United States Patent Application Publication	20250256413
Kind Code	A1
Publication Date	August 14, 2025
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ACTUATOR AND ROBOT

Abstract

An actuator including a fixed member, a mobile member, a hollow hole penetrating the actuator, an umbilical member passing through the inside of the hollow hole, a first fixing part having a first gripping part that grips one portion of the umbilical member, and a second fixing part having a second gripping part that grips another portion of the umbilical member. The first gripping part and the second gripping part are positioned inside of the hollow hole.

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Family ID: **1000008591860**

Appl. No.: **19/194139**

Filed: **April 30, 2025**

Related U.S. Application Data

parent WO continuation PCT/JP2023/009914 20230314 PENDING child US 19194139

Publication Classification

Int. Cl.: **B25J19/00** (20060101); **B25J9/00** (20060101); **B25J9/12** (20060101)

U.S. Cl.:

CPC **B25J19/0029** (20130101); **B25J9/0009** (20130101); **B25J9/126** (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a bypass continuation application of International Application No. PCT/JP2023/009914 filed Mar. 14, 2023.

BACKGROUND

Field

[0002] The present disclosure relates to an actuator and a robot.

Discussion of the Related Art

[0003] Industrial robots, particularly articulated robots, include at least one joint in which two links are connected to each other. Each joint is provided with an actuator for driving the link, and at least a power line and a signal line for driving the actuator are required. Furthermore, signal lines for driving the end effector installed at the tip of the industrial robot, air piping, and signal lines for high-speed communication are required. In the present description, these power lines, air piping, and various signal lines are collectively referred to as a “filamentary bodies.”

[0004] In Japanese Unexamined Patent Publication (Kokai) No. 2017-159397, an actuator comprises a fixed member and a movable member which rotate relative to each other. A filamentary body penetrates the interior of the actuator, and the filamentary body is affixed to the fixed member and the movable member by a first fixed part and a second fixed part, respectively.

[0005] However, in the prior art, the first fixed part and the second fixed part protrude outside the actuator. Thus, there is a problem in that the robot arm comprising the actuator and the robot become large.

[0006] Thus, there is a demand for an actuator which enables a reduction in size of the robot and the robot arm.

SUMMARY

[0007] According to a first aspect of the present disclosure, there is provided an actuator comprising a fixed member, a movable member which rotates relative to the fixed member, a hollow hole which penetrates the actuator, a filamentary body which passes through an interior of the hollow hole, a first fixed part including a first gripping part for gripping a portion of the filamentary body, and a second fixed part including a second gripping part for gripping another portion of the filamentary body, wherein the first gripping part and the second gripping part are positioned inside the hollow hole, a distance between the first gripping part and the second gripping part is shorter than a length of the hollow hole, and a length of the filamentary body between the first gripping part and the second gripping part gripped by the first gripping part and the second gripping part is longer than a length of the hollow hole.

[0008] The objects, features, and advantages of the present disclosure will become more apparent from the following description of the embodiments in conjunction with the accompanying drawings.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. **1** is a perspective view of a robot comprising an actuator based on a first embodiment.

[0010] FIG. **2** is an axial cross-sectional view of the actuator based on the first embodiment.

[0011] FIG. **3**A is a view showing a first fixed part and a second fixed part.

[0012] FIG. **3**B is an exploded view of the first fixed part and the second fixed part shown in FIG. **3**A.

[0013] FIG. **4** is a partial perspective view of a pipe member.

[0014] FIG. **5**A is a first view showing a production method for the actuator shown in FIG. **2**.

[0015] FIG. **5**B is a second view showing a production method for the actuator shown in FIG. **2**.

[0016] FIG. **6**A is another view showing the first fixed part and the second fixed part.

[0017] FIG. **6**B is an exploded view of the first fixed part and the second fixed part shown in FIG. **6**A.
[0018] FIG. **7**A is an end view of an actuator according to a modification example.
[0019] FIG. **7**B is a perspective view of the actuator shown in FIG. **7**A.
[0020] FIG. **8**A is an axial cross-sectional view of an actuator based on a second embodiment.
[0021] FIG. **8**B is an axial cross-sectional view of an actuator based on a third embodiment.
[0022] FIG. **9** is an axial cross-sectional view of an actuator according to the prior art.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0023] The embodiments of the present disclosure will be described below with reference to the attached drawings. In the drawings, corresponding constituent elements have been assigned common reference signs.

