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(54) Title: DUAL ARM ROBOT

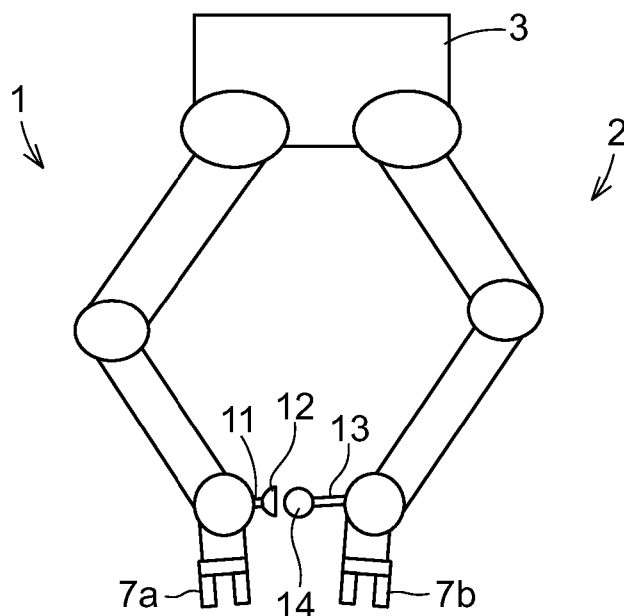


Fig. 1

(57) Abstract: The invention relates to an industrial robot having two arms (1, 2). According to the invention at least one of the arms includes abutment means (11, 12) arranged to abut the other arm.



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DUAL ARM ROBOT

5 *Field of invention*

The present invention in a first aspect relates to an industrial robot having two arms and in a second aspect to a method for operating such a robot.

Background of invention

10 A dual arm robot is useful for assembly operation. To perform an assembly operation it is often necessary to apply a process force, so that the parts to be assembled snap into place. Assembly with a dual arm robot can be done in two different ways. The first type is when one robot arm carries the assembly and the other arm carries the component to be assembled. The second type is when a
15 robot arm holds either the assembly or the component to be assembled and the other part is located in a stationary fixture, typically on the assembly table.

For both types of operation the maximum force that can be exerted by one arm limits what can be performed and the accuracy that can be obtained.

Examples of how the two arms of a dual arm robot co-operate can be
20 found in JP 2003159683, JP 8185 218, US 4260 941, US 4826 392, DE 3932013, Dauchez P. et al; Task modelling and force control for a two-arm robot, Proceedings of the 1991 IEEE International Conference on Robotics and Automation, Bonitz, R.G. et. al; Robust Dual-arm Manipulation of Rigid Objects via Palm Grasping-Theory and Experiments, Proceedings of the 1996 IEEE Conference on
25 Robotics and Automation, Jazidiec, A et. al; Multi-Point Compliance Control of Dual-Arm Robots, Proceedings of the 1992 IEEE/RSJ International Conference on Intelligent Robots and Systems, Meghadari; The Cooperative Dual-arm Cam-lock manipulators, Robotics and Automation, 1994. Proceedings of the 1994 IEEE
30 International Conference, Kosuge, K et al; Unified Control for Dynamic Cooperative Manipulation, Proceedings of the IEEE/RSJ/GI International Conference on Munich, Germany 12-16 September and Osumi, H. et al; Cooperative Control between two Position-controlled Manipulators, Proceedings of the 1994 IEEE International Conference on San Diego, USA 8-13 May 1994.

None of the prior art documents, however discloses a satisfactory solution how to in a simple way increase the available force and/or increase the relative accuracy between the arms.

The object of the present invention is to extend the operation possibilities
5 with a dual arm robot.

Summary of invention

The object of the invention is in the first aspect met in that a robot of the kind initially specified includes the specific feature that at least a first of the robot
10 arms includes a first abutment means arranged to abut the other arm.

Since the two arms in that way are pre-arranged to co-operate by abutting each other, the stability and the effective force will be increased.

When the robot operates according to the first type of operation mentioned above the maximum process force can be increased since the arms support each
15 other. More important, however is that the accuracy will increase. The only accuracy relevant to this type of assembly process is the relative accuracy between the two arms. If the two arms abut each other the relative accuracy is related to the free arm length. By the support from the abutment means the free arm length is substantially reduced which leads to the increased accuracy.

