in a second direction; the cutter assembly comprises a cutter holder and a cutter disposed in the cutter holder; the cutter is rotatable relative to the cutter holder around a second rotating shaft extending in a third direction; the first direction, the second direction, and the third direction are perpendicular to one another; and the outer wall of the cutter holder is in sealing fit with the inner wall of the channel, and the cutter holder is movably disposed in the channel in the second direction.

[0008] In some embodiments, the cutter assembly has a working position in which the edge of the cutter projects beyond the end face of a first end of the sleeve; and a cutter changing position, which the cutter holder moves in the channel towards a second end of the sleeve to reach when a cutter needs to be changed, and in which the cutter holder rotates under the driving of the rotating sleeve.

[0009] In some embodiments, in the cutter changing position the distance between the first rotating shaft and the edge of the cutter is smaller than the distance between the first rotating shaft and the inner wall of the sleeve.

[0010] In some embodiments, the outer wall of the cutter holder comprises a mating surface in sealing fit with the inner wall of the channel, wherein the inner wall of the channel comprises a first cylindrical surface and the mating surface comprises a second cylindrical surface, and the first cylindrical surface and the second cylindrical surface are abutted and in sealing fit.

[0011] In some embodiments, a sealing groove is provided on the mating surface, and the cutter assembly further comprises a first sealing structure provided within the sealing groove.

[0012] In some embodiments, the sleeve comprises a sleeve body and a first flange disposed at a first end of the sleeve body, wherein an inner wall of the first flange is flush with an inner wall of the channel.

[0013] In some embodiments, there is a gap between an end surface of the rotating sleeve and the first flange. The cutter device further comprises a second sealing structure provided between the rotating sleeve and the first flange. The second sealing structure seals the gap such that a sealed cavity is formed between the rotating sleeve and the sleeve.

[0014] In some embodiments, the second sealing structure comprises a sealing ring body and an annular strip projecting radially inward from the sealing ring body, wherein the axis of the sealing ring body extends in the first direction, and the annular strip is disposed within the gap.

[0015] In some embodiments, the outer wall of the rotating sleeve comprises a spherical surface, and the side of the sealing ring body close to the rotating sleeve is adapted to the shape of the spherical surface.

[0016] In some embodiments, the sleeve body is provided with an oil injection hole for injecting grease into the sealed cavity.

[0017] In some embodiments, the cutter device further comprises a baffle connected to a second end of the cutter holder, wherein the baffle is configured to drive the cutter assembly to move in the second direction.

[0018] In some embodiments, the sleeve comprises a sleeve body and a second flange disposed at a second end of the sleeve body, to which second flange the baffle is detachably connected.

[0019] In some embodiments, the second flange has an air hole and an oil drain hole, wherein a height of the oil drain hole is smaller than a height of the air hole.

[0020] In some embodiments, the cutter device further comprises a mechanical seal configured to be connected to a second end of the sleeve when the cutter assembly is in a cutter changing position.

[0021] In some embodiments, the outer wall of the cutter holder comprises a mating surface in sealing fit with the inner wall of the channel and a spherical surface connected to a second end of the mating surface.

[0022] A second aspect of the disclosure provides a tunneling machine, which comprises a cutterhead and a cutter device provided on the cutterhead.

[0023] A third aspect of the disclosure provides a cutter changing method based on said cutter device, comprising the steps of:

Causing the cutter holder to move in the channel towards the second end of the sleeve so that the cutter assembly enters a cutter changing position from a working position; and

Causing the rotation of the rotating sleeve to drive the cutter holder to rotate.

[0024] In some embodiments, the cutter changing method further comprises injecting grease into the sealed cavity between the rotating sleeve and the sleeve before causing the movement of the cutter assembly.

[0025] In some embodiments, the cutter changing method further comprises mounting a mechanical seal on the second end of the sleeve after causing the cutter holder to move in the channel towards the second end of the sleeve so that the cutter assembly enters the cutter changing position from the working position, and before causing the rotating sleeve to rotate.

[0026] In some embodiments, grease in the sealed cavity formed between the mechanical seal and the sleeve is drained, the mechanical seal is detached and the cutter is changed when the rotating sleeve rotates the cutter assembly so that the cutter rotates to a position towards the second end.

[0027] Based on the aspects provided by the disclosure, the cutter device comprises a sleeve, a rotating sleeve, and a cutter assembly; the sleeve has an inner cavity; the rotating sleeve is disposed in the inner cavity of the sleeve and is rotatable relative to the sleeve around a first rotating shaft extending in a first direction, and the rotating sleeve comprises a channel passing through in a second direction; the cutter assembly comprises a cutter holder and a cutter disposed in the cutter holder; the cutter is rotatable relative to the cutter holder around a second rotating shaft extending in a third direction; the first direction, the second direction, and the third direction are perpendicular to one another; and the outer wall of the cutter holder is in sealing fit with the inner wall of the channel, and the cutter holder is movably disposed in the channel in the second direction. The cutter device in the disclosure guarantees the sealing performance by means of the sealing fit of the outer wall of the cutter holder and the inner wall of the channel, which saves the gate space as compared with the gate sealing in the prior art, and enables in turn an arrangement of a smaller cutter distance and fully utilizes the space of a cutterhead. Further disclosed are a tunneling machine and a cutter changing method. Moreover, the cutter device in the embodiments of the disclosure can achieve the cutter change at normal pressure by rotating the cutter holder with a swivelble rotating sleeve, which involves simple operation steps and improves the cutter changing efficiency.

[0028] Other features and advantages of the disclosure will become apparent from the following detailed description of exemplary embodiments thereof with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The accompanying drawings illustrated herein, which are incorporated in and constitute a part of this disclosure, are used to provide a further understanding of the disclosure. The exemplary embodiments of the disclosure and the description thereof serve to explain the disclosure and not to constitute an undue limitation of the disclosure. In the drawings:

Fig. 1 is a schematic perspective view of a cutter device according to some embodiments of the disclosure.

Fig. 2 is a schematic perspective view at another angle of the cutter device of Fig. 1.

Fig. 3 is a schematic side view of the cutter device of Fig. 1.

Fig. 4 is a schematic front view of the cutter device of Fig. 1.

Fig. 5 is a schematic sectional view of the cutter device in the direction A-A in Fig. 4.

Fig. 6 is a perspective schematic view of a cutter holder according to some embodiments of the disclosure.

Fig. 7 is a perspective schematic view at another angle of a cutter holder according to some embodiments of the disclosure.

Fig. 8 is a perspective schematic view of a sleeve body according to some embodiments of the disclosure.

Fig. 9 is a perspective schematic view of a first flange according to some embodiments of the disclosure.

Fig. 10 is a perspective schematic view of a second flange according to some embodiments of the disclosure.

Fig. 11 is a perspective schematic view at another angle of a second flange according to some embodiments of the disclosure.

Fig. 12 is a perspective schematic view of a rotating sleeve according to some embodiments of the disclosure.

Fig. 13 is a perspective schematic view of a second sealing structure according to some embodiments of the disclosure.

Fig. 14 is a schematic view of the cutter assembly in the working position according to some embodiments of the disclosure.

Fig. 15 is a schematic view of the cutter assembly moved from the working position to the cutter changing position according to some embodiments of the disclosure.

Fig. 16 is a schematic view of the cutter assembly in the cutter changing position according to some embodiments of the disclosure.

Fig. 17 is a schematic view of the cutter assembly in the cutter changing position after the cutter holder has been rotated by the rotating sleeve according to some embodiments of the disclosure.

Fig. 18 is a flowchart of the steps of a cutter changing method according to some embodiments of the disclosure.

[0030] In the drawings:

1. cutter assembly; 11. cutter holder; 111. cutter groove; 112. mating surface; 113. sealing groove; 12. cutter; 121. cutter shaft; 114. spherical surface; 115. mounting plane; 13. first seal structure;
2. sleeve; 21. sleeve body; 211. rotating shaft hole; 212. oil injection hole; 22. first flange; 23. second flange; 231. air hole; 232. oil drain hole;
3. rotating sleeve; 31. rotating sleeve shaft;
4. baffle;
5. second sealing structure;
6. mechanical seal;
7. third sealing structure;
Z. first direction; X. second direction; Y third direction.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0031] With reference to the accompanying drawings in the embodiments of the disclosure, the technical solutions in the embodiments of the disclosure will be described clearly and completely. Apparently, the embodiments described are only some embodiments of the disclosure, rather than all embodiments. The following description of at least one exemplary embodiment is in fact merely illustrative and is in no way limits the disclosure and its application, or uses. All other embodiments, which can be derived by a person skilled in the art from the embodiments disclosed herein without creative effort, are intended to be within the scope of the present disclosure.