[0024] FIG. **1** is a perspective view of a robot comprising an actuator according to a first embodiment. Each of a plurality of joints of a robot **1**, for example, a vertical articulated robot, comprises actuators **5***a* to **5***f*. The actuators **5***a* to **5***f* may be incorporated in a machine other than the robot **1**, for example, a machine tool. Though the actuator **5** will be described below, the actuators **5***a* to **5***f* shown in FIG. **1** also have the same configuration.

[0025] FIG. **2** is an axial cross-sectional view of the actuator according to the first embodiment. The actuator **5** is mainly composed of a fixed member **21** and a movable member **22** which rotates relatively to the fixed member **21**. Specifically, the fixed member **21** comprises a motor **10**, for example, a servo motor, composed of a stator and a rotor, and a speed reducer **20** connected to a motor shaft **13** of the motor **10**. The movable member **22** comprises an output shaft **23** of the speed reducer **20** and a force sensor S coupled to the output shaft **23**. As will be described later, the movable member **22** may be configured so as to include only the output shaft **23** of the speed reducer **20**.

[0026] In the present disclosure, the speed reducer **20** is defined as being arranged in front of the motor **10**, and the motor **10** is defined as being arranged behind the speed reducer **20**. Furthermore, in principle, the “radial direction” in the present disclosure means the radial direction of the actuator **5**, etc., and the “axial direction” means the axial direction of the actuator **5**, etc.

[0027] The motor shaft **13** of the motor **10** is connected to the speed reducer **20**. The tip of the output shaft **23** of the speed reducer **20** is connected to a link **2** (not illustrated) via the force sensor S. Thus, the actuator **5** controls the positioning of the link **2** (not illustrated) by rotating the link **2** relative to the actuator **5** within a predetermined operating range. The reduction ratio of the speed reducer **20** is, for example, 1:50.

[0028] The motor shaft **13** is, for example, a hollow shaft. An extension part **23***a*, for example, a pipe member, is coupled to the output shaft **23** of the speed reducer **20**, and this extension part **23***a* passes through the hollow motor shaft **13** and extends toward the motor **10**. The output shaft **23** of the speed reducer **20** and the extension part **23***a* may be integrally formed. In other words, the extension part **23***a* may be a portion of the output shaft **23**. Thus, hereinafter, the “extension part **23***a*” may be expressed as the “output part **23**.”

[0029] The force sensor S is composed of a torque sensor for detecting the force acting around the axis of the actuator **5**. As shown in FIG. **7**A, which will be described later, the force sensor S generally comprises a sensor component S**1**, a sensor component S**2**, and a strain detection unit S**3** which connects between them. Since the rigid strain detection unit S**3** elastically deforms in a direction which slightly extends when a force acts around the axis of the actuator **5**, the force acting around the axis can be detected by the deformation amount of the strain detection unit S**3**. The force sensor S may be a strain gauge, a capacitance sensor, a magnetic sensor, an optical encoder, etc.

[0030] As shown in the drawing, the force sensor S, the speed reducer **20**, and the motor **10**, which are coaxially connected to each other, have a common hollow hole **29**. It is preferable that the hollow holes **29** of the force sensor S, the speed reducer **20**, and the motor **10** have a common inner

