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(54) **ROBOT ARM AND ROBOT ARM MANUFACTURING METHOD**

(71) Applicant: **OMRON Corporation**, KYOTO (JP)

(72) Inventor: **Takeshi KIRIBUCHI**, Osaka-shi, OSAKA (JP)

(73) Assignee: **OMRON Corporation**, KYOTO (JP)

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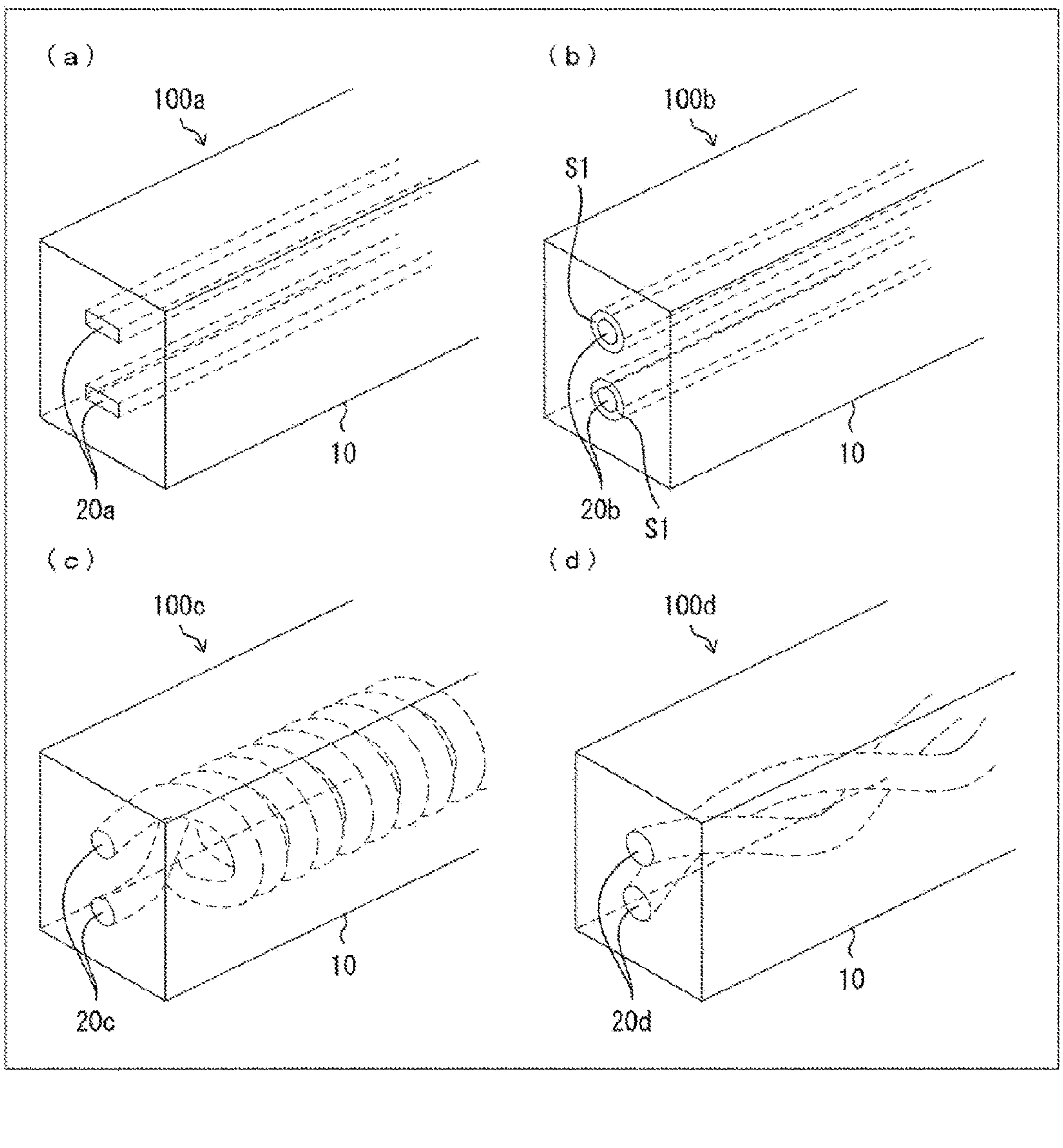
(57) **ABSTRACT**

A robot arm (**100***a*-**100***d*) comprises an arm member (**10**) and at least two wires (**20***a*-**20***d*). The two wires (**20***a*-**20***d*) have a configuration wherein: each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to the flat shape face; a shield wire (S**1**) is provided around each wire; each wire has a helical shape; or the wires are twisted together.