[0032] The relative arrangement of parts and steps, numerical expressions and numerical values set forth in these embodiments do not limit the scope of the disclosure unless specifically stated otherwise. Meanwhile, it should be understood that the sizes of the respective portions shown in the drawings are not drawn in an actual proportional relationship for the convenience of description. Techniques, methods, and apparatus known to one of ordinary skill in the relevant art may not be discussed in detail, but are intended to be part of the specification where appropriate. In all examples shown and discussed herein, any particular value should be construed as exemplary only and not as limiting. Thus, other examples of the exemplary embodiments may have different values. It should be noted that: similar reference signs and letters refer to similar items in the accompanying drawings bellow, and thus, once an item is defined in one figure, it need not be discussed further in subsequent figures.

[0033] For ease of description, spatially relative terms, such as "above", "over", "on", "upper", and the like, may be used herein to describe one device or feature's spatial positional relationship to another device or feature as illustrated in the figures. It should be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation of the device depicted in the figures. For example, if a device in the figures is inverted, the device described as "above other devices or configurations" or "over other devices or configurations" would later be oriented as "below other devices or configurations" or "under other devices or configurations". Thus, the exemplary term "above" may include two orientations of "above" and "below". The device may also be positioned in other different ways and the spatially relative

descriptors used herein interpreted accordingly.

[0034] Referring to Figs. 1 to 5, in some embodiments, the cutter device comprises a sleeve 2, a rotating sleeve 3 and a cutter assembly 1. The sleeve 2 therein has an inner cavity. The rotating sleeve 3 is disposed in the inner cavity of the sleeve 2 and is rotatable relative to the sleeve 2 around a first rotating shaft extending in a first direction Z. And the rotating sleeve 3 comprises a channel passing through in a second direction X. The cutter assembly 1 comprises a cutter holder 11 and a cutter 12 disposed in the cutter holder 11. The cutter 12 is rotatable relative to the cutter holder 11 around a second rotating shaft extending in a third direction Y The first direction Z, the second direction X, and the third direction Y are perpendicular to one another. The outer wall of cutter holder 11 is in sealing fit with the inner wall of the channel and the cutter holder 11 is movably disposed in the channel in the second direction X.

[0035] When the cutter of the cutter device needs to be changed, the cutter holder 11 can be first controlled to move away from the tunnel face relative to the rotating sleeve 3 in the channel in the second direction X to reach a cutter changing position, in which the rotating sleeve 3 is then controlled to rotate relative to the sleeve 2 about the first rotating shaft (rotating sleeve shaft 31), and further to drive the cutter holder 11 in the rotating sleeve 3 to rotate together, so that the cutter 12 rotates from the position facing the tunnel face to the position facing away the tunnel face, thereby realizing the cutter change. And the outer wall of cutter holder 11 is in sealing fit with the inner wall of the channel to ensure the sealing performance of the cutter holder 11 during movement in the channel. This shows that the cutter device in the embodiments of the disclosure ensures the sealing performance by means of the sealing fit of the outer wall of the cutter holder 11 and the inner wall of the channel, which saves the gate space as compared with the gate sealing in the prior art, and enables in turn an arrangement of a smaller cutter distance and fully utilizes the space of a cutterhead. Further, the cutter device in the embodiments of the disclosure can achieve the cutter change at normal pressure by rotating the cutter holder 11 with a swivelble rotating sleeve 3, which involves simple operation steps and improves the cutter changing efficiency. Furthermore, when a cutter is changed in a cutter the cutter device in the embodiments of the disclosure, the cutter holder 11 is controlled first to move away from the tunnel face, and then the rotating sleeve 3 is controlled to rotate, thereby avoiding interference problem between the cutter 12 and the tunnel face during rotation process.

[0036] Referring to Figs. 1 and 5, in the description of the embodiments of the disclosure, the first direction Z refers to the extending direction of the first rotating shaft, about which the rotating sleeve 3 rotates relative to the sleeve 2, in particular, the direction in which the rotating sleeve shaft 31 extends. The second direction X refers to the direction in which the cutter holder 11 moves relative to the rotating sleeve 3. The third direction Y refers to the extending direction of the second rotating shaft, about which the cutter 12 rotates relative to the cutter holder 11, in particular, the direction in which the cutter shaft 121 extends. The first direction Z, the second direction X, and the third direction Y are perpendicular to one another. In particular in the following description, the direction near the tunnel face in the second direction X is referred to as front, and the direction away from the tunnel face in the second direction X is referred to as rear.

[0037] Referring to Figs. 14 to 17, in some embodiments, the cutter device 1 has a working position and a cutter changing position. Referring to Fig. 14, in the working position the edge of the cutter 12 projects beyond the end face of a first end of the sleeve 2. Referring to Figs. 15 and 16, the cutter holder 11 moves in the channel towards a second end of the sleeve 2 to reach the cutter changing position when a cutter change is required. Referring to Fig. 17, in the cutter changing position the cutter holder 11 rotates under the driving of the rotating sleeve 3.

[0038] In particular, as shown in Fig. 14, in the working position the end face of the first end of the cutter holder 11 is flush with the end face of the first end of the sleeve 2, so that the edge of the cutter 12 projects beyond the end face of the first end of the sleeve 2, and in turn the cutter 12 can be embedded into the tunnel face F, thus realizing the cutting of the tunnel face. When a cutter change is required, as shown in Fig. 15, the cutter holder 11 moves in the channel of the rotating sleeve 3 towards the second end of the sleeve 2, so that the cutter 12 retracts into the sleeve 2, and then the rotating sleeve 3 is controlled to rotate about the first rotating shaft and thus rotate the cutter 12 to the position as shown in Fig. 17, facing the manned cabin, thereby realizing the cutter change. This shows that, when the rotating sleeve 3 rotates about the first rotating shaft, it needs to rotate together with the cutter assembly 1, wherein the rotating sleeve 3 and the cutter assembly 1 rotate as a whole in the inner cavity of the sleeve 2. In order to avoid interference of the cutter 12 of the cutter assembly 1 with the inner wall of the sleeve 2, in some embodiments, in the cutter changing position the distance between the first rotating shaft and the edge of the cutter 12 is smaller than the distance between the first rotating shaft and the inner wall of the sleeve 2.

[0039] That is to say, in the channel of the rotating sleeve 3, the cutter assembly 1 in the embodiment moves backward in the second direction X, in order to avoid interference of the cutter 12 with the tunnel face during rotation on one hand, and on the other hand, when the cutter assembly 1 moves backward to the cutter changing position, it is necessary to make the distance of the rotating sleeve shaft 31 to the edge of the cutter 12 smaller than the distance of the rotating sleeve shaft 31 to the inner wall of the sleeve 2, thus avoiding interference of the cutter 12 with the inner wall of the sleeve 2 during rotation process. Further, the cutter assembly 1 is moved backward and then rotated, so that the inner cavity of the

sleeve 2 can be designed to be relatively small, and further the structure of the entire cutter device more compact and the size is reduced.

[0040] In some embodiments, referring to Figs. 6 and 7, the outer wall of the cutter holder 11 comprises a mating surface 112 in sealing fit with the inner wall of the channel. The inner wall of the channel comprises a first cylindrical surface and the mating surface comprises a second cylindrical surface, and the first cylindrical surface and the second cylindrical surface are abutted and in sealing fit. The cutter holder 11 is movably disposed in the channel of the rotating sleeve 3, and the outer wall of the cutter holder 11 and the inner wall of the channel need to maintain a sealing fit. By using the sealing fit between the cylindrical surfaces, the above embodiments can realize both the movement of the cutter holder 11 relative to the channel and the sealing connection between the two. And the sealing fit between the cylindrical surfaces also enables the cutter holder 11 to realize the relative rotation along its own axis with respect to the channel, so as to facilitate adjusting the circumferential position of the cutter 12 relative to the sleeve 2.

[0041] Of course, in other embodiments, the outer wall of the cutter holder 11 and the inner wall of the channel may also adopt sealing fit in other structures and forms, such as prismatic surfaces, which can also achieve the relative movement and sealing connection between them.

[0042] In particular, as shown in Figs. 6 and 7, a sealing groove 113 is provided on the mating surface 112. As shown in Fig. 5, the cutter assembly 1 further comprises a first sealing structure 13 provided within the sealing groove 113. The first sealing structure 13 may be, for example, a sealing ring made of rubber, which can deform during movement, thereby acting as a seal.

[0043] In some embodiments, referring to Figs. 6 and 7, the outer wall of the cutter holder 11 comprises a mating surface 112 in sealing fit with the inner wall of the channel and a spherical surface 114 connected to a second end of the mating surface 112. The rear end of the spherical surface 114 is the mounting plane 115, on which a plurality of bolt holes are provided. The rear end of the mating surface is configured as spherical surface, which can avoid the interference problems when the cutter holder 11 is rotating.