diameter. As a result, the extension part **23**_a_, for example, a pipe member, can smoothly be arranged. In other words, the actuator **5** has a hollow hole **29** which penetrates the entire actuator **5** formed in the axial direction. The hollow hole **29** is formed by the inner peripheral surface of the motor **10**, the inner peripheral surface of the speed reducer **20**, and the inner peripheral surface of the force sensor S. Thus, the hollow hole **29** includes the extension part **23**_a_ and the motor shaft **13** located outside the extension part **23**_a_. As shown in the drawing, the extension part **23**_a_ extends over substantially the entire length of the actuator **5**. It is preferable that the extension part **23**_a_ be shorter than the entire length of the actuator **5**. At least one filamentary body L, such as a signal line or a current supply line, passes through the interior of the extension part **23**_a_.
[0031] As shown in FIG. **2**, a portion of the filamentary body L is affixed to the fixed member **21** by a first fixed part **31**. The other portion of the filamentary body L is affixed to the movable member **22** by a second fixed part **32**.
[0032] In FIG. **2**, the first fixed part **31** is affixed to the rear end surface of the motor **10**, and the second fixed part **32** is affixed to a front end surface close to the inner periphery of the sensor S, which does not affect the detection of the sensor S. However, when the actuator **5** is the actuator **5**_d_ mounted on the robot **1**, the first fixed part **31** may be affixed to an arm member **62** on the arm affixation (non-rotating) side, and the second fixed part **32** may be affixed to another arm member **61** on the arm rotation side adjacent to the arm member **62**. It will be assumed below that the first fixed part **31** is affixed to the rear end surface of the fixed member **21**, the fixed member **21** is connected to the arm member **61**, the second fixed part **32** is affixed to the front end surface of the movable member **22**, and the movable member **22** is connected to the arm member **61**. Regarding the mounting direction of the actuator, the force sensor S may be connected to the arm member **62** on the affixation (non-rotating) side of the arm, and the fixed member **21** may be connected to the arm member **61** on the arm rotation side.
[0033] FIG. **3**A is a view showing the first fixed part and the second fixed part, and FIG. **3**B is an exploded view of the first fixed part and the second fixed part shown in FIG. **3**A. As shown in these drawings, the first fixed part **31** includes a plate part **41**_a_ to be affixed to the fixed member **21**, a bracket **42**_a_ extending perpendicular to the plate part **41**_a_, and a first gripping part **43**_a_ attached to the bracket **42**_a_. Likewise, the second fixed part **32** includes a plate part **41**_b_ to be affixed to the movable member **22**, a bracket **42**_b_ extending perpendicular to the plate part **41**_b_, and a second gripping part **43**_b_ attached to the bracket **42**_b_.
[0034] Fixtures such as bolts may affix between the fixed member **21** and the plate part **41**_a_ and between the movable member **22** and the plate part **41**_b_. Any fixtures may be used as long as it can facilitate attachment and detachment. Likewise, Fixtures such as bolts or an adhesive may affix between the plate part **41**_a_ and the bracket **42**_a_ and between the plate part **41**_b_ and the bracket **42**_b_. The first gripping part **43**_a_ and the second gripping part **43**_b_ serve to partially grip the filamentary body L. The first gripping part **43**_a_ and the second gripping part **43**_b_ may be, for example, pressing clamp members or resin bands. The first gripping part **43**_a_ and the second gripping part **43**_b_ may be structured to grip the filamentary body L by wrapping it in a protective member such as a rubber sheet.
[0035] As can be understood with reference again to FIG. **2**, the plate part **41**_a_ of the first fixed part **31** is arranged outside the fixed member **21**, and the plate part **41**_b_ of the second fixed part **32** is arranged outside the movable member **22**. The bracket **42**_a_ attached to the plate part **41**_a_ enters the interior of the hollow hole **29** from one end of the actuator **5**, and the bracket **42**_b_ attached to the plate part **41**_b_ enters the interior of the hollow hole **29** from the other end of the actuator **5**. Thus, the length A**1** between the first gripping part **43**_a_ and the second gripping part **43**_b_ on a line segment parallel to the central axis of the actuator **5** is shorter than the net length A**2** in the axial direction of the hollow hole **29**.
[0036] Note that the length A**1** between the first gripping part **43**_a_ and the second gripping part **43**_b_ means the length measured when the phase of the first gripping part **43**_a_ and the phase of the