20 In case of operation according to the second type mentioned above, one of the arms holds the work piece and is capable to manipulate the work piece with a certain maximum force. When this arm is supported by the contact with the other arm, the contact force from the latter via the abutment means increases the maximum force to be the sum of the maximum force from each arm. Normally this
25 represents doubling the possible maximum force. Due to the support there will also be an increase in stability which increases the precision.

According to a preferred embodiment the second arm includes a second abutment means arranged to abut the first abutment means of the first arm.

By providing an abutment means also at the second arm, the position of
30 the contact between the two arms becomes well defined and the precision of the operation when one arm supports the other will be increased.

According to a further preferred embodiment each arm includes at least, six axes, preferably at least seven axes and a corresponding number of joints, and

the abutment means of each arm are located on joints which joints are located so that in total three joints can move after the abutment means.

The three joints can all be on one of the arms, or there can be one joint on one of the arms and two on the other one.

5 Thereby the arms support each other as close to the robot tool as possible which optimizes the force transfer from one arm to the other and results in high stability. When the robot operates according to the first type of operation the distance from the supporting area to the tools is short resulting in high accuracy.

 According to a further preferred embodiment each abutment means
10 includes two oppositely directed abutment surfaces.

This arrangement allows a freedom to use either of the arms as support for the other when operating according to the second type of operation and a greater freedom regarding the direction of the operating force.

 According to a further preferred embodiment each abutment surface is
15 planar.

This embodiment has manufacturing advantages since it is easy to provide such planar surfaces. It makes also the programming of the robot simple. The contact force will be easy to distribute over a large area and the force direction becomes distinctly defined.

20 Preferably each abutment surface is formed by a coating applied on a part of the arm.

The abutment surfaces thereby can be made of a material that is harder than the material of the robot arm and better withstand the contact forces.

 According to a further preferred embodiment each of the first and second
25 abutment means includes a non-planar surface, which two non-planar surfaces match each other in a male/female-relationship.

Such abutment surfaces might be more complicated to manufacture than planar surfaces but this embodiment has the advantage that the direction of the force transferred from one arm to the other can be varied. This embodiment is
30 particular valuable when operating according to the first type of operation since the matching surfaces contributes to increase the relative accuracy between the arms.

 According to a further preferred embodiment the non-planar surfaces are spherical surfaces.

With spherical surfaces the freedom to vary the direction of the supporting force will be comparatively high, and the force can easily be distributed on a relatively large area.

According to a further preferred embodiment the abutment means of at
5 least one of the arms is arranged on a projecting part, projecting from the arm.

Thereby the arms can support each other without the need to have them close to each other. This reduces the risk for interference between the arms and widens the possibility how to perform the force transmission between the arms.

When operating according to the first type of operation, the orientation of
10 the projection can be adapted such that it optimizes the accuracy. For achieving this it is normally preferred that both abutment means are arranged on a respective projection.

In the embodiment where there are non-planar abutment surfaces that match each other it is preferred that each arm has a male and a female abutment
15 surface. This offers two different possibilities for the cooperation according to the first type of operation. This is particularly preferred when the non-planar surfaces are arranged on projections.

Preferably, each abutment means include both planar abutment surfaces arranged to co-operate and non-planar abutment surfaces arranged to co-operate.
20 Since the non-planar surfaces are best suited for the mentioned first type of operation and the planar surfaces in many cases are best suited for the mentioned second type of operation, the robot thereby will be flexible and adapted to perform both kind of operation with optimized result.

According to a further preferred embodiment the robot is arranged to
25 operate in either of two modes, namely a collaborative mode, in which the two arms jointly operate on one work-piece, and a precision assembly mode, in which the two arms operate on separate work-pieces.

The robot thereby can be easily adapted to operate with the aid of the abutment means in case an increased force is required and to operate indepen-
30 dently with the two arms in case that is required. Thereby the robot will be well suited to perform either of the two types of operation.

According to a further preferred embodiment the robot includes soft-ware arranged to select one of said modes in response to a command and which soft-

ware includes operation instructions depending on which mode that has been selected.

This embodiment contributes to further simplify operation in either of the two modes.

5 According to a further preferred embodiment the soft-ware in the collaborative mode includes instruction to one of the arms to abut the other arm, instruction to define one of the arms to be a master arm and the other arm to be a slave arm, instruction to the master arm to perform a certain operation and instruction to the slave arm to follow the master arm.

10 By arranging the software to provide these instructions the collaborative mode operation will be effectively executed.