[0044] In some embodiments, as shown in Fig. 5, the sleeve 2 comprises a sleeve body 21 and a first flange 22 disposed at a first end of the sleeve body 21. The inner wall of the first flange 22 is flush with an inner wall of the channel. The inner wall of the first flange 22 is flush with an inner wall of the channel of the rotating sleeve 3, i.e. the inner diameter of the first flange 22 equals to the inner diameter of the channel of the rotating sleeve 3. When the cutter assembly 1 is in the working position, the front section of the outer wall of the cutter holder 11 is located in the first flange 22, and the rear section of the cutter holder 11 is located in the channel of the rotating sleeve 3. When a cutter change is required, as shown in Fig. 15, the cutter holder 11 moves backward, such that the cutter holder 11 is disposed within the rotating sleeve 3, thereby reducing the overall volume of the rotating sleeve 3 and the cutter assembly 1. The arrangement of the first flange 22 provides space for the retraction of the cutter 12.

[0045] When the cutter holder 11 moves backward in the second direction X relative to the rotating sleeve 3 into its inside, substances such as slurry and sand may possibly enter the cutter device through the gap between the rotating sleeve 3 and the sleeve 2. In order to solve this problem, referring to Fig. 5, a gap is provided between the end face of the rotating sleeve 3 and the first flange 22 in some embodiments. The cutter device further comprises a second sealing structure 5 provided between the rotating sleeve 3 and the first flange 22. The second sealing structure 5 seals the gap such that a sealed cavity is formed between the rotating sleeve 3 and the sleeve 2.

[0046] In particular, as shown in Fig. 12, the outer wall of the rotating sleeve 3 comprises a spherical surface, and the inner wall of the rotating sleeve 3 comprises a first cylindrical surface. And the central axis of the rotating sleeve 3 extends in a second direction X. As shown in Fig. 13, the axis of the second sealing structure 5 also extends in the second direction X, so that the gaps between the entire circumferential end surface of the rotating sleeve 3 and the sleeve 2 are all sealed by the second sealing structure 5, thereby preventing the entry of slurry and the like.

[0047] In other embodiments not shown in the drawings, the outer wall of the rotating sleeve 3 may be other curved surfaces and not limited to a spherical surface, as long as the rotating sleeve 3 can realize the shape of rotation in the sleeve 2.

[0048] Referring to Fig. 13, in some embodiments, the second sealing structure 5 comprises a sealing ring body and an annular strip projecting radially inward from the sealing ring body. The axis of the sealing ring body extends in the second direction X, and the annular strip is disposed within the gap.

[0049] In some embodiments, as shown in Fig. 12, the outer wall of the rotating sleeve 3 comprises a spherical surface, and the side of the sealing ring body close to the rotating sleeve 3 is adapted to the shape of the spherical surface. In particular, the side of the sealing ring body close to the rotating sleeve 3 is also a spherical surface, so that the sealing ring body abuts the outer wall of the rotating sleeve 3, achieving a better sealing performance.

[0050] Referring to Fig. 8, in some embodiments, the sleeve body 21 is provided with an oil injection hole 212 for injecting grease into the sealed cavity. In particular, as shown in Fig. 8, a plurality of oil injection holes 212 are evenly disposed in the circumferential direction of the sleeve body 21. Before the cutter holder 11 moves backward, grease has been injected into the sealed cavity at the oil injection holes 212 by means of an oil pump, thereby ensuring the sealing performance between the rotat-

ing sleeve 3 and the sleeve 2 during the movement of the cutter holder 11 and preventing slurry and the like from entering the interior. And the efficiency of oil injection is improved by injecting grease through the plurality of oil injection holes 212 at the same time.

[0051] Further, the action of injection of grease into the sealed cavity through the oil injection holes 212 starts before the cutter holder 11 moves backward and continues till the rotation of the cutter holder 11 under the driving of the rotating sleeve 3 is finished. That is, the injection of grease should be continued during the cutter changing process, in order to ensure better sealing performance.

[0052] In some embodiments, referring to Fig. 5, the cutter device further comprises a baffle 4 connected to a second end of the cutter holder 11. The baffle 4 moves the cutter holder 11 in the second direction X. On the rear end of the cutter holder, the baffle 4 fixedly connected thereto is disposed, so that the movement of the cutter holder 11 can be achieved as soon as the baffle 4 is pulled, which is a simple and convenient operation.

[0053] Of course, in other embodiments, the movement of the cutter holder 11 can also be achieved by the direct connection of the driving device with the cutter holder 11.

[0054] Referring to Fig. 5, in some embodiments, the sleeve 2 comprises a sleeve body 21 and a second flange 23 disposed at a second end of the sleeve body 21. The baffle 4 is detachably connected to the second flange 23. When the cutter assembly 1 is in the working position, the baffle 4 is connected to the second flange 23, which has the function of preventing intrusion of slurry and the like into the rear side. When a cutter change is required, it is necessary to detach the connector between the baffle 4 and the second flange 23 first, and then pull the baffle 4 in such a way that the cutter holder 11 is moved backward to the predefined position.

[0055] As described above, the injection of grease is to be carried out continuously during the cutter changing process. However, as shown in Fig. 12, the outer wall of the rotating sleeve 3 is a partial spherical surface, so during the rotation of the rotating sleeve 3 relative to the sleeve 2, when the rotating sleeve 3 rotates to 90°, it is possible to pass through the inside of the cutter device, and the inner cavity is filled with grease. If no mechanical seal is provided, slurry and grease will pour into the manned cabin behind the cutter holder. Therefore, before the rotating sleeve 3 rotates, it is necessary to mount a mechanical seal 6 on the second end of the sleeve 2. As shown in Fig. 16, in some embodiments, the cutter device further comprises a cutter assembly 6. The mechanical seal 6 is configured to be connected to a second end of the sleeve 2 when the cutter assembly 1 is in the cutter changing position.

[0056] When the cutter holder 11 is rotated in place under the driving of the sleeve 3, it is further necessary to detach the mechanical seal 6, so that the cutter 12 can be changed. At this time, the cutter device is filled with grease, and thus it is also necessary to drain the grease inside the cutter device before the mechanical seal 6 is detached. Referring to Figs. 10 and 11, in some embodiments, the second flange 23 has an air hole 231 and an oil drain hole 232. The height of the oil drain hole 232 is smaller than the height of the air hole 231. In particular, high-pressure gas can be introduced through the air hole 231 by the air pump, and grease inside the cutter device is drained from the oil drain hole 232. The mechanical seal 6 is then detached, the old cutter is removed and replaced with a new one.

[0057] The embodiments of the disclosure further provide a tunneling machine, which comprises a cutterhead and said cutter device provided on the cutterhead. In particular, the tunneling device comprises a shield machine.

[0058] The embodiments of the disclosure further provide a cutter changing method based on said cutter device. Referring to Fig. 18, the cutter changing method comprises the steps of:

S701, causing the cutter holder 11 to move in the channel towards the second end of the sleeve 2 so that the cutter assembly 1 enters the cutter changing position from the working position; and

S702, causing the rotation of the rotating sleeve 3 to drive the cutter holder 11 to rotate.

[0059] The cutter changing method according to the embodiments of the disclosure moves the cutter assembly 1 in the cutter changing position from the working position by first causing the cutter holder 11 to move backward in the channel, and then causing the rotating sleeve 3 to rotate, so as to drive the cutter holder 11 to rotate, thereby achieving the cutter changing. This cutter changing method involves simple operation steps and improves the cutter changing efficiency.

[0060] In some embodiments, the cutter changing method further comprises injecting grease into the sealed cavity between the rotating sleeve 3 and the sleeve 2 before causing the movement of the cutter assembly 1. By the action of injection grease into the sealed cavity, the slurry carried by the cutter holder 11 during the backward movement is prevented from entering the sealing ring and causing damages to the seal. Therefore, continuous injection of grease into the sealed cavity can improve the sealing reliability of the cutter changing process in the embodiments of the disclosure.

[0061] In some embodiments, the cutter changing method further comprises mounting a mechanical seal 6 on the second end of the sleeve 2 after controlling the cutter holder 11 to move in the channel towards the second end of the sleeve 2 so that the cutter assembly 1 enters the cutter changing position from the working position, and before controlling the rotating sleeve 3 to rotate. During rotation of the cutter holder 11, there will be the problem that it is possible to pass through the cutter device. If no mechanical seal is provided, slurry and grease will pour into the manned cabin behind the cutter holder. Therefore, before the rotating sleeve 3 is control-

led to rotate, a mechanical seal 6 is mounted on the second end of the sleeve 2, preventing grease and slurry from pouring into the manned cabin and causing hazards to the staff.

[0062] In some embodiments, when the rotating sleeve 3 rotates the cutter assembly 1 so that the cutter 12 rotates to a position towards the second end, grease in the sealed cavity formed between the mechanical seal 6 and the sleeve 2 is drained, the mechanical seal 6 is detached and the cutter is changed.