second gripping part **43***b* around the rotation axis are consistent and when the first gripping part **43***a* and the second gripping part **43***b* are affixed relatively immovably to the hollow hole **29**.
[0037] FIG. **4** is a partial perspective view of a pipe member. In FIG. **4**, a notch **23***b* extending in the circumferential direction is formed at one end of the extension part **23***a*. FIG. **4** also shows an area C including the notch **23***b*. The case in which the notch **23***b* is formed in the extension part **23***a* in this manner is also included in the scope of the present disclosure.
[0038] The length from one end of the extension part **23***a* to the first gripping part **43***a* is preferably less than half the axial length A**2** of the extension part **23***a*. Likewise, the length from the other end of the extension part **23***a* to the second gripping part **43***b* is preferably less than half the axial length A**2** of the extension part **23***a*.
[0039] More specifically, the length from one end of the extension part **23***a* to the first gripping part **43***a* and the length from the other end of the extension part **23***a* to the second gripping part **43***b* are preferably equal to or less than one-fourth of the axial length A**2**. This is to prevent the weight of the brackets **42***a*, **42***b* comprising the gripping parts **43***a*, **43***b* from increasing. Furthermore, as will be described later, this is to facilitate the affixing operations of the first fixed part **31** and the second fixed part **32**.
[0040] As can be understood from FIG. **2**, the filamentary body L has a predetermined slack between the first gripping part **43***a* and the second gripping part **43***b*. Specifically, the length of the portion of the filamentary body L between the first gripping part **43***a* and the second gripping part **43***b* and is gripped by the first gripping part **43***a* and the second gripping part **43***b* is longer than the net length A**2** of the hollow hole **29** in the axial direction.
[0041] In the present disclosure, both the first gripping part **43***a* of the first fixed part **31** and the second gripping part **43***b* of the second fixed part **32** are positioned in the interior of the hollow hole **29**. In other words, only the plate parts **41***a*, **41***b* of the first fixed part **31** and the second fixed part **32** are exposed to the outside of the actuator **5**. Further, since the plate parts **41***a*, **41***b* are, for example, metal plates having a predetermined thickness, the exposed portions thereof are extremely small.
[0042] In this manner, in the present disclosure, the first gripping part **43***a* and the second gripping part **43***b* are positioned in the interior of the hollow hole **29**, and the exposed portions of the plate parts **41***a*, **41***b* are extremely small. Thus, an increase in size of the actuator **5** can be prevented. Furthermore, an increase in size of the robot **1** comprising the actuators **5***a* to **5***f* can be prevented.
[0043] The filamentary body L has a predetermined slack between the first gripping part **43***a* and the second gripping part **43***b*. Thus, even if the fixed member **21** and the movable member **22** rotate relatively when the actuator **5** is incorporated into the joint of the robot **1**, the slack absorbs the twisting of the filamentary body L. In other words, damage to the filamentary body L due to excessive stress being applied to the filamentary body L can be prevented, and kinking of the filamentary body L can be prevented.
[0044] If the filamentary body L is affixed to the first fixed part **31** and the second fixed part **32** in a state in which the two fixed parts **31**, **32** of the filamentary body L are completely exposed to the outside, and then the first gripping part **43***a* and the second gripping part **43***b* on the first fixed part **31** and the second fixed part **32** are both inserted into the hollow hole interior of the extension part **23***a*, the amount of slack in the filamentary body L becomes excessive. In such a case, the filamentary body L is pressed strongly against the inner surface of the hollow hole, which may result in a large stress acting on the filamentary body L, thus shortening the lifespan of the filamentary body L.
[0045] FIG. **9** is an axial cross-sectional view of an actuator according to the prior art. In FIG. **9**, the first gripping part **43***a* of the first fixed part **31** protrudes outward from one end of the hollow hole **29** by a protrusion amount B**1**, and the second gripping part **43***b* of the second fixed part **32** protrudes outward from the other end of the hollow hole **29** by a protrusion amount B**2**. Thus, the actuator **5′** has a drawback in that it becomes larger in the axial direction by the protrusion amounts

B**1**, B**2**. As a result, the housing (not illustrated) of a robot comprising a plurality of the actuators **5′** also becomes larger in accordance with the lengths of the actuators **5′**.

[0046] FIGS. **5**A and **5**B are views showing a production method for the actuator shown in FIG. **2**. In an initial stage, the first fixed part **31** and the second fixed part **32** have already been assembled as shown in FIG. **3**A, and both the first fixed part **31** and the second fixed part **32** are not affixed to the actuator **5**.

[0047] As shown in FIG. **5**A, the filamentary body L is passed through the hollow hole **29**, and a portion of the filamentary body L is “temporarily affixed” to the first gripping part **43***a* of the first fixed part **31**. Then, the filamentary body L is pulled in the direction of the arrow in FIG. **5**A to fully extend the filamentary body L. As a result, the plate part **41***a* of the first fixed part **31** abuts against the rear end surface of the fixed member **21**. In this state, the second gripping part **43***b* of the second fixed part **32** is caused to properly grip the other portion of the filamentary body L. As can be seen from FIG. **5**A, the gripping operation of the filamentary body L by the second gripping part **43***b* is performed outside the actuator **5**.