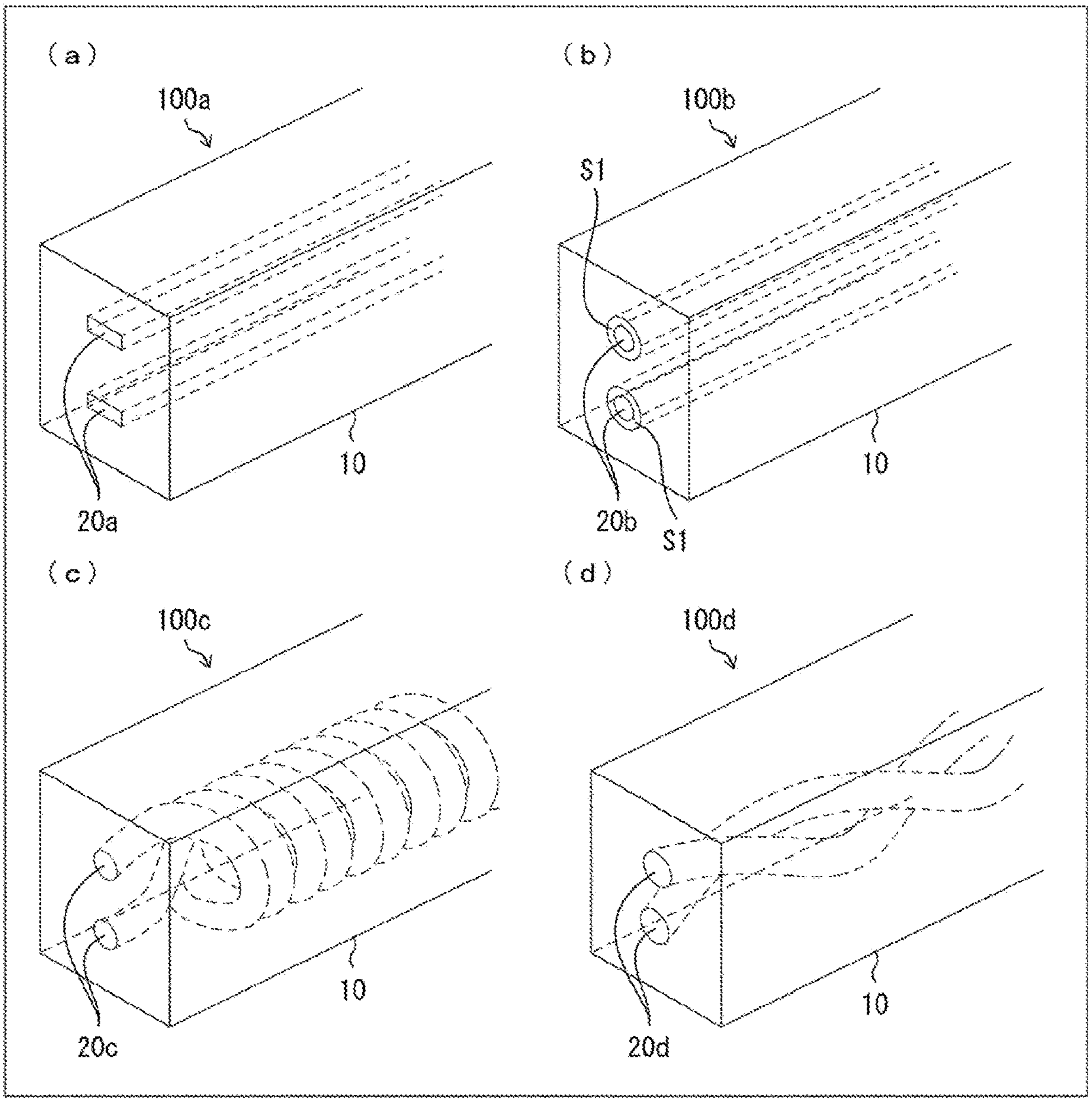


FIG. 1

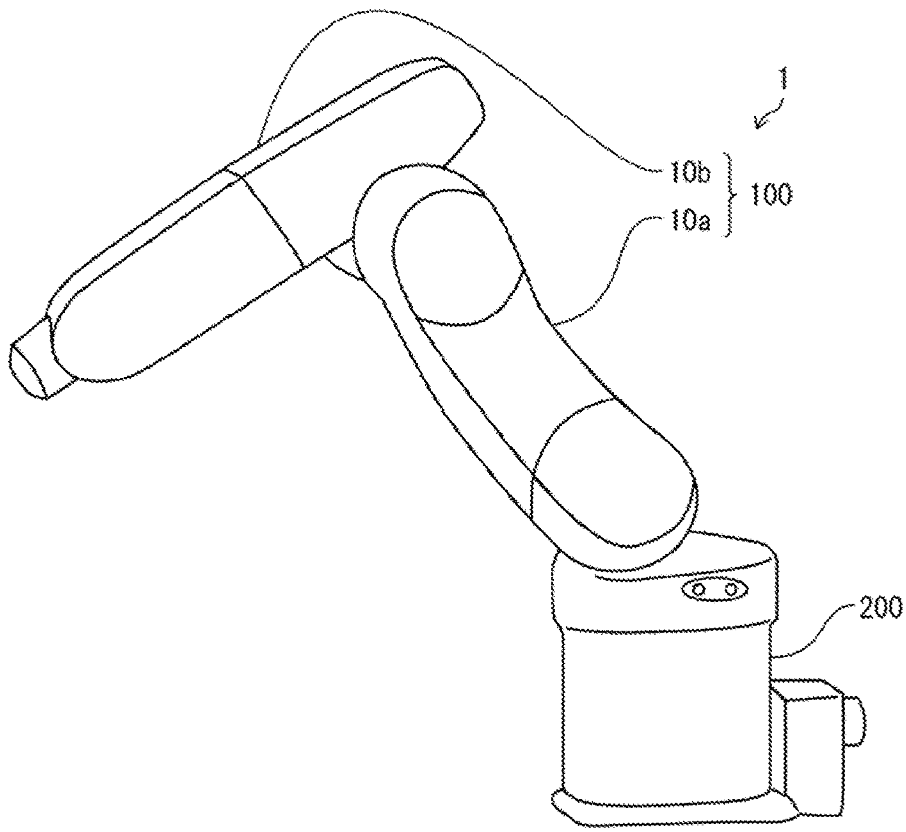


FIG. 2

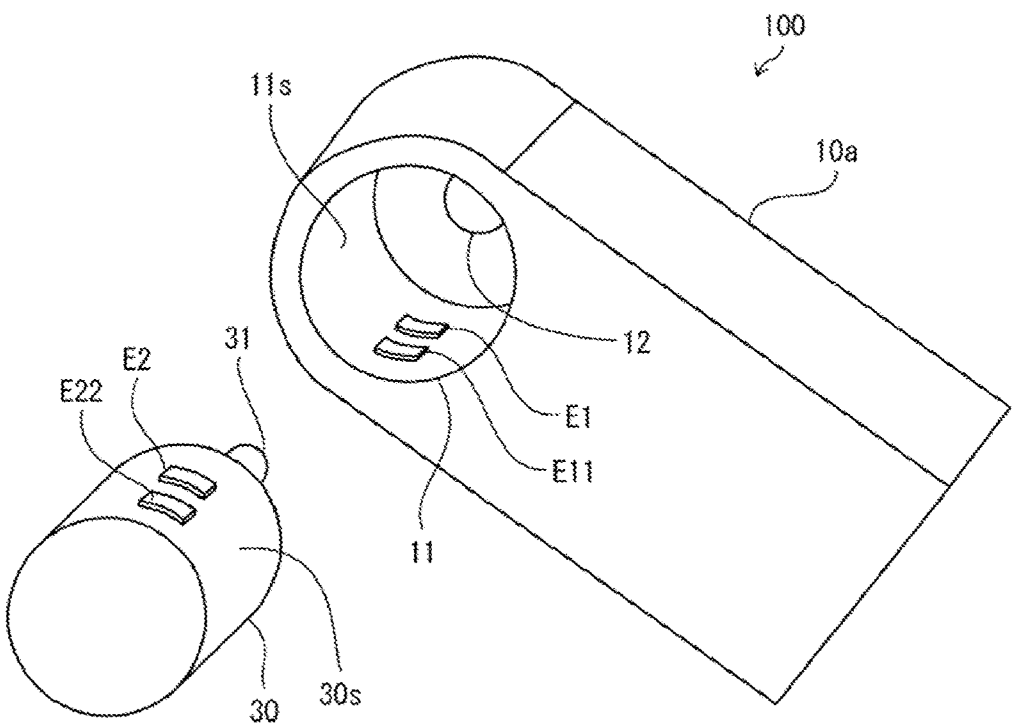


FIG. 3

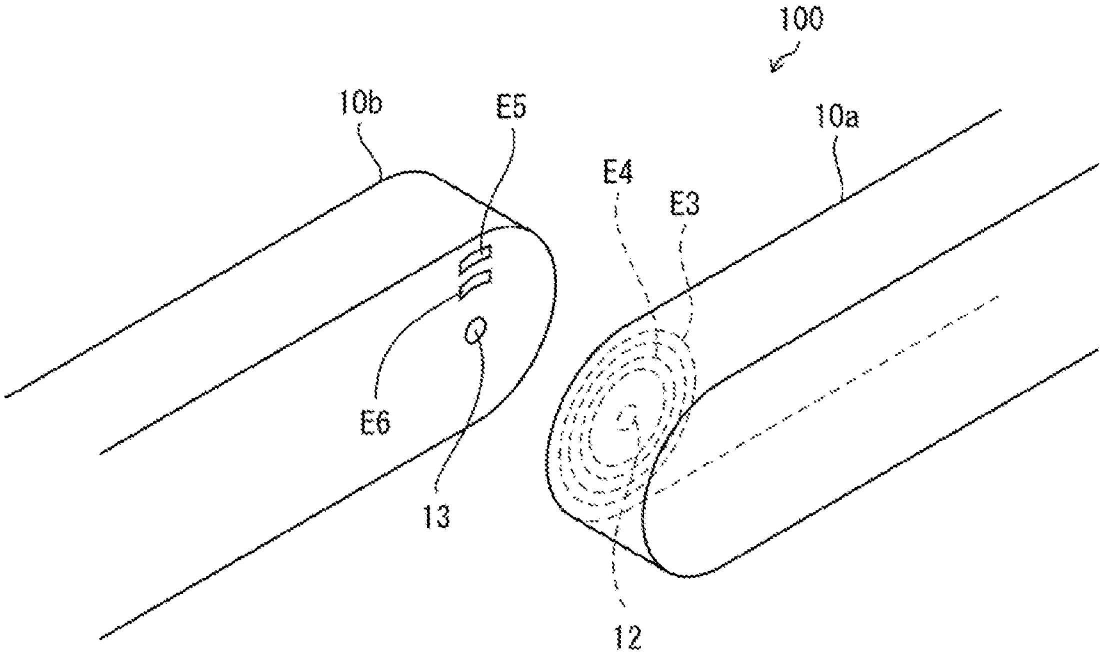

100
10b
E5
10a
E4
E3
E6
13
12

FIG. 4

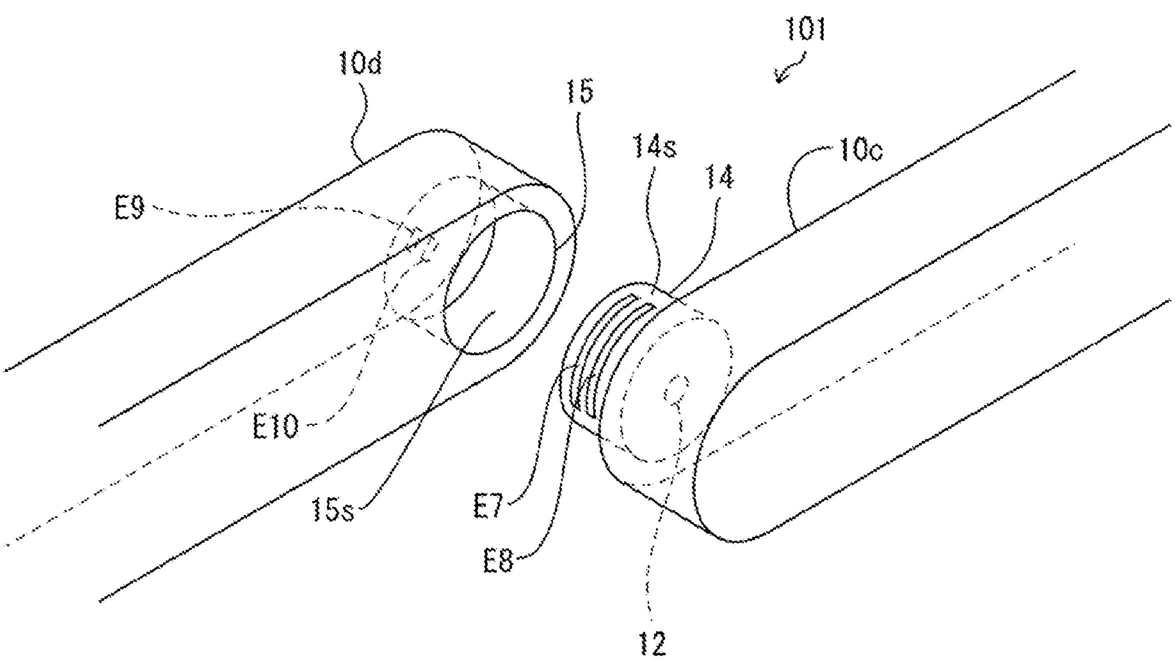

101
10d
15
14s
14
10c
E9
E10
15s
E7
E8
12

FIG. 5

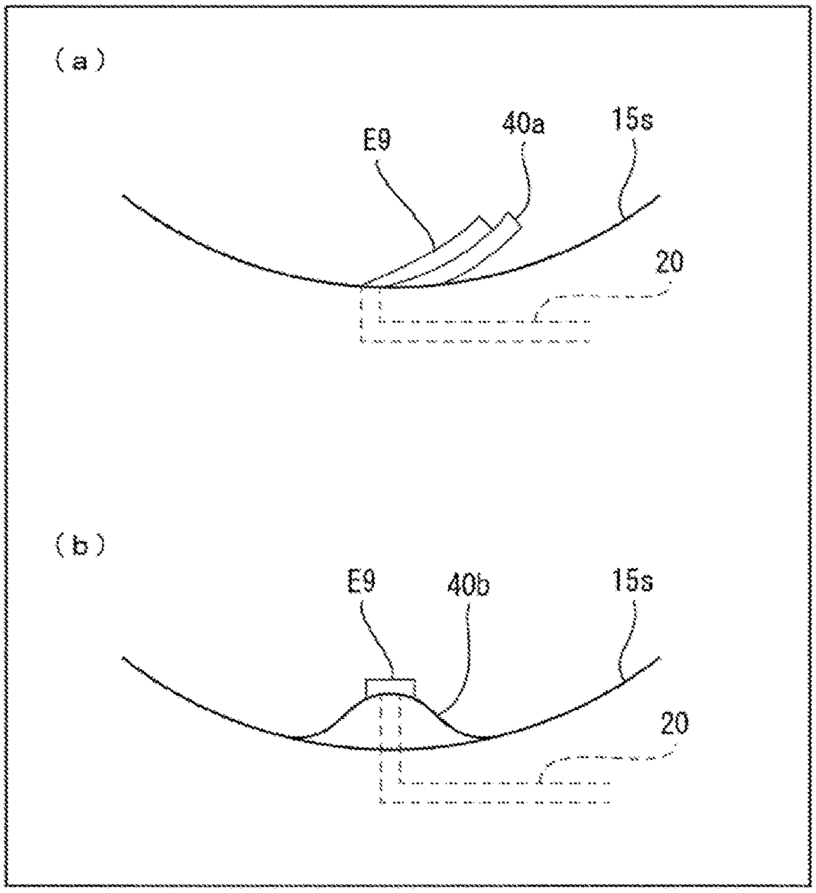


FIG. 6

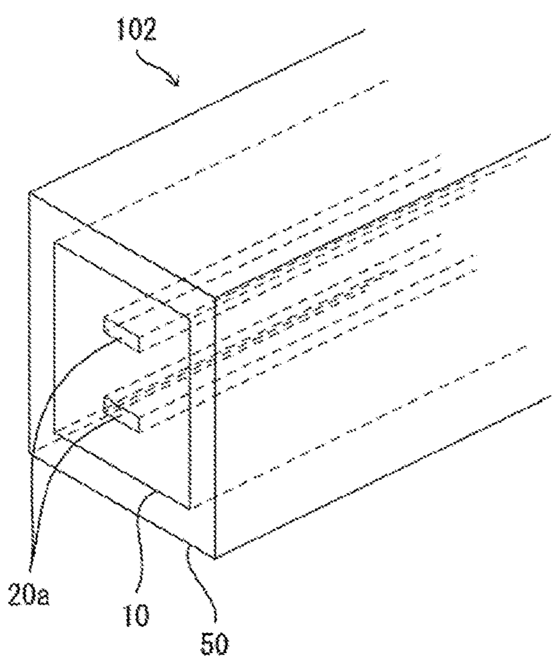


FIG. 7

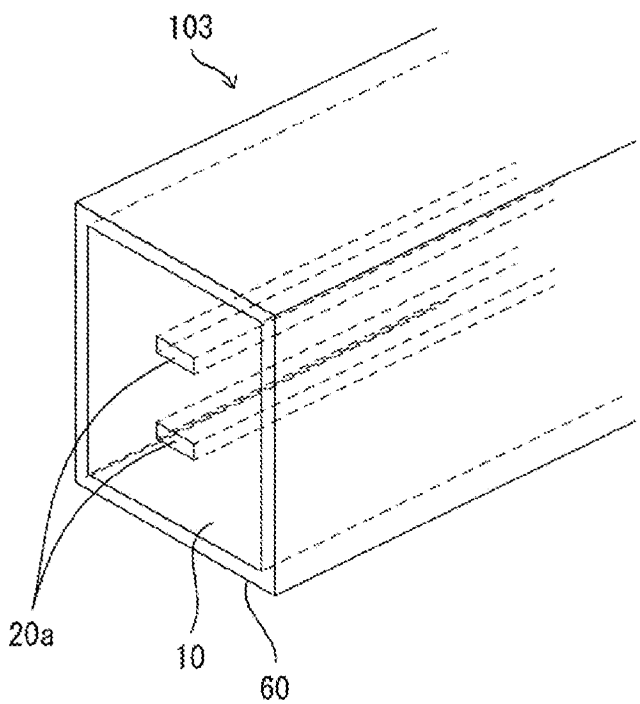


FIG. 8

ROBOT ARM AND ROBOT ARM MANUFACTURING METHOD

TECHNICAL FIELD

[0001] The present invention relates to a robot arm and a robot arm manufacturing method.

BACKGROUND ART

[0002] As a related art, a work robot including a robot arm configured with a plurality of arm members is known. For example, Patent Literature 1 discloses a work robot including a plurality of arm members sequentially provided from a proximal end side to a distal end side and joint shafts interposed between the arm members.

CITATION LIST

Patent Literature

[Patent Literature 1]

[0003] Japanese Patent Laid-Open No. 2009-113188 (published on May 28, 2009)

SUMMARY OF INVENTION

Technical Problem

[0004] However, in a case in which the work robot disclosed in Patent Literature 1 is manufactured, it is necessary to perform an operation of disposing wires in a space inside a robot arm and connecting the wires between an electrode provided in a motor or the like and an input electrode or the like from the outside of the robot arm. Also, since a space through which the wires pass is required in the robot arm, the robot arm increases in size.

[0005] Further, since the robot arm is driven by a motor, there is a problem that noise caused by the motor is emitted from the wires in the robot arm to the outside. In other words, although the wires in the robot arm require a measure against the noise, there is a problem that in a case in which a structure for a measure against the noise is employed, the wire structure becomes complicated.