[0063] The structure of the cutter device and the cutter changing method based on this cutter device in one embodiment of the disclosure will be described in detail below according to Figs. 1 to 17.

[0064] As shown in Figs. 1 to 5, the cutter device of the embodiment comprises a cutter assembly 1, a sleeve 2, a rotating sleeve 3 and a baffle 4.

[0065] Here, the cutter assembly 1 comprises a cutter holder 11 and a cutter 12. The cutter 12 may be a hob. As shown in Figs. 6 and 7, the cutter holder 11 comprises a cutter groove 111 for mounting the cutter 12. The cutter 12 is rotatably mounted in the cutter groove 111. The cutter holder 11 further comprises a mating surface 112, at least two sealing grooves 113 disposed on the mating surface 112, a spherical surface 114 disposed at a rear end of the mating surface 112, and a mounting plane 115 disposed on the end of the spherical surface. The axis of the cutter holder 11 extends in a second direction X. The mating surface 112 is a cylindrical surface, and the mating surface 112 is provided with at least two sealing grooves 113 that are axially spaced from one another. Each of the sealing grooves 113 extends in the circumferential direction of the mating surface 112. The spherical surface 114 is disposed on the rear end of the mating surface 112. The mounting plane 115 is provided with a plurality of bolt holes evenly distributed in the circumferential direction for connecting with the baffle 4 by screw connection. The outer wall of the cutter holder 11 as described above is configured as a cylindrical surface in fit with the channel of the rotating sleeve 3, which can facilitate the cutter holder 11 to rotate about its own axis. In this way, the mounting plane 115 is provided with a plurality of bolt holes evenly distributed in the circumferential direction, so that the baffle 4 can be connected to the cutter holder 11 through the bolt holes on the mounting plane 115 regardless of the angle to which the cutter holder 11 rotates relative to the rotating sleeve 3.

[0066] As shown in Fig. 5, the sleeve 2 comprises a sleeve body 21, a first flange 22 and a second flange 23 respectively disposed at the front and rear end of the sleeve body 21. The first flange 22 and the second flange 23 are connected to the sleeve body 21 by screw connection, and the diameter of the first flange 22 and the diameter of the second flange 23 are both greater than the inner diameter of the sleeve body 21, so that the inner cavity of the sleeve 2 forms a stepped surface.

[0067] Of course, in other embodiments, the sleeve 2 can also be integrated.

[0068] As shown in Fig. 8, the sleeve body 21 is a cylindrical barrel-like structure, i.e. the inner cavity of the sleeve body 21 is a cylindrical inner cavity. The sleeve body 21 is provided with two rotating shaft holes 211 disposed symmetrically with respect its axis. The rotating shaft holes 211 serve to allow the rotating sleeve shaft 31 of the rotating sleeve 3 to pass through, so that the rotating sleeve 3 is rotatable relative to the sleeve 2. The sleeve body 21 is further provided with a plurality of oil injection holes 212 spaced apart from one another in the circumferential direction. And the plurality of oil injection holes 212 have the same axial positions, and they are all located at the front side of the rotating shaft holes 211 and close to the front face of the sleeve body 21.

[0069] As shown in Fig. 9, the first flange 22 is fixedly connected to the front end of the sleeve body 21 through a plurality of bolt holes on its flanged disc. In conjunction with Fig. 5, the inner diameter of the first flange 22 is smaller than the inner diameter of the sleeve body 21, so that the first flange 22 and the sleeve body 21 collectively enclose to form a rotary inner cavity of the rotating sleeve 3.

[0070] As shown in Figs. 10 and 11, the second flange 23 is fixedly connected to the rear end of the sleeve body 21 through a plurality of bolt holes on its flanged disc. In order to avoid interference formed between the second flange 23 and the cutter holder 11 when the cutter holder 11 moves backward to the cutter changing position, a chamfer is provided at one end of the inner wall of the second flange 23 near the sleeve body 21 with reference to Fig. 5. The second flange 23 further comprises symmetrically arranged air holes 231 and oil drain holes 232 for draining grease from the sealed cavity. Referring again to Fig. 5, the inner diameter of the second flange 23 is larger than the inner diameter of the first flange 22, so that the opening area of the second flange 23 is relatively small and the flow area of slurry can be reduced. The baffle 4 is connected to the second flange 23 by screw connection.

[0071] As shown in Fig. 12 in conjunction with Fig. 5, the outer wall of the rotating sleeve 3 is a spherical surface. The inner wall of the rotating sleeve 3 is a cylindrical surface. And the rotating sleeve 3 has a channel passing through in the second direction X, and thus the spherical surface of the outer wall of the rotating sleeve 3 is not a complete spherical surface, and is equivalent to the partial spherical surface formed after the two ends of a complete spherical surface are cut off. The upper and lower ends of the rotating sleeve 3 are both fixedly provided with a rotating sleeve shaft 31. The rotating sleeve shaft 31 is inserted into the rotating shaft hole 211 of the sleeve body 21, so that the rotating sleeve 3 is rotatable about the rotating sleeve shaft 31.

[0072] As shown in Fig. 5, the inner wall of the first flange 22 is flush with an inner wall of the rotating sleeve 3. A part of the mating surface of the cutter holder 11 is in sealing fit with the inner wall of the first flange 22, and the other part of the mating surface of the cutter holder

11 is in sealing fit with the inner wall of the rotating sleeve 3, thereby guaranteeing the sealing performance of the cutter holder 11 during the entire movement process.

[0073] In order to further improve the sealing performance of the cutter device in the embodiment during the cutter changing process, a second sealing structure 5 and a third sealing structure 7 are further provided between the rotating sleeve 3 and the sleeve 2 as shown in Fig. 5. Here, the second sealing structure 5 is disposed between the rotating sleeve 3 and the first flange 22, and the third sealing structure is disposed between the rotating sleeve 3 and the second flange 23. The structure of the second sealing structure 5 is as shown in Fig. 13, and the second sealing structure 5 is a sealing ring. As shown in Fig. 5, the second sealing structure 5 seals the gap between the rotating sleeve 3 and the second flange 23, and further seals the cavity between the outer wall of the rotating sleeve 3 and the sleeve 2 to form a sealed cavity.

[0074] As shown in Fig. 14, when the cutter assembly 1 is in the working position, the edge of the cutter 12 projects beyond the front end face of the sleeve 2 to embed into the tunnel face F. When it is determined that the cutter 12 is seriously worn and needs to be changed, grease is first injected into the sealed cavity between the rotating sleeve 3 and the sleeve 2 through the oil injection holes 212 on the sleeve body 21, preventing the slurry carried by the cutter holder 11 during the backward movement from entering the sealed cavity and causing damages to the sealing ring. The connection bolt between the baffle 4 and the second flange 23 is then detached, as shown in Fig. 15, the baffle 14 is pulled out to move the cutter holder 11 and the cutter 12 backward simultaneously to the cutter changing position. Here, the cutter holder 11 has fully retracted into the rotating sleeve 3 and is further rotatable together with the rotating sleeve 3. Since the outer wall of the rotating sleeve 3 is not a complete spherical surface, a whole process sealing between the rotating sleeve 3 and the sleeve 2 cannot be achieved during rotation of the rotating sleeve 3. For example, when the rotating sleeve 3 rotates by 90°, the cutter device presents a state in which it is possible to pass through it, so that slurry and grease inside the sealed cavity will invade the manned cabin. In order to solve this problem, as shown in Fig. 16, before the rotating sleeve 3 is controlled to rotate, the baffle 4 is first detached from the rear end of the cutter holder 11, and the mechanical seal 6 is mounted on the rear end of the second flange 23 to ensure the sealing inside the cutter device. Then, as shown in Fig. 17, by controlling the rotating sleeve shaft 31 to rotate, the rotating sleeve 3, the cutter holder 11 and the cutter 12 are rotated together, starting from the working position as 0° and rotating by 180°, so that the cutter 12 faces the rear end. After the rotation of the cutter holder 11 is completed, the cavity formed by the mechanical seal 6 and the cutter assembly 1 as well the second flange 23 is filled with grease. At this time, the oil injection is stopped and meanwhile the air hole 231 and the oil drain hole 232 on the second flange 23 are opened. High-pressure gas is injected into the interior through the air hole 231 by the air pump and the grease is drained from inside through the oil drain hole 232. The mechanical seal 6 is detached and the cutter 12 is replaced. After the cutter 12 is replaced, the mechanical seal 6 is further mounted on the rear end of the second flange 23, grease is then injected into the interior through the oil drain hole 232, the rotating sleeve 3 is then controlled to rotate the cutter holder 11 to the working position and then the grease injection is stopped.