[0048] Then, as indicated by the arrow in FIG. **5**B, the filamentary body L is pulled in the opposite direction to fully extend the filamentary body L. As a result, the plate part **41***b* of the second fixed part **32** abuts against the front end surface of the movable member **22**, and the plate part **41***a* of the first fixed part **31** moves away from the fixed member **21**. In this state, the plate part **41***b* of the second fixed part **32** is affixed to the end surface of the movable member **22** as described above. Furthermore, the first gripping part **43***a* of the first fixed part **31** is caused to properly grip the portion of the filamentary body L described above. The gripping operation of the filamentary body L by the first gripping part **43***a* is performed outside the actuator **5**.

[0049] Thereafter, the plate part **41***a* of the first fixed part **31** is affixed to the end surface of the fixed member **21**. As a result, as described above, the filamentary body L has a predetermined slack between the first gripping part **43***a* and the second gripping part **43***b*, and the length of the slack is longer than the axial length A**2** of the hollow hole **29**. As described above, the affixing operations of affixing the plate parts **41***a*, **41***b* to the fixed member **21** and the movable member **22**, respectively, and the gripping operations of the filamentary body L by the first gripping part **43***a* and the second gripping part **43***b* are performed outside the actuator **5**. It will be understood that the affixing operations by the first fixed part **31** and the second fixed part **32** can therefore be performed smoothly and easily.

[0050] The production procedure is not limited to the foregoing. The affixation of the first fixed part **31** and the second fixed part **32** may be full affixation instead of temporary affixation. In this case, it is necessary to mark the affixation positions on the filamentary body L in advance so that the distance between the clamps is accurate. The plate part **41***a* and the plate part **41***b* are attached to the actuator **5** in advance, and after the filamentary body L is affixed only with the bracket **42***a* and the bracket **42***b*, the bracket **42***a* and the bracket **42***b* may be affixed to the plate part **41***a* and the plate part **41***b*, respectively, to provide optimal slack. Regarding the order of affixation, the affixation operations may start from either of the two fixed parts **31**, **32**.

[0051] FIG. **6**A is another view showing a first fixed part and a second fixed part, and FIG. **6**B is an exploded view of the first fixed part and the second fixed part shown in FIG. **6**A. The first fixed part **31** shown in these drawings includes at least one ring-shaped spacer N (four ring-shaped spacers N in FIG. **6**A) between the plate part **41***a* and the bracket **42***a*. As shown in the drawings, a bolt **50** connects the plate part **41***a*, the at least one ring-shaped spacer N, and the bracket **42***a* to each other. Alternatively, the plate part **41***a*, the at least one ring-shaped spacer N, and the bracket **42***a* may be connected by another method, for example, an adhesive, without using the bolt **50**.

[0052] Furthermore, the second fixed part **32** includes a single spacer W**1** having a predetermined dimension between the plate part **41***b* and the bracket **42***b*. The plate part **41***b*, the spacer W**1**, and the bracket **42***b* may be bonded together by an adhesive, or may be bonded together by a bolt (not illustrated).

[0053] Due to the presence of the at least one ring-shaped spacer N and the spacer W**1**, the gripping positions of the filamentary body L gripped by the first gripping part **43***a* and the second gripping part **43***b* move to the axial center position of the hollow hole **29**. In other words, the two gripping positions of the filamentary body L shift farther from one end toward the other end of the hollow hole **29**. As a result, the presence of the at least one ring-shaped spacer N and the spacer W**1** increases the amount of slack of the filamentary body L.

[0054] The left side of FIG. **6**B shows an embodiment in which the spacer W**1** is replaced with another spacer W**2** which is larger than the spacer W**1** and the spacer W**2** is arranged between the plate part **41***b* and the bracket **42***b*. This causes the second gripping part **43***b* of the second fixed part **32** to shift further away from the end of the hollow hole **29**, and as a result, the amount of slack in the filamentary body L is further increased.