[0006] The present invention was made in view of the aforementioned problem, and an objective thereof is to provide a robot arm that realizes assembly cost reduction, size reduction of the apparatus, and also a measure against noise and a manufacturing method thereof.

Solution to Problem

[0007] In order to solve the aforementioned problem, a robot arm according to an aspect of the present invention includes: an arm member configured with a resin to be solid; and at least two wires embedded in the resin configuring the arm member and configured with a conductive material, the two wires having a configuration in which (1) each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to a face of the flat shape, (2) a shield wire is provided around each wire, (3) each wire has a helical shape, or (4) the wires are twisted together.

[0008] In order to solve the aforementioned problem, a robot arm manufacturing method according to an aspect of the present invention is a robot arm manufacturing method of manufacturing a robot arm using a three-dimensional shaping apparatus configured to shape a three-dimensionally shaped article by stacking a shaping material, the method including: stacking the shaping material including a resin and a conductive material such that at least two wires configured with the conductive material are embedded in an arm member configured with the resin to be solid, the stacking being performed such that the two wires have a configuration in which (1) each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to a face of the flat shape, (2) a shield wire is provided around each wire, (3) each wire has a helical shape, or (4) the wires are twisted together.

Advantageous Effects of Invention

[0009] According to an aspect of the present invention, it is possible to provide a robot arm that realizes assembly cost reduction, a size reduction of the apparatus, and also a measure against noise and a manufacturing method thereof.

BRIEF DESCRIPTION OF DRAWINGS

[0010] (a) to (d) of FIG. **1** are perspective views illustrating an example of a wire structure of a robot arm according to an embodiment.

[0011] FIG. **2** is a diagram illustrating an example of a configuration of a robot according to the embodiment.

[0012] FIG. **3** is a diagram illustrating how an arm member and a drive unit are connected to each other in the robot arm.

[0013] FIG. **4** is a diagram illustrating how two arm members are connected to each other in the robot arm.

[0014] FIG. **5** is a diagram illustrating how two arm members are connected to each other in a robot arm according to a modification example of the robot arm illustrated in FIG. **4**.

[0015] (a) and (b) of FIG. **6** are sectional views illustrating a section perpendicular to a cylindrical face of a second arm member-side recessed portion in the robot arm illustrated in FIG. **5**.

[0016] FIG. **7** is a diagram illustrating a robot arm configured such that an arm member including the wire illustrated in (a) of FIG. **1** is fitted into a tubular metal member.

[0017] FIG. **8** is a diagram illustrating how surroundings of the arm member including the wire illustrated in (a) of FIG. **1** are covered with a shield wire.

DESCRIPTION OF EMBODIMENTS

Embodiment

[0018] An embodiment according to an aspect of the present invention (hereinafter, also referred to as the "present embodiment") will be described on the basis of the drawings. First, an example of a situation to which an aspect of the present invention is applied will be described. A robot arm according to an aspect of the present invention is shaped using a three-dimensional shaping apparatus such as a 3D printer (three-dimensional shaping machine). Specifically, the robot arm is manufactured by stacking a shaping material including an insulating material or a conductive material using the three-dimensional shaping apparatus. The three-dimensional shaping apparatus is an apparatus that shapes a three-dimensionally shaped article by stacking a shaping material.

[0019] An arm member **10**, first arm members **10***a* and **10***c*, second arm members **10***b* and **10***d*, wires **20** and **20***a* to **20***d*, a shield wire S**1**, arm-side electrodes E**1** and E**11**, first arm member-side electrodes E**3**, E**4**, E**7**, and E**8**, second arm-side electrodes E**5**, E**6**, E**9**, and E**10**, a projecting portion **14**, elastic portions **40***a* and **40***b*, and a shield wire **60**, which will be described later, are shaped by the three-dimensional shaping apparatus.

[0020] (Example of Configuration of Robot)

[0021] FIG. **2** is a diagram illustrating an example of a configuration of a robot **1** according to the present embodiment. The robot **1** includes a robot arm **100** and a main body portion **200** as illustrated in FIG. **2**. A wire structure inside the robot arm **100** may be any of wire structures inside robot arms **100***a* to **100***d* illustrated in (a) to (d) of FIG. **1**. The robot arm **100** includes a first arm member **10***a* and a second arm member **10***b*. The first arm member **10***a* and the second arm member **10***b* are rotatably connected to each other in a state in which at least a part of the first arm member **10***a* and at least a part of the second arm member **10***b* overlap each other. Also, although the robot arm **100** includes the two arm members, the robot arm **100** may include three or more arm members.

[0022] The first arm member **10***a* and the second arm member **10***b* have configurations similar to that of the arm member **10**, which will be described later. The second arm member **10***b* is connected to the main body portion **200**, and control equipment configured to control the robot **1** is provided inside the main body portion **200**.

[0023] (a) to (d) of FIG. **1** are perspective views illustrating an example of a wire structure of the robot arms **100***a* to **100***d* according to the present embodiment. Also, (a) to (d) of FIG. **1** illustrate sections of the robot arms **100***a* to **100***d* at predetermined positions.

[0024] (Example of Wire Structure of Robot Arm)

[0025] The robot arm **100***a* includes an arm member **10** and at least two wires **20***a* as illustrated in (a) of FIG. **1**. The at least two wires **20***a* are embedded in the arm member **10**. Each of the two wires **20***a* has a flat shape, and the two wires **20***a* are disposed in parallel with each other in a state in which the two wires **20***a* face each other in a direction perpendicular to the flat shape faces. Also, the two wires **20***a* may not be disposed in exactly parallel with each other to such an extent that electrostatic capacitance is generated therebetween.

[0026] The arm member **10** is an insulating material and is configured with a resin, for example, to be solid. Also, "configured to be solid" includes a configuration in which the wires **20***a* are embedded in the resin as a material for maintaining structural strength of the arm member **10**. For example, a shape recessed inward from the side face of the arm member **10** in (a) of FIG. **1** may be employed. Further, a shape obtained by the recessed shape extending up to a portion between the two wires **20***a* may also be employed. In this case, it is possible to provide an air layer between the two wires **20***a*. Also, although the sectional shape of the arm member **10** is a rectangular shape in (a) to (d) of FIG. **1**, the sectional shape may be a circular shape, an oval shape, or another shape, for example. In this manner, the sectional shape of the arm member **10** is not particularly limited.

[0027] The wires **20***a* are configured with a conductive material. The wires **20***a* are for transmitting power and signals to each component (such as a drive unit **30**, which will be described later) electrically connected to the wires **20***a* in the robot arm **100***a*. Details related to the wires **20***a* described here are also applicable to wires **20** and **20***b* to **20***d*, which will be described later.

[0028] Since the wires **20***a* are already embedded in the arm member **10** in this manner, it is possible to reduce the operation of connecting the wires **20***a* and to realize manufacturing cost reduction. Also, since it is not necessary to provide a coating film for covering the wires **20***a*, it is possible to reduce the robot arm **100***a* in size in accordance with the amount corresponding to the unnecessary coating film. In addition, since the wires **20***a* are embedded in the arm member **10**, it is possible to reduce a likelihood that the wires **20***a* are disconnected, and it is not necessary for wires to be disposed in a space inside the robot arm **100***a*. Further, since the conductive material is embedded in the resin configuring the arm member **10**, it is possible to improve a reinforcing effect of the arm member **10** with the conductive material.

[0029] Also, each of the two wires **20***a* has a flat shape, and the two wires **20***a* are disposed in parallel with each other in a state in which the two wires **20***a* face each other in a direction perpendicular to the flat shape faces. Therefore, it is possible to adjust the electrostatic capacitance between the two wires **20***a* by adjusting the distance between the two wires **20***a* and the width of the two wires **20***a*. It is possible to adjust the electrostatic capacitance between the two wires **20***a* in this manner and thereby to curb noise output from the wires **20***a* to the outside. Also, it is possible to curb influences of noise from the outside on a current flowing through the wires **20***a*. The width is a length in a direction that is perpendicular to a direction in which the wires **20***a* extend (the longitudinal direction of the wires **20***a*) and is parallel to the flat shape faces.

[0030] A robot arm **100***b* is different from the robot arm **100***a* in that the at least two wires **20***a* are changed to at least two wires **20***b* and that shield wires S**1** are provided around the two wires **20***b* as illustrated in (b) of FIG. **1**. The shield wires S**1** can curb noise output from the wires **20***b* to the outside by the shield wires S**1** being provided around the wires **20***b*. Also, it is possible to curb influences of noise from the outside on a current flowing through the wires **20***b*.