[0075] It is to be noted here, both the movement of the cutter holder 11 relative to the rotating sleeve 3 and the rotation of the rotating sleeve 3 relative to the sleeve 2 as described in the above embodiments can be achieved through the automatic driving by the driving device. Furthermore, by providing a sensor, the position of the cutter holder 11 is detected, the controller automatically controls the driving device to drive the movement of the cutter holder 11 relative to the rotating sleeve 3 depending on the position of the cutter holder 11, and automatically controls another driving device to drive the rotation of the rotating sleeve 3, thus achieving the automatic control of the cutter device.

[0076] Finally, it should be noted: the above embodiments are only intended to illustrate the technical solution of the disclosure and not to limit it; although the disclosure has been described in detail with reference to preferred embodiments, the ordinary skill in the art will understand that: modifications to the specific embodiments of the disclosure or equivalent substitutions for parts of the technical features may still be made; all of which are intended to be covered by the scope of the technical solutions claimed in this disclosure without departing from the spirit thereof.

Claims

1. A cutter device, comprising:

A sleeve (2) having an inner cavity;

A rotating sleeve (3) that is disposed in the inner cavity of the sleeve (2) and is rotatable relative to the sleeve (2) around a first rotating shaft extending in a first direction (Z), the rotating sleeve (3) comprising a channel passing through in a second direction (X); and

A cutter assembly (1), comprising a cutter holder (11) and a cutter (12) disposed in the cutter holder (11), the cutter (12) being rotatable relative to the cutter holder (11) around a second rotating shaft extending in a third direction (Y), the first direction (Z), the second direction (X), and the third direction (Y) being perpendicular to one another, and the outer wall of cutter holder (11) being in sealing fit with the inner wall of the channel, and the cutter holder (11) being movably

disposed in the channel in the second direction (X).

2. The cutter device according to claim 1, wherein the cutter assembly (1) has a working position in which the edge of the cutter (12) projects beyond the end face of a first end of the sleeve (2), and a cutter changing position, which the cutter holder (11) moves in the channel towards a second end of the sleeve (2) to reach when a cutter needs to be changed, and in which the cutter holder (11) rotates under the driving of the rotating sleeve (3).

3. The cutter device according to claim 2, wherein in the cutter changing position the distance between the first rotating shaft and the edge of the cutter (12) is smaller than the distance between the first rotating shaft and the inner wall of the sleeve (2).

4. The cutter device according to any one of claims 1-3, wherein the outer wall of the cutter holder (11) comprises a mating surface (112) in sealing fit with the inner wall of the channel, the inner wall of the channel comprising a first cylindrical surface, the mating surface comprising a second cylindrical surface, and the first cylindrical surface and the second cylindrical surface being abutted and in sealing fit.

5. The cutter device according to claim 4, wherein a sealing groove (113) is provided on the mating surface (112), and the cutter assembly (1) further comprises a first sealing structure (13) provided within the sealing groove (113).

6. The cutter device according to any one of claims 1-5, wherein the sleeve (2) comprises a sleeve body (21) and a first flange (22) disposed at a first end of the sleeve body (21), an inner wall of the first flange (22) being flush with an inner wall of the channel.

7. The cutter device according to claim 6, wherein there is a gap between an end surface of the rotating sleeve (3) and the first flange (22), the cutter device further comprises a second sealing structure (5) provided between the rotating sleeve (3) and the first flange (22), wherein the second sealing structure (5) seals the gap such that a sealed cavity is formed between the rotating sleeve (3) and the sleeve (2).

8. The cutter device according to claim 7, wherein the second sealing structure (5) comprises a sealing ring body and an annular strip projecting radially inward from the sealing ring body, the axis of the sealing ring body extending in the first direction (X), the annular strip being disposed within the gap.

9. The cutter device according to claim 7, wherein the outer wall of the rotating sleeve (3) comprises a spherical surface, a side of the sealing ring body close to the rotating sleeve (3) being adapted to the shape of the spherical surface.

10. The cutter device according to claim 6, wherein the sleeve body (21) is provided with an oil injection hole (212) for injecting grease into the sealed cavity.

11. The cutter device according to any one of claims 1-10, further comprising a baffle (4) connected to a second end of the cutter holder (11), the baffle (4) is configured to drive the cutter assembly (1) to move in the second direction (X).

12. The cutter device according to claim 11, wherein the sleeve (2) comprises a sleeve body (21) and a second flange (23) disposed at a second end of the sleeve body (21), to which second flange the baffle (4) is detachably connected.

13. The cutter device according to claim 12, wherein the second flange (23) has an air hole (231) and an oil drain hole (232), a height of the oil drain hole (232) being smaller than a height of the air hole (231).

14. The cutter device according to any one of claims 1-10, further comprising a mechanical seal (6) configured to be connected to a second end of the sleeve (2) when the cutter assembly (1) is in the cutter changing position.

15. The cutter device according to any one of claims 1-10, wherein the outer wall of the cutter holder (11) comprises a mating surface (112) in sealing fit with the inner wall of the channel and a spherical surface (114) connected to a second end of the mating surface (112).

16. A tunneling machine, comprising a cutterhead and a cutter device according to any one of claims 1 to 15 provided on the cutterhead.

17. A cutter changing method based on the cutter device according to any one of claims 1 to 15, comprising the steps of:

causing the cutter holder (11) to move in the channel towards the second end of the sleeve (2) so that the cutter assembly (1) enters a cutter changing position from a working position; and causing the rotation of the rotating sleeve (3) to drive the cutter holder (11) to rotate.

18. The cutter changing method according to claim 17, further comprising injecting grease into the sealed cavity between the rotating sleeve (3) and the sleeve (2) before causing the cutter assembly (1) to move.

19. The cutter changing method according to claim 18, further comprising mounting a mechanical seal (6) on the second end of the sleeve (2) after causing the cutter holder (11) to move in the channel towards the second end of the sleeve (2) so that the cutter assembly (1) enters the cutter changing position from the working position, and before causing the rotating sleeve (3) to rotate.

20. The cutter changing method according to claim 19, further comprising draining grease in the sealed cavity formed between the mechanical seal (6) and the sleeve (2), detaching the mechanical seal (6) and changing the cutter when the rotating sleeve (3) rotates the cutter assembly (1) so that the cutter (12) rotates to a position towards the second end.