[0055] The right side of FIG. **6**B shows an embodiment in which two of the four ring-shaped spacers N are removed and the remaining two ring-shaped spacers N are arranged between the plate part **41***a* and the bracket **42***a*. By reducing the number of ring-shaped spacers N, the first gripping part **43***a* of the first fixed part **31** approaches the end of the hollow hole **29**, and as a result, the amount of slack in the filamentary body L is reduced.

[0056] By using the at least one ring-shaped spacer N and/or spacers W**1**, W**2** in this manner, the amount of slack of the filamentary body L can be changed. In other words, at least one ring-shaped spacer N, bolt **50**, and spacers W**1**, W**2** serve as an adjustment mechanism for adjusting the amount of slack of the filamentary body L. By employing such an adjustment mechanism, the amount of slack of the filamentary body L in the interior of the hollow hole **29** can easily be adjusted even after the first fixed part **31** and the second fixed part **32** are affixed to the actuator **5**. Note that the use of an annular member such as a washer instead of the ring-shaped spacer N is within the scope of the present disclosure.

[0057] FIG. **7**A is an end view of the actuator of a modification example, and FIG. **7**B is a perspective view of the actuator shown in FIG. **7**A. As shown in FIG. **7**A, the sensor S includes two sensor components S**1**, S**2** arranged concentrically. Furthermore, the sensor S includes a plurality of strain detection units S**3** which connect the sensor components S**1**, S**2** and extend in the radial direction of the actuator **5-1**. Furthermore, the sensor S has a plurality of openings **52** which are surrounded by the sensor components S**1**, S**2** and the strain detection units S**3**. As described above, the sensor S detects force acting around the axis of the actuator **5-1** through the elastic deformation of the strain detection unit S**3**.

[0058] The movable member **22** of the actuator **5** shown in FIG. **2**, etc., includes the sensor S. Thus, the plate part **41***b* of the second fixed part **32** can be directly attached to the end surface of the sensor S. However, if at least a portion of the second fixed part **32** is in partial contact with the sensor S or if the filamentary body L is directly affixed onto the sensor S, the sensitivity of the sensor S may be adversely affected, and the sensor S may output an undesirable detection result.

[0059] In the modification examples shown in FIGS. **7**A and **7**B, a plurality of rod-shaped members **44** extend from the plate part **41***b* of the second fixed part **32**. The plurality of rod-shaped members **44** are affixed to the end surface of the output part **23** through the opening **52** of the sensor S. Thus, in the modification example, the second fixed part **32** is affixed to the movable member **22** of the actuator **5-1** without contacting the sensor S. In such a case, due to the presence of the second fixed part **32**, the sensor S is not directly subjected to a torsional reaction force from the filamentary body L, and thus, it will be understood that suitable force control can be performed using the sensor S.

[0060] FIG. **8**A is an axial cross-sectional view of an actuator based on a second embodiment, and FIG. **8**B is an axial cross-sectional view of an actuator based on a third embodiment. The actuator **5-2** shown in FIG. **8**A does not include a sensor S. Specifically, the movable member **22** of the actuator **5-2** includes only the output part **23**. The second fixed part **32** is affixed to the end surface of the extension part **23***a*, and specifically, the end of the hollow hole **29**. The fixed member **21**