 According to a further preferred embodiment the soft-ware in the precision assembly mode includes a first set of instructions for the third arm section of one of the arms and a second set of instructions for the third section of the other arm.

15 By arranging the soft-ware to provide such instructions, the precision assembly mode operation will be efficiently executed with a high degree of accuracy.

 The above preferred embodiments of the invented industrial robot are specified in the claims depending on claim 1.

20 In the second aspect of the invention the object is met in that a method for operating an industrial robot having two arms includes the specific measures that the arms are brought in physical contact with each other such that a contact force is established between the arms and in that the robot is operated with the two arms in contact with each other.

25 According to a preferred embodiment of the invented method, the method is performed on a robot of the kind where each arm includes at least six axes preferably at least at least seven axes and a corresponding number of joints, and the abutment means of each arm are located on joints, which are located so that in total three joints can move after the abutment means.

30 The three joints can all be on one of the arms, or there can be one joint on one of the arms and two on the other one.

 According to a further preferred embodiment of the invented method, the robot is arranged to work on either of two modes, a collaborative mode, in which the two arms jointly operate on one work-piece, and a precision assembly mode,

in which the two arms operate on separate work-pieces, whereby the mode is selected before the robot starts to operate.

According to further preferred embodiments the method is performed with a robot according to the present invention, and in particular to any of the preferred
5 embodiments thereof.

The invented method and the preferred embodiments thereof have corresponding advantages as those of the invented robot and the preferred embodiments thereof and which have been described above.

It is to be noted that further preferred embodiments of course can be
10 realised by any possible combination of preferred embodiments mentioned above.

The invention will be further explained by the following detailed description of examples thereof and with reference to the accompanying drawings.

Brief description of the drawing

15 Fig. 1 is a schematic illustration of a first example of a robot according to the invention.

Fig. 2 is a schematic illustration of a second example of a robot according to the invention.

Fig. 3 is a perspective view of a third example of the invention.

20 Fig. 4 in a perspective view illustrates a detail of fig. 3.

Fig. 5 illustrates a further example of a robot according to the invention.

Detailed description of examples of the invention

Fig. 1 schematically illustrates a dual arm industrial robot for assembly
25 operation and having a first robot arm 1 with a first tool having grip fingers 7a and a second robot arm 2 with a second tool having grip fingers 7b, which arms are connected to a robot base 3. Each arm has seven axes.

In a first mode of operation the fingers 7a of the first arm 1 carries the assembly, and the fingers 7b of the second arm 2 carries the component to be
30 assembled.

On an arm portion moving with the fourth axis of the first arm 1 is provided a first abutment means consisting of a projection 11, in the present example in the form of a short pin. At the outer end of the pin there is a socket 12 with a spherical concavity.

On an arm portion moving with the fifth axis of the second arm 2 is provided a second abutment means consisting of a projection 13, in the present example in the form of a pin. At the outer end of the pin there is a ball 14.

The radius of the ball 14 equals the radius of the spherical concavity of the socket 12, or might be somewhat smaller.

In operation the ball 14 and socket 12 are brought into engagement with each other forming a rigid support. When performing the precision assembling operation the length of the free arms from the support is short in comparison with the total arm length and the assembly can be made with very high stiffness and accuracy. Sufficient DOF:s are left for the interaction between the tools.

The arrangement illustrated in fig. 1 can also be used for assembly according to the mentioned second mode of operation, i.e. when one of the arms carries the component to be assembled and the other part is located in a stationary fixture.

Also when performing this mode of operation the ball 14 and socket 12 are brought into engagement with each other. Assume that the grip fingers 7a of the first arm 1 carries the component to be assembled and is arranged to press it into place in the leftward direction in the figure. The ball 14 on the second arm 2 presses against the socket 12 on the first arm 1 such that the force of the second arm 2 adds to the force of the first arm when pressing the component leftwards into its place. In this mode the robot thus can perform the operation with a force that is the sum of the individual arm forces.

Only one of the arms has to be programmed for performing the operation, whereas the other arm acts as a slave arm programmed to follow the master arm.

Figure 2 illustrates a second example of a robot according to the invention. The main structure of this robot is similar to that of the robot in fig. 1. The main difference is the arrangement of the abutment means. In this example the abutment means of the first arm 1 consists of a first planar surface 15 on a plate attached to one side of wrist joint 10a and a second planar surface 16 on a plate attached to the opposite side of the wrist joint 10a. The second arm 2 has correspondingly arranged planar surfaces 17, 18.