[0031] Also, a structure in which the at least two wires **20***b* are collectively covered with the shield wire S**1** may also be employed instead of the structure in which the shield wire S**1** is provided around each of the at least two wires **20***b*.

[0032] A robot arm **100***c* is different from the robot arm **100***a* in that the at least two wires **20***a* are changed to at least two wires **20***c* and each of the two wires **20***c* has a helical shape as illustrated in (c) of FIG. **1**. It is possible to curb noise output from the wire **20***c* to the outside and to curb influences of noise from the outside on a current flowing through the wires **20***c* by each of the two wires **20***c* having a helical shape. Also, it is possible to adjust inductance of the wires **20***c* by changing the number of windings of the helical wires **20***c*, thereby to further curb noise output from the wires **20***c* to the outside, and to further curb influences of noise from the outside on the current flowing through the wires **20***c*.

[0033] Although (c) of FIG. **1** illustrates the case in which the number of wires **20***c* is two, a configuration in which one wire **20***c* has a helical shape may be employed. Also, a configuration in which the two wires **20***c* have a helical shape at mutually different positions may also be employed.

[0034] A robot arm **100***d* is different from the robot arm **100***a* in that the at least two wires **20***a* are changed to at least two wires **20***d*, and the two wires **20***d* are twisted together as illustrated in (d) of FIG. **1**. It is possible to curb noise output from the wire **20***d* to the outside by the two wires **20***d* being twisted together. Also, it is possible to curb influences of noise from the outside on a current flowing through the wires **20***d*.

[0035] As described above, since a motor is used to drive the robot arm, for example, there may be a case in which noise generated by the motor is transmitted to the wires and is emitted from the wires to the outside. On the other hand, since the configurations of the wires **20***a* to **20***d* have structures capable of curbing noise emission to the outside, it is possible to provide the robot arms **100***a* to **100***d* curbing noise emission to the outside. Also, the electrostatic capacitance of the wires **20***a* and the inductance of the wires **20***c* have effects of storing energy such as magnetic fields or electric fields. In this manner, it is possible to achieve accumulation of regenerative power at the time of stopping the operations of the robot arms **100***a* to **100***d* and instantaneous emission of power running power at the time of accelerating the operations of the robot arms **100***a* to **100***d*.

[0036] (Example of Robot Arm Manufacturing Method)

[0037] The aforementioned robot arms **100***a* to **100***d* are shaped using the three-dimensional shaping apparatus. Specifically, a shaping material including a resin and a conductive material is stacked such that at least two wires configured with the conductive material are embedded in the arm member **10** configured with the resin to be solid (stacking process). The wires may be any of the wires **20***a* to **20***d*.

[0038] At the time of stacking the shaping material, the stacking is performed such that the two wires have the following configurations (1) to (4). (1) A configuration in which each of the two wires **20***a* has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to the flat shape face. (2) A configuration in which the shield wire S**1** is provided around each of the two wires **20***b*. (3) A configuration in which each of the two wires **20***c* has a helical shape. (4) A configuration in which the two wires **20***d* are twisted together.

[0039] (Example of Configuration of Robot Arm)

[0040] FIG. **3** is a diagram illustrating how the first arm member **10***a* and a drive unit **30** are connected to each other in the robot arm **100**. The robot arm **100** includes the drive unit **30** as illustrated in FIG. **3**. The drive unit **30** is fitted to the arm-side recessed portion **11** formed in a side face of the first arm member **10***a*. In other words, the drive unit **30** is attached to the first arm member **10***a*. The drive unit **30** drives and rotates the second arm member **10***b* connected to the first arm member **10***a*. Although the drive unit **30** may be, for example, a motor, the drive unit **30** is not particularly limited as long as the drive unit **30** can cause the second arm member **10***b* to rotate.

[0041] A cylindrical face **11***s* is formed in the arm-side recessed portion **11**. The cylindrical face **11***s* of the first arm member **10***a* is provided with arm-side electrodes E**1** and E**11**, and each of the arm-side electrodes E**1** and E**11** is integrated with the wire **20** embedded in the first arm member **10***a*. In other words, each of the arm-side electrodes E**1** and E**11** is continuously configured with the same material as that of the wires **20**. The structure of the wires **20** may be any of the structures of the wires **20***a* to **20***d* illustrated in (a) to (d) of FIG. **1**. A cylindrical face **30***s* of the drive unit **30** is provided with drive unit-side electrodes E**2** and E**22**. Also, the cylindrical face **11***s* of the first arm member **10***a* may be provided with three or more arm-side electrodes.

[0042] The arm-side electrodes E**1** and E**11** are electrically connected to the drive unit-side electrode E**2** and E**22**, respectively, by the drive unit **30** being fitted into the arm-side recessed portion **11**. In other words, the arm-side electrodes E**1** and E**11** are electrically connected to the drive unit-side electrodes E**2** and E**22** by the drive unit **30** being attached to the first arm member **10***a*.

[0043] Since the arm-side electrodes E**1** and E**11** are electrically connected to the drive unit-side electrodes E**2** and E**22** by the drive unit **30** being attached to the first arm member **10***a*, a connecting portion between the first arm member **10***a* and the drive unit **30** can have a simple structure. For example, a complicated structure as in a robot arm in the related art in which a plurality of wires is jumbled up from the drive unit to the control equipment due to wire connection between the arm-side electrodes and the drive unit-side electrodes is not achieved. Also, it is not necessary to provide wires to connect the arm-side electrodes E**1** and E**11** to the drive unit-side electrodes E**2** and E**22**. Therefore, it is possible to reduce the operation of connecting wires.

[0044] Also, a joint shaft **31** of the drive unit **30** passes through an opening **12** formed in a bottom face of the arm-side recessed portion **11** by the drive unit **30** being fitted into the arm-side recessed portion **11**. The joint shaft **31** passing through the opening **12** is connected to the second arm member **10***b*. The drive unit **30** drives and rotates the second arm member **10***b* by causing the joint shaft **31** to rotate. The joint shaft **31** is for mutually rotating the first arm member **10***a* and the second arm member **10***b*. In this manner, the robot arm **100** includes the joint shaft **31**.

[0045] FIG. **4** is a diagram illustrating how the first arm member **10***a* and the second arm member **10***b* are connected to each other in the robot arm **100**. In FIG. **4**, the arm-side recessed portion **11** and the drive unit **30** illustrated in FIG. **3** are omitted. The aforementioned joint shaft **31** is connected to the second arm member **10***b* by passing through the opening **12** and entering an opening **13** formed in a side face of the second arm member **10***b*.

[0046] Also, in the robot arm **100**, first arm member-side electrodes E**3** and E**4** are provided in a side face of the first arm member **10***a* perpendicular to the axial direction of the joint shaft **31**, and second arm member-side electrodes E**5** and E**6** are provided in a side face of the second arm member **10***b* perpendicular to the axial direction of the joint shaft **31**. In this manner, the structure in which the first arm member-side electrodes E**3** and E**4** and the second arm member-side electrodes E**5** and E**6** are caused to slide in a state in which conduction therebetween is maintained can be a simple structure. For example, a complicated structure as in the robot arm in the related art in which a plurality of wires is jumbled at the connecting portion between the first arm member and the second arm member due to wire connection between the first arm member-side electrode and the second arm member-side electrode is not achieved.

[0047] Also, although the first arm member **10***a* and the second arm member **10***b* are disposed relative to the joint shaft **31** in a manner in which the first arm member **10***a* and the second arm member partially overlapping each other in a direction perpendicular to the longitudinal direction of the first arm member **10***a* and the second arm member **10***b* in the configuration in the example illustrated in FIG. **4**, the present invention is not limited thereto. For example, a case in which the first arm member **10***a* and the second arm member **10***b* are disposed in an overlapping manner in the longitudinal direction of the first arm member **10***a* and the second arm member **10***b* will be considered. In this case, a configuration in which two projecting portions are formed in the first arm member **10***a*, a projecting portion formed in the second arm member **10***b* is sandwiched between the two projecting portions, and the joint shaft **31** is provided to penetrate through these projecting portions may be employed. Also, a configuration in which a plurality of projecting portions is formed in each of the first arm member **10***a* and the second arm member **10***b* and the joint shaft **31** is provided to penetrate through the plurality of projecting portions at portions at which the projecting portions are alternately meshed with each other may be employed.