includes the speed reducer **20** and the motor **10**.
[0061] The actuator **5-3** shown in FIG. **8**B comprises an encoder E on the rear end side of the motor **10**. The encoder E detects the rotation speed of the motor shaft **13** and the rotation speed of the extension part **23***a* by a known method. Thus, the fixed member **21** includes the speed reducer **20**, the motor **10**, and the encoder E. Therefore, in FIG. **8**B, the first fixed part **31** is attached to the rear end of the encoder E. The movable member **22** includes the output part **23** and the sensor S. Though not illustrated, a driver with a hollow structure may be further mounted on the right side (rear end side) of the encoder E.
[0062] In this manner, the fixed member **21** and movable member **22** of the actuator are not limited to the configuration shown in FIG. **2**, and the scope of the present disclosure also includes cases in which the fixed member **21** includes an encoder E and in which the movable member **22** does not include a sensor S.
[0063] At least one of the embodiments described above has the advantage that the first gripping part and the second gripping part are positioned in the interior of the hollow hole **29**, whereby the actuator and the robot comprising such an actuator can be prevented from becoming large.
[0064] Though the embodiments of the present disclosure have been described in detail, the present disclosure is not limited to the individual embodiments described above. Various additions, replacements, modifications, or partial deletions can be made to these embodiments within the scope of the spirit of the invention, or within the scope of the idea and intent of the present invention derived from the contents described in the claims and their equivalents. For example, the order of each operation and the order of each process of the embodiments described above are shown as examples, and are not limited to these. The same applies when numerical values or formulas are used in the description of the embodiments described above. Furthermore, appropriate combinations of some of the embodiments described above are included in the scope of the present disclosure.
[0065] In relation to the embodiments and modification examples described above, the following Addenda are further disclosed.
(Addendum 1)
[0066] An actuator comprising: [0067] a fixed member, [0068] a movable member which rotates relative to the fixed member, [0069] a hollow hole which penetrates the actuator, [0070] a filamentary body which passes through an interior of the hollow hole, [0071] a first fixed part including a first gripping part for gripping a portion of the filamentary body, and [0072] a second fixed part including a second gripping part for gripping another portion of the filamentary body, wherein [0073] the first gripping part and the second gripping part are positioned inside the hollow hole, [0074] a distance between the first gripping part and the second gripping part is shorter than a length of the hollow hole, and [0075] a length of the filamentary body between the first gripping part and the second gripping part gripped by the first gripping part and the second gripping part is longer than a length of the hollow hole.
(Addendum 2)
[0076] The actuator according to Addendum 1, wherein the filamentary body gripped by the first gripping part and the second gripping part has a predetermined amount of slack between the first gripping part and the second gripping part.
(Addendum 3)
[0077] The actuator according to Addendum 1 or 2, wherein the first gripping part and the second gripping part are configured to be detachable from remaining portions of the first fixed part and remaining portions of the second fixed part, respectively.
(Addendum 4)
[0078] The actuator according to any one of Addenda 1 to 3, further comprising an adjustment mechanism with which slack of the filamentary body can be adjusted.
(Addendum 5)

[0079] The actuator according to any one of Addenda 1 to 4, wherein the first fixed part is affixed to the fixed member, and the second fixed part is affixed to the movable member.
(Addendum 6)
[0080] A robot, comprising at least one of the actuator according to any one of Addenda 1 to 5.
REFERENCE SIGNS LIST
[0081] **1** robot [0082] **5**, **5-1**, **5-2** actuator [0083] **10** motor [0084] **13** motor shaft [0085] **20** speed reducer [0086] **21** fixed member [0087] **22** movable member [0088] **23** output part [0089] **23***a* extension part [0090] **29** hollow hole [0091] **31** first fixed part [0092] **32** second fixed part [0093] **41***a*, **41***b* plate part [0094] **42***a*, **42***b* bracket [0095] **43***a* first gripping part [0096] **43***b* second gripping part [0097] **50** bolt (adjustment mechanism) [0098] **61**, **62** arm member [0099] E encoder [0100] L filamentary body [0101] N ring-shaped spacer (adjustment mechanism) [0102] S force sensor [0103] W**1**, W**2** spacer (adjustment mechanism)

Claims

1. An actuator comprising: a fixed member, a movable member which rotates relative to the fixed member, a hollow hole which penetrates the actuator, a filamentary body which passes through an interior of the hollow hole, a first fixed part including a first gripping part for gripping a portion of the filamentary body, and a second fixed part including a second gripping part for gripping another portion of the filamentary body, wherein the first gripping part and the second gripping part are positioned inside the hollow hole, a distance between the first gripping part and the second gripping part is shorter than a length of the hollow hole, and a length of the filamentary body between the first gripping part and the second gripping part gripped by the first gripping part and the second gripping part is longer than a length of the hollow hole.
2. The actuator according to claim 1, wherein the filamentary body gripped by the first gripping part and the second gripping part has a predetermined amount of slack between the first gripping part and the second gripping part.
3. The actuator according to claim 1, wherein the first gripping part and the second gripping part are configured to be detachable from remaining portions of the first fixed part and remaining portions of the second fixed part, respectively.
4. The actuator according to claim 1, further comprising an adjustment mechanism with which slack of the filamentary body can be adjusted.
5. The actuator according to claim 1, wherein the first fixed part is affixed to the fixed member, and the second fixed part is affixed to the movable member.
6. A robot, comprising at least one actuator according to claim 1.