Although also the arrangement of the abutment means in this example can be used for either of the operation modes, it is mainly intended for the second operation mode. When the grip fingers 7a of the first arm 1 is to move the compo-

ment to be assembled into place in the leftward direction, the movement is supported by the second arm 2 as its abutment surface 17 pushes on the abutment surface 16 of the first arm. With an abutment surface on both sides of each wrist joint the support is obtained also if one or both wrist joints are in a position 180°
5 from what is illustrated.

It is, however, to be understood that it is possible to have only one abutment surface on each wrist joint. It can also suffice to have a dedicated abutment surface on only one of the wrist joints, although this leads to less accuracy.

The example illustrated in fig. 1 can be modified such that each wrist joint
10 has one projection with a socket and one projection with a ball.

In a further alternative example each wrist joint can have a ball and/or a socket and in addition a planar abutment surface of similar kind as those of fig. 2.

Fig. 3 illustrates an example where the abutment means on the first arm 1 includes one socket 12a and one ball 14a. Correspondingly the abutment means
15 of the second arm 2 has one socket 12b and one ball 14b.

In fig. 4 the socket 12a and the ball 14a of the abutment means of the first arm 1 is illustrated in an enlarged scale.

Fig. 5 illustrates an example of the invention where the operation mode can be selected in an easy way. By providing a signal I or II to the software 101 of
20 the robot 100 the robot is programmed to work according to a precision assembly mode, i.e. the first mentioned mode of operation or according to a collaborative mode, i.e. the second mentioned mode of operation.

The signal can be initiated by a physical button on the robot or its controller, or it can be initiated by a software button or a robot program command. In the
25 precision assembly mode I only the wrist axes of the respective arm are programmed. In the collaborative mode I I only one arm, the master arm is programmed and the other arm, the slave arm is arranged to follow the master arm.

CLAIMS

1. An industrial robot having two arms (1, 2), **characterized in** that at least a first of the arms includes a first abutment (11, 12, 15, 16) means arranged to abut
5 the second arm
2. An industrial robot according to claim 1 **characterized in** that a second of the arms includes a second abutment (13, 14, 17, 18) means arranged to abut the first abutment (11, 12, 15, 16) means of the first arm.
10
3. An industrial robot according to claim 2 **characterized in** that each arm (1, 2) includes at least seven axes and a corresponding number of joints, and in that the abutment means (11, 12, 13, 14, 15, 16, 17, 18) of each arm (1, 2) are located on joints which joints are located so that in total three joints can move after the
15 abutment means.
4. An industrial robot according to claim 3 **characterized in** that each abutment means (15, 16, 17, 18) includes two oppositely directed abutment surfaces (15, 16, 17, 18).
20
5. An industrial robot according to claim 4 **characterized in** that each abutment surface (15, 16, 17, 18) is planar.
6. An industrial robot according to claim 3 **characterized in** that each of the first (11, 12) and second (13, 14) abutment means includes a non-planar surface
25 (12, 14), which two non-planar surfaces (12, 14) match each other in a male/female-relationship.
7. An industrial robot according to claim 6 **characterized in** that the non-planar surfaces (12, 14) are spherical surfaces.
30
8. An industrial robot according to any of claims 1 - 7 **characterized in** that the abutment means (11, 12, 13, 14) of at least one of the arms is arranged on a projecting part (11, 13), projecting from the arm.

9. An industrial robot according to any of claims 1 - 8 **characterized in** that the robot is arranged to operate in either of two modes (I-II), namely a collaborative mode (II), in which the two arms (1, 2) jointly operate on one work-piece,
5 and a precision assembly mode (I), in which the two arms (1, 2) operate on separate pieces.

10. An industrial robot according to claim 9 **characterized in** that the robot includes soft-ware (101) arranged to select one of said modes (I-II) in response to
10 a command and which soft-ware includes operation instructions depending on which mode that has been selected.

11. An industrial robot according to claim 10 **characterized in** that the soft-ware (101) in the collaborative mode (II) includes instruction to one of the arms (1,
15 2) to abut the other arm (2, 1), instruction to define one of the arms (1, 2) to be a master arm and the other arm (2, 1) to be a slave arm, instruction to the master arm to perform a certain operation and instruction to the slave arm to follow the master arm.