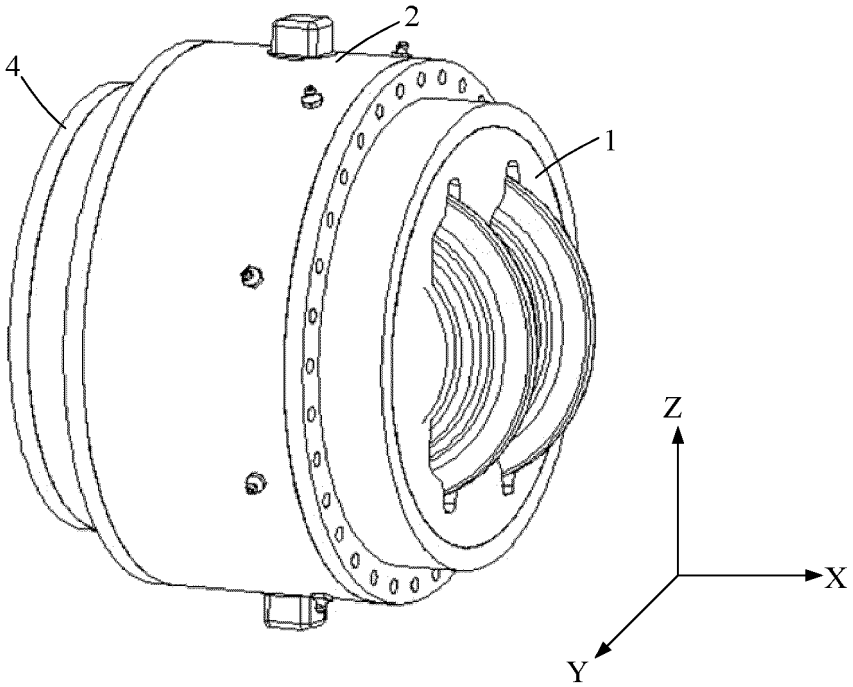

FIG. 1

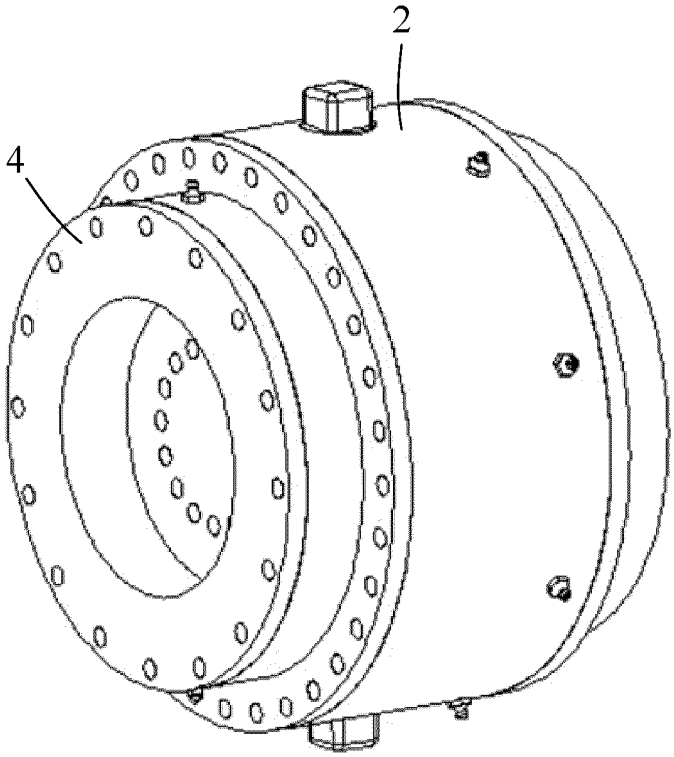

FIG. 2

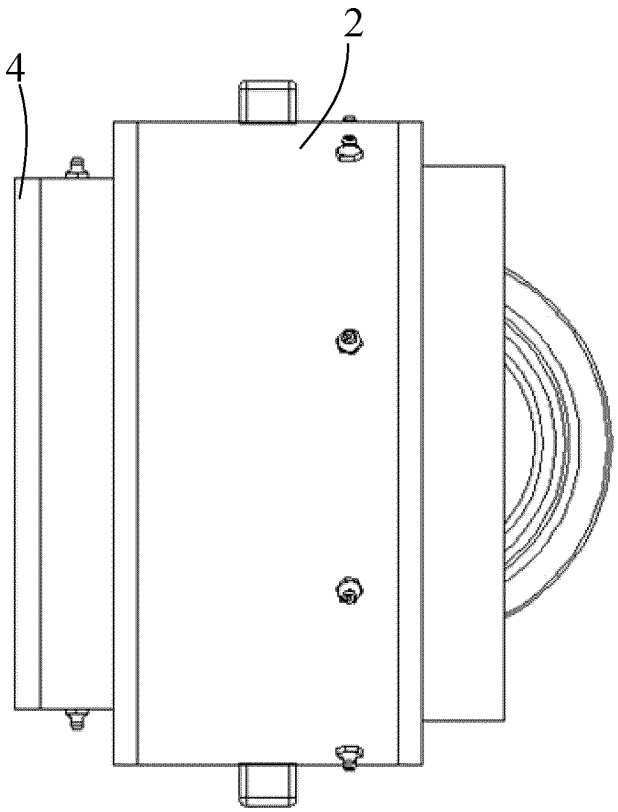

FIG.3

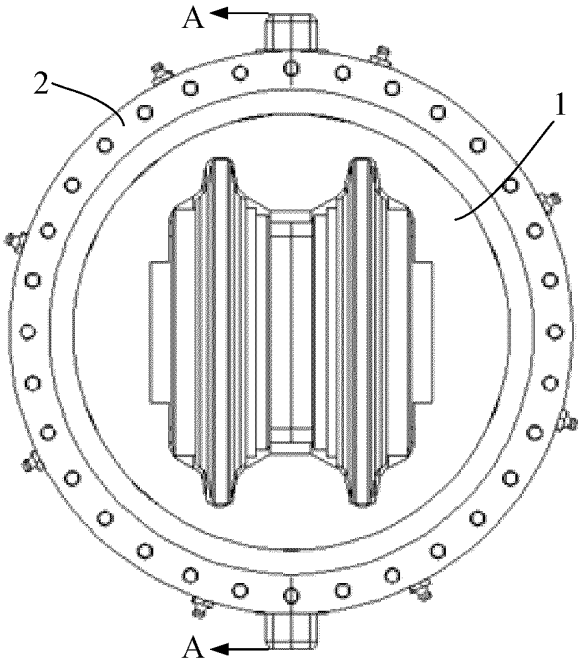

FIG.4

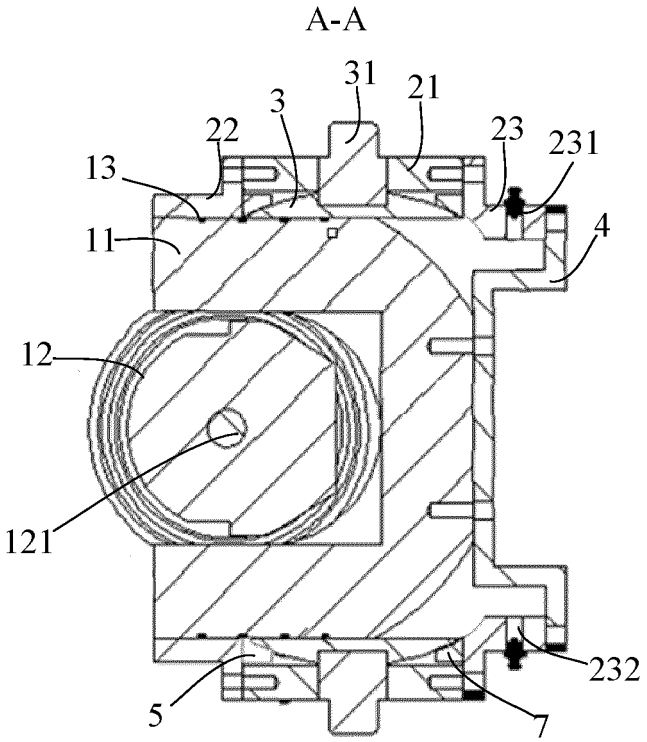

FIG.5

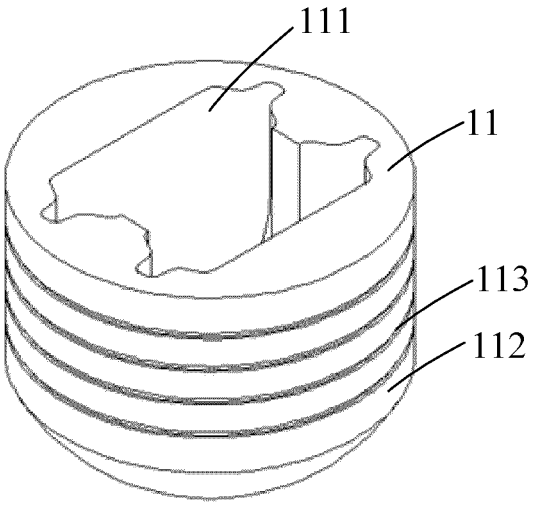

FIG.6

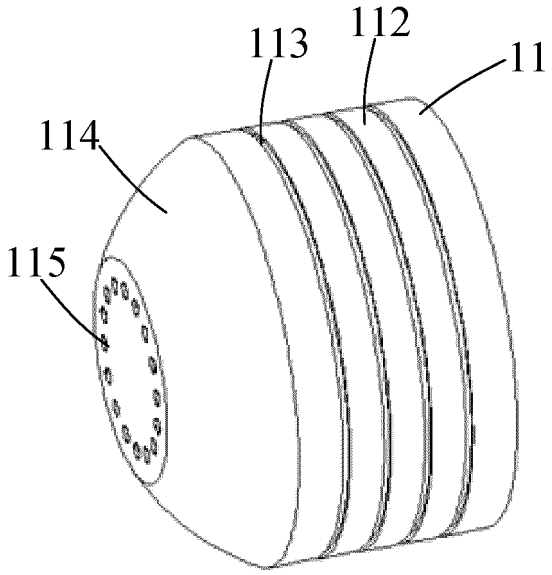

FIG.7

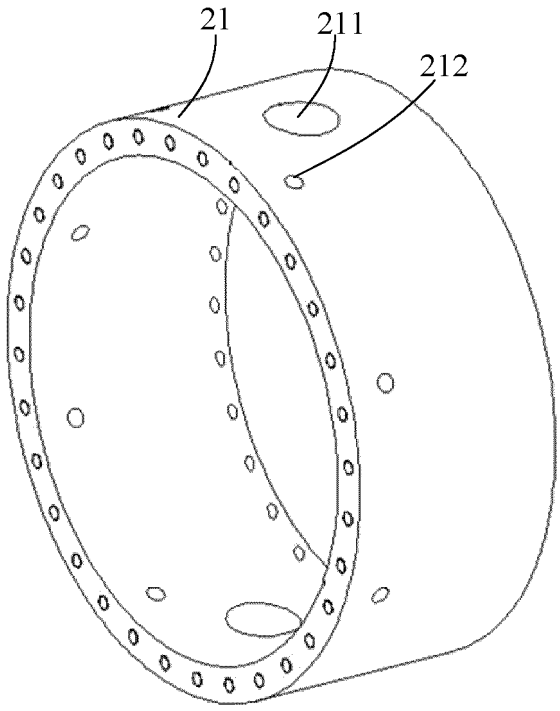

FIG.8

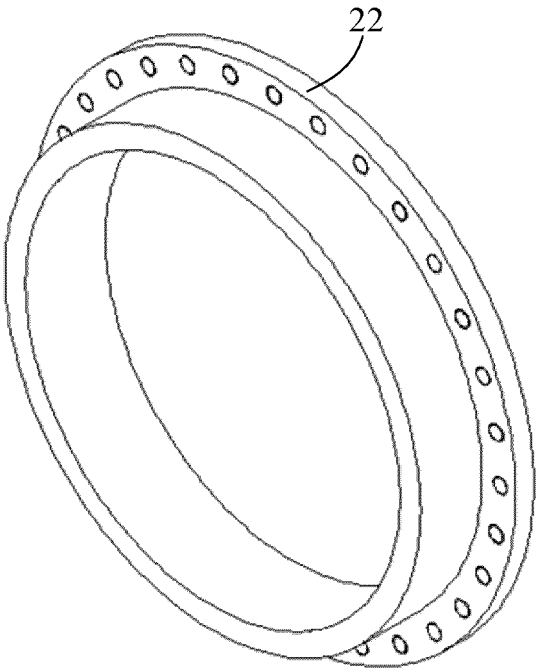

FIG.9

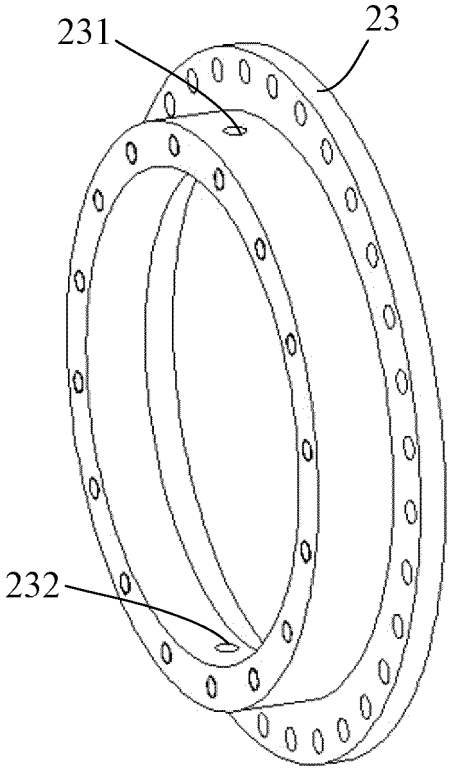

FIG.10

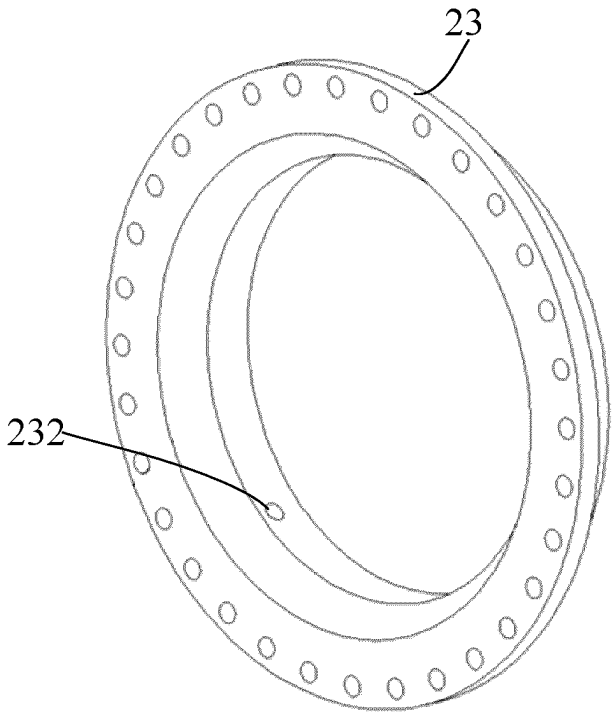

FIG.11

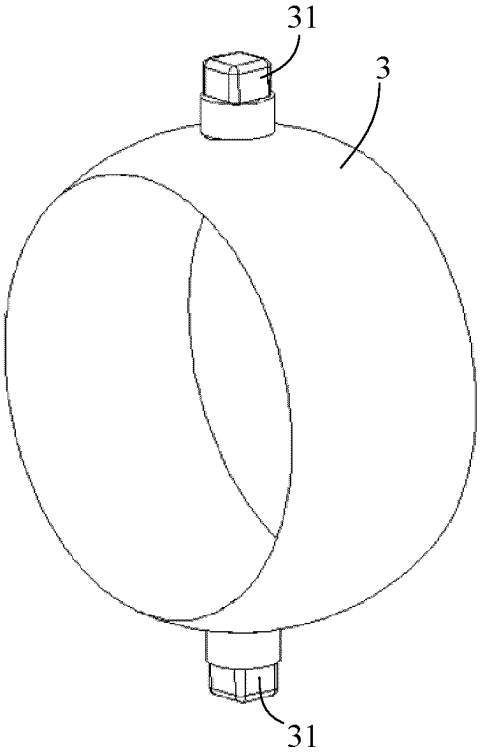

FIG.12

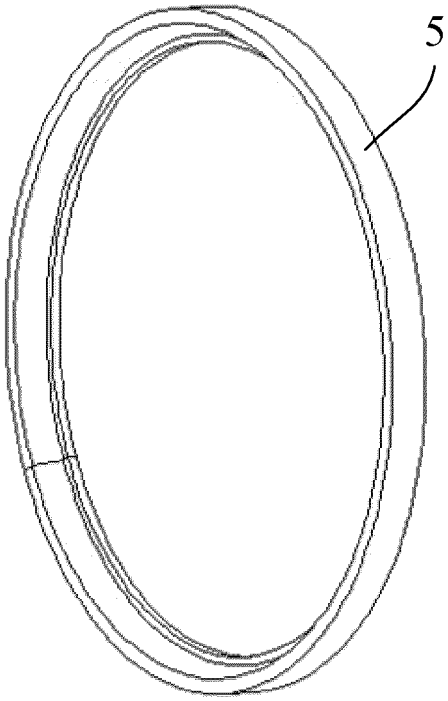

FIG.13

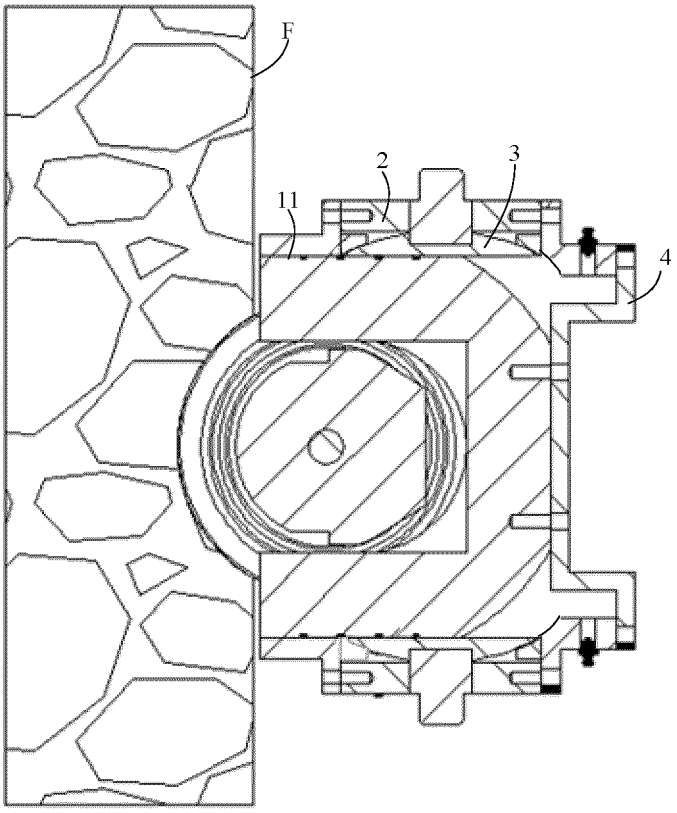

FIG.14

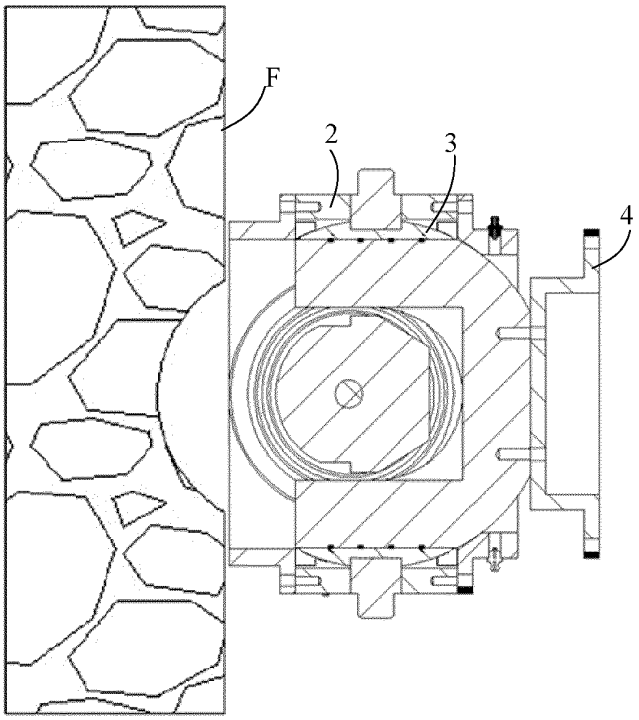

FIG.15

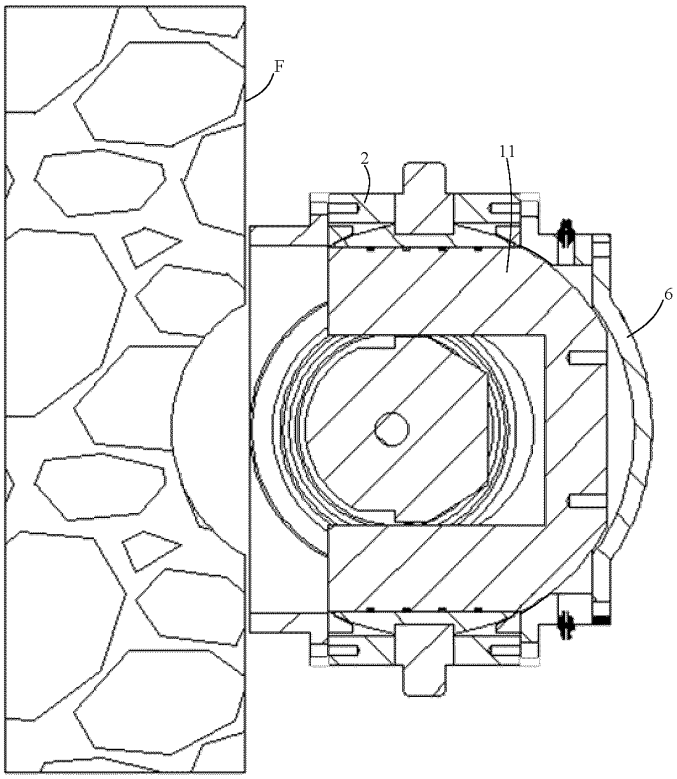

FIG.16

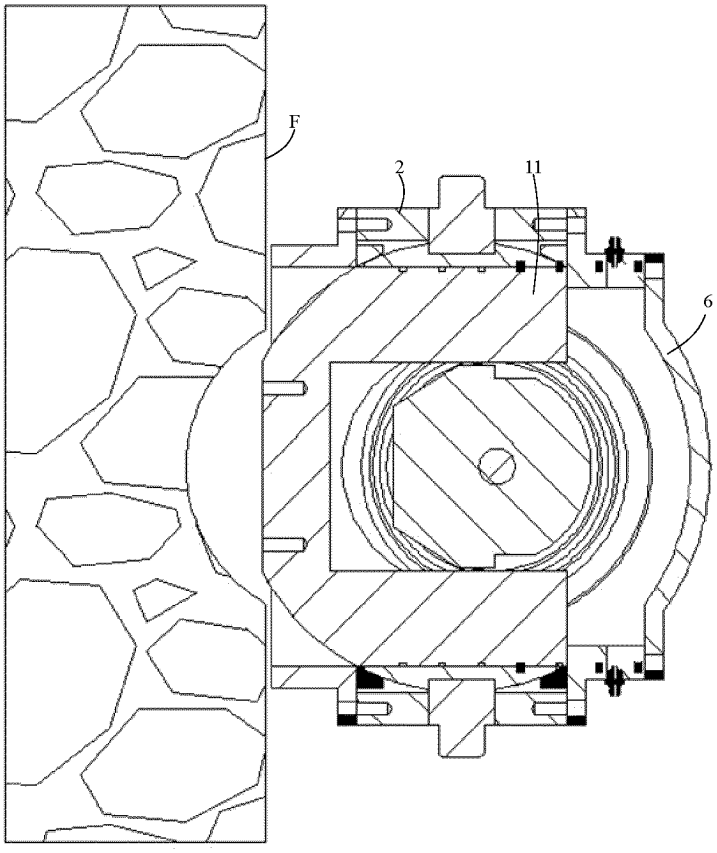
F
2
11
6

FIG.17

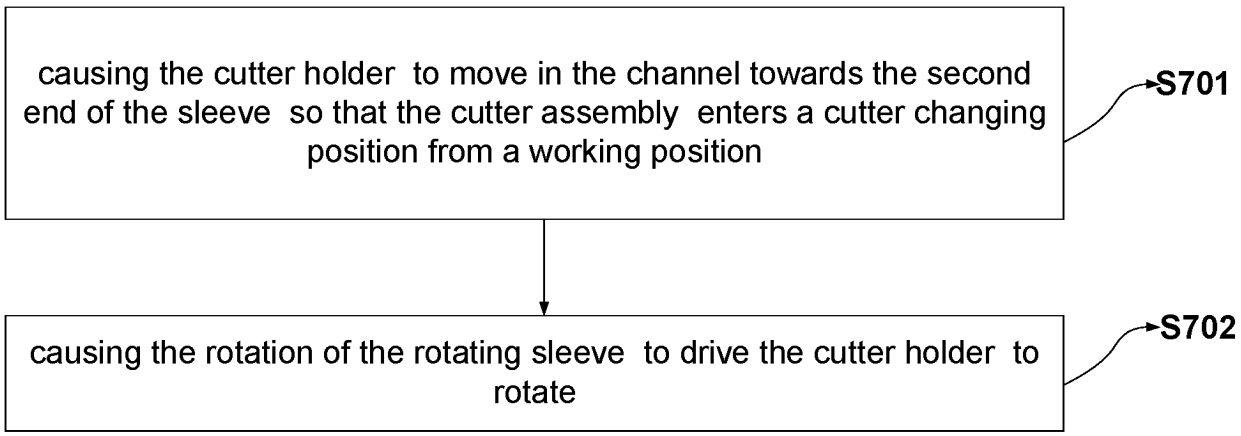
causing the cutter holder to move in the channel towards the second end of the sleeve so that the cutter assembly enters a cutter changing position from a working position