[0048] Further, when the first arm member **10***a* and the second arm member **10***b* mutually rotate, the first arm member-side electrode E**3** slides in a state in which the first arm member-side electrode E**3** maintains conduction with the second arm member-side electrode E**5**, and the first arm member-side electrode E**4** slides in a state in which the first arm member-side electrode E**4** maintains conduction with the second arm member-side electrode E**6**. In addition, each of the first arm member-side electrodes E**3** and E**4** is integrated with the wire **20** embedded in the first arm member **10***a*, and each of the second arm member-side electrodes E**5** and E**6** is integrated with the wire **20** embedded in the second arm member **10***b*. In other words, each of the first arm member-side electrodes E**3** and E**4** is continuously configured with the same material as that of the wire **20** embedded in the first arm member **10***a*. Moreover, each of the second arm member-side electrodes E**5** and E**6** is continuously configured with the same material as that of the wire **20** embedded in the second arm member **10***b*.

[0049] In this manner, it is not necessary to provide a wire to connect the wire **20** embedded in the first arm member **10***a* to the wire **20** embedded in the second arm member **10***b*. Therefore, it is possible to reduce the operation of connecting wires and to reduce the likelihood that the wires are disconnected. Also, it is possible to maintain the conduction even when the first arm member **10***a* and the second arm member **10***b* mutually rotate. In this manner, it is possible to obtain the following effects as compared with a case in which a wire to connect the wire **20** embedded in the first arm member **10***a* to the wire **20** embedded in the second arm member **10***b* is provided.

[0050] Specifically, it is possible to prevent a movable range related to rotation of the joint shaft **31** between the first arm member **10***a* and the second arm member **10***b* from being limited and to prevent the apparatus from increasing in size by providing a margin for the length of the wire to allow rotation of the joint shaft **31**, for example.

[0051] Also, although the two first arm member-side electrodes E**3** and E**4** are provided in the side face of the first arm member **10***a* in FIG. **4**, three or more first arm member-side electrodes may be provided in the side face of the first arm member **10***a*. Also, although the two second arm member-side electrodes E**5** and E**6** are provided in the side face of the second arm member **10***b*, three or more second arm member-side electrode may be provided in the side face of the second arm member **10***b*.

[0052] Also, each of the first arm member-side electrodes E**3** and E**4** may be a slip ring, and each of the second arm member-side electrodes E**5** and E**6** may be a brush. On the contrary, each of the first arm member-side electrodes E**3** and E**4** may be a brush, and each of the second arm member-side electrodes E**5** and E**6** may be a slip ring.

[0053] In this manner, the connecting portion of the wires **20** between the first arm member **10***a* and the second arm member **10***b* can have a simple structure. For example, a complicated structure as in the robot arm in the related art in which a plurality of wires is jumbled at the connecting portion between the first arm member and the second arm member is not achieved.

[0054] In addition, since the brush and the slip ring are integrated with the wires **20** embedded in the first arm member **10***a* and the second arm member **10***b*, portions that slide in a state in which the brush and the slip ring maintain conduction can have a simple structure. For example, a complicated structure in which the brush, the slip ring, and the wires are separately provided is not achieved as compared with the robot arm in the related art.

[0055] FIG. **5** is a diagram illustrating how a first arm member **10***c* and a second arm member **10***d* are connected to each other in a robot arm **101** according to a modification example of the robot arm **100** illustrated in FIG. **4**. The robot arm **101** is different from the robot arm **100** in that the first arm member-side electrodes E**3** and E**4** are changed to the first arm member-side electrodes E**7** and E**8**, respectively, and the second arm member-side electrodes E**5** and E**6** are changed to the second arm member-side electrodes E**9** and E**10**, respectively, as illustrated in FIG. **5**. In addition, the robot arm **101** is different from the robot arm **100** in that a projecting portion **14** is provided in a side face of the first arm member **10***c* and a second arm member-side recessed portion **15** is formed in a side face of the second arm member **10***d*.

[0056] A cylindrical projecting portion **14** that is coaxial with the joint shaft **31** is provided in the side face of the first arm member **10***c*, and the second arm member-side recessed portion **15** is formed in the side face of the second arm member **10***d*. The projecting portion **14** is fitted into the second arm member-side recessed portion **15**.

[0057] Also, a joint shaft **31** (not illustrated) of a drive unit **30** passes through an opening **12** of the first arm member **10***c* and penetrates through the projecting portion **14**. The joint shaft **31** is connected to the second arm member **10***d*. In this manner, the second arm member-side recessed portion **15** slides with the projecting portion **14** in a state in which the projecting portion **14** is fitted into the second arm member-side recessed portion **15** by the drive unit **30** (not illustrated) provided in the first arm member **10***c* rotating the joint shaft **31**.

[0058] In the robot arm **101**, first arm member-side electrodes E**7** and E**8** are provided in a cylindrical face **14***s* of the projecting portion **14**, and second arm member-side electrodes E**9** and E**10** are provided in a cylindrical face **15***s* of the second arm member-side recessed portion **15**. In this manner, the connecting portion between the first arm member **10***c* and the second arm member **10***d* can have a simple structure. Also, the structure of causing each of the first arm member-side electrodes E**7** and E**8** and each of the second arm member-side electrodes E**9** and E**10** to slide in a state in which conduction therebetween is maintained can be a simple structure. For example, a complicated structure as in the robot arm in the related art in which a plurality of wires is jumbled at the connecting portion between the first arm member and the second arm member is not achieved.

[0059] Also, although the two first arm member-side electrodes E**7** and E**8** are provided in the cylindrical face **14***s* of the projecting portion **14** in FIG. **5**, three or more first arm member-side electrodes may be provided in the cylindrical face **14***s* of the projecting portion **14**. Also, although the two second arm member-side electrodes E**9** and E**10** are provided in the cylindrical face **15***s* of the second arm member-side recessed portion **15**, three or more second arm member-side electrodes may be provided in the cylindrical face **15***s* of the second arm member-side recessed portion **15**.

[0060] Also, each of the first arm member-side electrodes E**7** and E**8** may be a slip ring, and each of the second arm member-side electrodes E**9** and E**10** may be a brush. On the contrary, each of the first arm member-side electrodes E**7** and E**8** may be a brush, and each of the second arm member-side electrodes E**9** and E**10** may be a slip ring.

[0061] (a) and (b) of FIG. **6** are sectional views illustrating a section of the robot arm **101** illustrated in FIG. **5** perpendicular to the cylindrical face **15***s* of the second arm member-side recessed portion **15**. As illustrated in (a) and (b) of FIG. **6**, elastic portions **40***a* and **40***b* with elasticity are provided in the cylindrical face **15***s* (front face) of the second arm member-side recessed portion **15** in the robot arm **101**. The second arm member-side electrode E**9** is formed in the front faces of the elastic portions **40***a* and **40***b*. The second arm member-side electrode E**10** also has a structure in which the second arm member-side electrode E**10** is formed in the front faces of the elastic portions **40***a* and **40***b*. The second arm member-side electrodes E**9** and E**10** are conductive materials.

[0062] Also, the second arm member-side electrodes E**5** and E**6** of the robot arm **101** illustrated in FIG. **4** may have a structure in which the second arm member-side electrodes E**5** and E**6** are formed in the front faces of the elastic portions **40***a* and **40***b*. Further, even in a case in which the first arm member-side electrodes E**3**, E**4**, E**7**, and E**8** are brushes, a structure in which the first arm member-side electrodes E**3**, E**4**, E**7**, and E**8** are formed in the front faces of the elastic portions **40***a* and **40***b* may be employed. Therefore, the elastic portion **40***a* or the elastic portion **40***b* can cause the slip rings and the brushes to come into strong contact with each other, by the elastic portions **40***a* and **40***b* being provided on the front face of the first arm member **10***c* or the second arm member **10***d*.