S701
causing the rotation of the rotating sleeve to drive the cutter holder to rotate
S702

FIG.18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/142769

A. CLASSIFICATION OF SUBJECT MATTER

E21D9/10(2006.01)i;F16J15/16(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: E21D F16J

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)

CNTXT, CNABS, VEN, CNKI: 常压, 刀盘, 刀座, 换刀, 旋转, 转动, atmospheric, holder, seat, replac+, cut+, rotat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 114294005 A (CHINA RAILWAY ENGINEERING EQUIPMENT GROUP CO., LTD.) 08 April 2022 (2022-04-08) claims 1-20	1-20
X	CN 110410087 A (CHINA RAILWAY ENGINEERING EQUIPMENT GROUP CO., LTD.) 05 November 2019 (2019-11-05) description, paragraphs 25-34, and figures 1-5	1-20
A	CN 108266200 A (CHINA RAILWAY TUNNEL GROUP CO., LTD. et al.) 10 July 2018 (2018-07-10) entire document	1-20
A	CN 206111193 U (CCCC TIANHE MECHANICAL EQUIPMENT MANUFACTURING CO., LTD.) 19 April 2017 (2017-04-19) entire document	1-20
A	CN 105507911 A (CHINA RAILWAY CONSTRUCTION HEAVY INDUSTRY CORP. LTD) 20 April 2016 (2016-04-20) entire document	1-20

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

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 March 2023	**27 March 2023**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/142769

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 108825258 A (CHINA RAILWAY CONSTRUCTION HEAVY INDUSTRY CORP. LTD) 16 November 2018 (2018-11-16) entire document	1-20
A	JP 2001040992 A (KAJIMA CORP.) 13 February 2001 (2001-02-13) entire document	1-20

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/142769

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 114294005 A	08 April 2022	None	
CN 110410087 A	05 November 2019	None	
CN 108266200 A	10 July 2018	None	
CN 206111193 U	19 April 2017	None	
CN 105507911 A	20 April 2016	None	
CN 108825258 A	16 November 2018	None	
JP 2001040992 A	13 February 2001	JP 3547119 B2	28 July 2004

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 202111682045 **[0001]**