[0063] As illustrated in (a) of FIG. **6**, the elastic portion **40***a* is inclined relative to the cylindrical face **15***s* of the second arm member-side recessed portion **15** and projects from the cylindrical face **15***s*. Also, the elastic portion **40***a* extends obliquely upward relative to the cylindrical face **15***s*. In addition, as illustrated in (b) of FIG. **6**, the elastic portion **40***b* has a mountain shape, and a space between the elastic portion **40***b* and the cylindrical face **15***s* serves as a moving space using elastic deformation. The wire **20** embedded in the second arm member **10***d* passes through the elastic portion **40***b* and is integrated with the second arm member-side electrode E**9**.

[0064] FIG. **7** is a diagram illustrating a robot arm **102** in which an arm member **10** including a wire **20***a* is fitted into a tubular metal member **50** as illustrated in (a) of FIG. **1**. The robot arm **102** includes a tubular metal member **50** as illustrated in FIG. **7**. The metal member **50** may be, for example, a metal pipe. In other words, the arm member **10** is provided with the metal member **50** as a reinforcing member made of metal.

[0065] In this manner, the robot arm **102** can have a stronger structure by the arm member **10** provided with the reinforcing member made of metal. Also, it is possible to relatively easily realize the configuration by fitting the arm member **10** made of a resin into the tubular metal member **50**.

[0066] Also, the aforementioned first arm members **10***a* and **10***c* and the second arm members **10***b* and **10***d* may be fitted into the metal member **50**. Also, the arm member **10** including the aforementioned at least two wires (any of the wires **20***b* to **20***d*) may be fitted into the metal member **50**.

[0067] FIG. **8** is a diagram illustrating how the surroundings of the arm member **10** including the wire **20***a* illustrated in (a) of FIG. **1** are covered with the shield wire **60**. The robot arm **103** includes the shield wire **60** as illustrated in FIG. **8**. The shield wire **60** covers the surroundings of the arm member **10**. In other words, the shield wire **60** is formed in the front face of the arm member **10**. It is thus possible to curb noise output from the wire **20***a* to the outside by the surroundings of the arm member **10** being covered with the shield wire **60**. Also, it is possible to curb influences of noise from the outside on a current flowing through the wire **20***a*.

[0068] The configuration illustrated in FIG. **8** is shaped by the three-dimensional shaping apparatus. Specifically, a shaping material including a resin and a conductive material is stacked such that the shield wire **60** configured with the conductive material is formed in the outer face of the arm member **10** configured with the resin to be solid.

[0069] Also, the surroundings of the aforementioned first arm members **10***a* and **10***c* and the second arm members **10***b* and **10***d* may be covered with the shield wire **60**. Also, the surrounding of the arm member **10** including the aforementioned at least two wires (any of the wires **20***b* to **20***d*) may be covered with the shield wire **60**.

CONCLUSION

[0070] A robot arm according to an aspect of the present invention includes: an arm member configured with a resin to be solid; and at least two wires embedded in the resin configuring the arm member and configured with a conductive material, the two wires having a configuration in which (1) each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to a face of the flat shape, (2) a shield wire is provided around each wire, (3) each wire has a helical shape, or (4) the wires are twisted together.

[0071] With the aforementioned configuration, since the wires are already embedded in the resin configuring the arm member, it is possible to reduce the operation of connecting the wires and to realize manufacturing cost reduction. Since the coating film covering the wires is not needed, it is possible to reduce the robot arm in size by the amount corresponding to the unnecessary coating film. Also, since the wires are embedded in the arm member, it is possible to reduce a likelihood that the wires are disconnected, and it is not necessary to provide a wire disposed in a space in the robot arm. Moreover, since the conductive material is embedded in the resin configuring the arm member, it is possible to improve an effect of reinforcing the arm member with the conductive material.

[0072] Also, since the motor is used for driving the robot arm, for example, there is a case in which noise generated by the motor is transmitted to the wires and is emitted from the wires to the outside. On the other hand, the aforementioned configurations (1) to (4) are structures capable of curbing emission of noise to the outside and curbing influences of noise from the outside on the current flowing through the wires. Therefore, it is possible to provide a robot arm curbing noise emission to the outside and influences of noise from the outside.

[0073] Two of the arm members may be referred to as a first arm member and a second arm member, and the first arm member and the second arm member may be rotatably connected to each other in a state in which at least a part of the first arm member and at least a part of the second arm member overlap each other, and a first arm member-side electrode that is integrated with the wire embedded in the first arm member may slide in a state in which the first arm member-side electrode is maintained to be conductive with a second arm member-side electrode that is integrated with the wire embedded in the second arm member when the first arm member and the second arm member mutually rotate.

[0074] With the aforementioned configuration, the first arm member-side electrode that is integrated with the wire embedded in the first arm member slides in a state in which the first arm member-side electrode maintains conduction with the second arm member-side electrode that is integrated with the wire embedded in the second arm member. Therefore, it is not necessary to provide a wire to connect the wire embedded in the first arm member to the wire embedded in the second arm member. It is thus possible to reduce the operation of connecting the wires and to reduce the likelihood that the wires are disconnected.

[0075] Also, it is possible to maintain conductivity even when the first arm member and the second arm member mutually rotate. In this manner, the following effects are obtained as compared with a case in which a wire to connect the wire embedded in the first arm member to the wire embedded in the second arm member is provided. Specifically, it is possible to prevent a movable range related to rotation of the joint shaft between the first arm member and the second arm member from being limited and to prevent the apparatus from increasing in size by providing a margin for the length of the wire to allow rotation of the joint shaft, for example.

[0076] One of the first arm member-side electrode and the second arm member-side electrode may be a slip ring, and the other one of the first arm member-side electrode and the second arm member-side electrode may be a brush.

[0077] With the aforementioned configuration, the connecting portion of the wires between the two arm members can have a simple structure. Also, since the brush and the slip ring are integrated with the wires embedded in the two arm members, the portions sliding in a state in which the brush and the slip ring maintain conductivity can have a simple structure.

[0078] The robot arm may further include: a drive unit attached to the first arm member and configured to drive and rotate the second arm member, and an arm-side electrode that is provided in the first arm member and is integrated with the wire embedded in the first arm member may be electrically connected to a drive unit-side electrode provided in the drive unit by the drive unit being attached to the first arm member. Although the drive unit may be, for example, a motor, the drive unit is not particularly limited as long as the drive unit can cause the second arm member to rotate.

[0079] With the aforementioned configuration, since the arm-side electrode and the drive unit-side electrode are electrically connected to each other by the drive unit being attached to the first arm member, the connecting portion between the first arm member and the drive unit can have a simple structure. Also, it is not necessary to provide a wire to connect the arm-side electrode to the drive unit-side electrode. Therefore, it is possible to reduce the operation of connecting the wires.

[0080] The robot arm may include: a joint shaft causing the first arm member and the second arm member to mutually rotate, and the first arm member-side electrode may be provided in a side face of the first arm member perpendicular to an axial direction of the joint shaft, and the second arm member-side electrode is provided in a side face of the second arm member perpendicular to the axial direction of the joint shaft. With the aforementioned configuration, a structure of causing the first arm member-side electrode and the second arm member-side electrode to slide in a state in which conduction is maintained therebetween can be a simple structure.

[0081] The robot arm may include: a joint shaft causing the first arm member and the second arm member to mutually rotate, a projecting portion with a cylindrical shape that is coaxial with the joint shaft may be provided in a side face of the first arm member, and a second arm member-side recessed portion configured to slide along the projecting portion may be formed in a side face of the second arm member, and the first arm member-side electrode may be provided in a cylindrical face of the projecting portion, and the second arm member-side electrode may be provided in a cylindrical face of the second arm member-side recessed portion.

[0082] With the aforementioned configuration, the connecting portion between the first arm member and the second arm member can have a simple structure. Also, the structure of causing the first arm member-side electrode and the second arm member-side electrode to slide in a state in which conduction is maintained therebetween can have a simple structure.

[0083] The robot arm according to claim **3**, in which the brush is a conductive material formed in a face of an elastic portion with elasticity provided in a face of the first arm member or the second arm member. With the aforementioned configuration, the elastic portion can cause the slip ring and the brush to come into strong contact with each other.

[0084] The arm member may be provided with a reinforcing member made of metal. According to the aforementioned configuration, since the arm member is provided with the reinforcing member made of metal, the robot arm can have a stronger structure. Also, it is possible to relatively easy realize the configuration by fitting the arm member made of a resin into a tubular metal member, for example.

[0085] A robot arm manufacturing method according to an aspect of the present invention is a robot arm manufacturing method of manufacturing a robot arm using a three-dimensional shaping apparatus configured to shape a three-dimensionally shaped article by stacking a shaping material, the method including: stacking the shaping material including a resin and a conductive material such that at least two wires configured with the conductive material are embedded in an arm member configured with the resin to be solid, the stacking being performed such that the two wires have a configuration in which (1) each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to a face of the flat shape, (2) a shield wire is provided around each wire, (3) each wire has a helical shape, or (4) the wires are twisted together.

[0086] With the aforementioned configuration, the aforementioned configurations (1) to (4) are structures capable of curbing emission of noise to the outside and influences of noise from the outside on the current flowing through the wires. Therefore, it is possible to provide a robot arm curbing noise emission to the outside and influences of noise from the outside.

[0087] In the robot arm manufacturing method, the stacking includes forming two arm members which are a first arm member and a second arm member, the method further includes attaching a drive unit configured to drive and rotate the second arm member to the first arm member, and the attaching of the drive unit to the first arm member is performed such that an arm-side electrode that is provided in the first arm member and is integrated with the wire embedded in the first arm member is electrically connected to a drive unit-side electrode provided in the drive unit.

[0088] With the aforementioned configuration, it is possible to easily attach the drive unit to the first arm member without performing soldering, for example, by attaching the drive unit to the first arm member such that the arm-side electrode is electrically connected to the drive unit-side electrode.

[0089] The present invention is not limited to each of the aforementioned embodiments, various modifications can be made within the scope defined by the claims, and embodiments obtained by appropriately combining technical means disclosed in different embodiments are also included within the technical scope of the present invention.

REFERENCE SIGNS LIST

[0090] **10** Arm member

[0091] **10***a*, **10***c* First arm member

[0092] **10***b*, **10***d* Second arm member

[0093] **14***s*, **15***s* Cylindrical face

[0094] **14** Projecting portion

[0095] **15** Second arm member-side recessed portion

[0096] **20**, **20***a*, **20***b*, **20***c*, **20***d* Wire

[0097] **30** Drive unit

[0098] **31** Joint shaft

[0099] **40***a*, **40***b* Elastic portion

[0100] **100**, **100***a*, **100***b*, **100***c*, **100***d*, **101**, **102** Robot arm

[0101] E**1**, E**11** Arm-side electrode

[0102] E**2**, E**22** Drive unit-side electrode

[0103] E**3**, E**4**, E**7**, E**8** First arm member-side electrode

[0104] E**5**, E**6**, E**9**, E**10** Second arm member-side electrode

[0105] S**1** Shield wire

1. A robot arm comprising:

an arm member configured with a resin to be solid; and

at least two wires embedded in the resin configuring the arm member and configured with a conductive material,

wherein the two wires have a configuration in which

(1) each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to a face of the flat shape,

(2) a shield wire is provided around each wire,

(3) each wire has a helical shape, or

(4) the wires are twisted together.

2. The robot arm according to claim **1**,

wherein two of the arm members are referred to as a first arm member and a second arm member, and

the first arm member and the second arm member are rotatably connected to each other in a state in which at least a part of the first arm member and at least a part of the second arm member overlap each other, and

a first arm member-side electrode that is integrated with the wire embedded in the first arm member slides in a state in which the first arm member-side electrode is maintained to be conductive with a second arm member-side electrode that is integrated with the wire embedded in the second arm member when the first arm member and the second arm member mutually rotate.

3. The robot arm according to claim **2**, wherein one of the first arm member-side electrode and the second arm member-side electrode is a slip ring, and the other one of the first arm member-side electrode and the second arm member-side electrode is a brush.

4. The robot arm according to claim **2**, further comprising:

a drive unit attached to the first arm member and configured to drive and rotate the second arm member,

wherein an arm-side electrode that is provided in the first arm member and is integrated with the wire embedded in the first arm member is electrically connected to a drive unit-side electrode provided in the drive unit by the drive unit being attached to the first arm member.

5. The robot arm according to claim **2**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein the first arm member-side electrode is provided in a side face of the first arm member perpendicular to an axial direction of the joint shaft, and the second arm member-side electrode is provided in a side face of the second arm member perpendicular to the axial direction of the joint shaft.

6. The robot arm according to claim **2**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein a projecting portion with a cylindrical shape that is coaxial with the joint shaft is provided in a side face of the first arm member, and a second arm member-side recessed portion configured to slide along the projecting portion is formed in a side face of the second arm member, and

the first arm member-side electrode is provided in a cylindrical face of the projecting portion, and the second arm member-side electrode is provided in a cylindrical face of the second arm member-side recessed portion.

7. The robot arm according to claim **3**, wherein the brush is a conductive material formed in a face of an elastic portion with elasticity provided in a face of the first arm member or the second arm member.

8. The robot arm according to claim **1**, wherein the arm member is provided with a reinforcing member made of metal.

9. A robot arm manufacturing method of manufacturing a robot arm using a three-dimensional shaping apparatus configured to shape a three-dimensionally shaped article by stacking a shaping material, the method comprising:

stacking the shaping material including a resin and a conductive material such that at least two wires configured with the conductive material are embedded in an arm member configured with the resin to be solid,

wherein the stacking is performed such that the two wires have a configuration in which

(1) each wire has a flat shape and the wires are disposed in parallel in a state of facing each other in a direction perpendicular to a face of the flat shape,

(2) a shield wire is provided around each wire,

(3) each wire has a helical shape, or

(4) the wires are twisted together.

10. The robot arm manufacturing method according to claim **9**,

wherein the stacking includes forming two arm members which are a first arm member and a second arm member,

the method further comprises attaching a drive unit configured to drive and rotate the second arm member to the first arm member, and

the attaching of the drive unit to the first arm member is performed such that

an arm-side electrode that is provided in the first arm member and is integrated with the wire embedded in the first arm member is electrically connected to a drive unit-side electrode provided in the drive unit.

11. The robot arm according to claim **3**, further comprising:

a drive unit attached to the first arm member and configured to drive and rotate the second arm member,

wherein an arm-side electrode that is provided in the first arm member and is integrated with the wire embedded in the first arm member is electrically connected to a drive unit-side electrode provided in the drive unit by the drive unit being attached to the first arm member.

12. The robot arm according to claim **3**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein the first arm member-side electrode is provided in a side face of the first arm member perpendicular to an axial direction of the joint shaft, and the second arm member-side electrode is provided in a side face of the second arm member perpendicular to the axial direction of the joint shaft.

13. The robot arm according to claim **3**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein a projecting portion with a cylindrical shape that is coaxial with the joint shaft is provided in a side face of the first arm member, and a second arm member-side recessed portion configured to slide along the projecting portion is formed in a side face of the second arm member, and

the first arm member-side electrode is provided in a cylindrical face of the projecting portion, and the second arm member-side electrode is provided in a cylindrical face of the second arm member-side recessed portion.

14. The robot arm according to claim **4**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein the first arm member-side electrode is provided in a side face of the first arm member perpendicular to an axial direction of the joint shaft, and the second arm member-side electrode is provided in a side face of the second arm member perpendicular to the axial direction of the joint shaft.

15. The robot arm according to claim **4**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein a projecting portion with a cylindrical shape that is coaxial with the joint shaft is provided in a side face of the first arm member, and a second arm member-side recessed portion configured to slide along the projecting portion is formed in a side face of the second arm member, and

the first arm member-side electrode is provided in a cylindrical face of the projecting portion, and the second arm member-side electrode is provided in a cylindrical face of the second arm member-side recessed portion.

16. The robot arm according to claim **11**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein the first arm member-side electrode is provided in a side face of the first arm member perpendicular to an axial direction of the joint shaft, and the second arm member-side electrode is provided in a side face of the second arm member perpendicular to the axial direction of the joint shaft.

17. The robot arm according to claim **11**, comprising:

a joint shaft causing the first arm member and the second arm member to mutually rotate,

wherein a projecting portion with a cylindrical shape that is coaxial with the joint shaft is provided in a side face of the first arm member, and a second arm member-side recessed portion configured to slide along the projecting portion is formed in a side face of the second arm member, and

the first arm member-side electrode is provided in a cylindrical face of the projecting portion, and the second arm member-side electrode is provided in a cylindrical face of the second arm member-side recessed portion.

* * * * *