20 12. An industrial robot according to claim 10 or 11 **characterized in** that the soft-ware in the precision assembly mode (I) includes a first set of instructions for the third arm section of one of the arms (1, 2) and a second set of instructions for the third arm section of the other (2, 1) arm.

25 13. A method for operating an industrial robot having two arms, **characterized in** that the arms are brought into physical contact with each other such that a contact force is established between the arms and in that the robot is operated with the two arms in contact with each other.

30 14. A method according to claim 13 **characterized in** that the method is performed on a robot of the kind where each arm includes at least seven axes and a corresponding number of joints, and in that the abutment means of each arm are located so that in total three joints can move after the abutment means.

15. A method according to claim 13 or 14 **characterized in** that the robot is arranged to work on either of two modes, namely a collaborative in which the two arms jointly operate on one work-piece, and an assembly mode, in which the two arms operate on separate work-pieces, and in that the mode is selected before the
5 robot starts to operate.

16. A method according to claim 13 **characterized in** that the method is performed with a robot according to any of claims 1 – 12.

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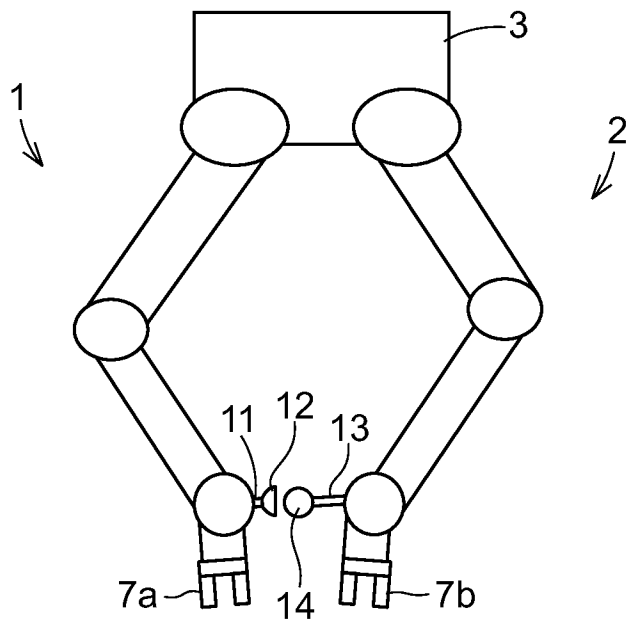


Fig. 1

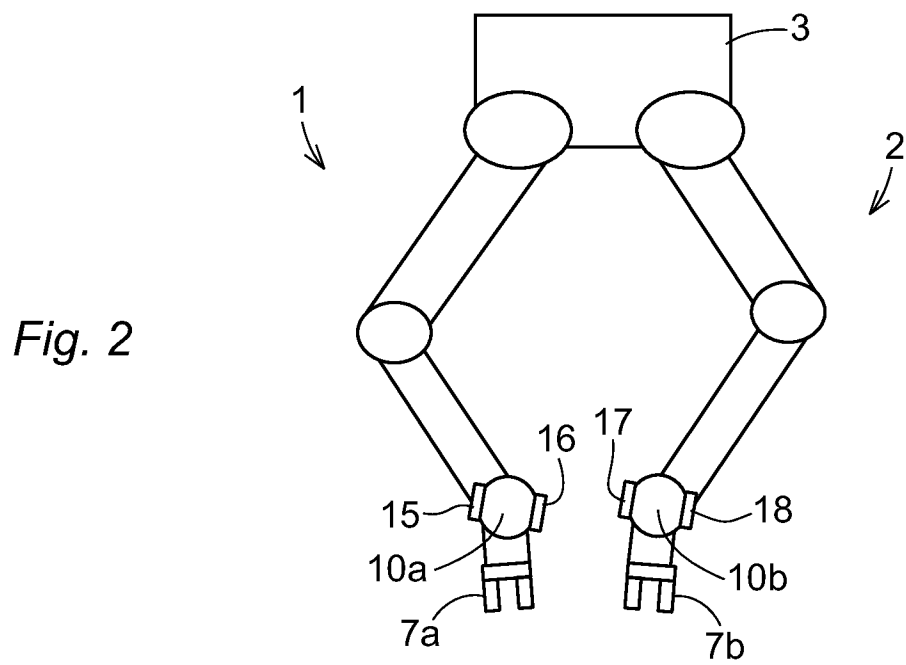


Fig. 2

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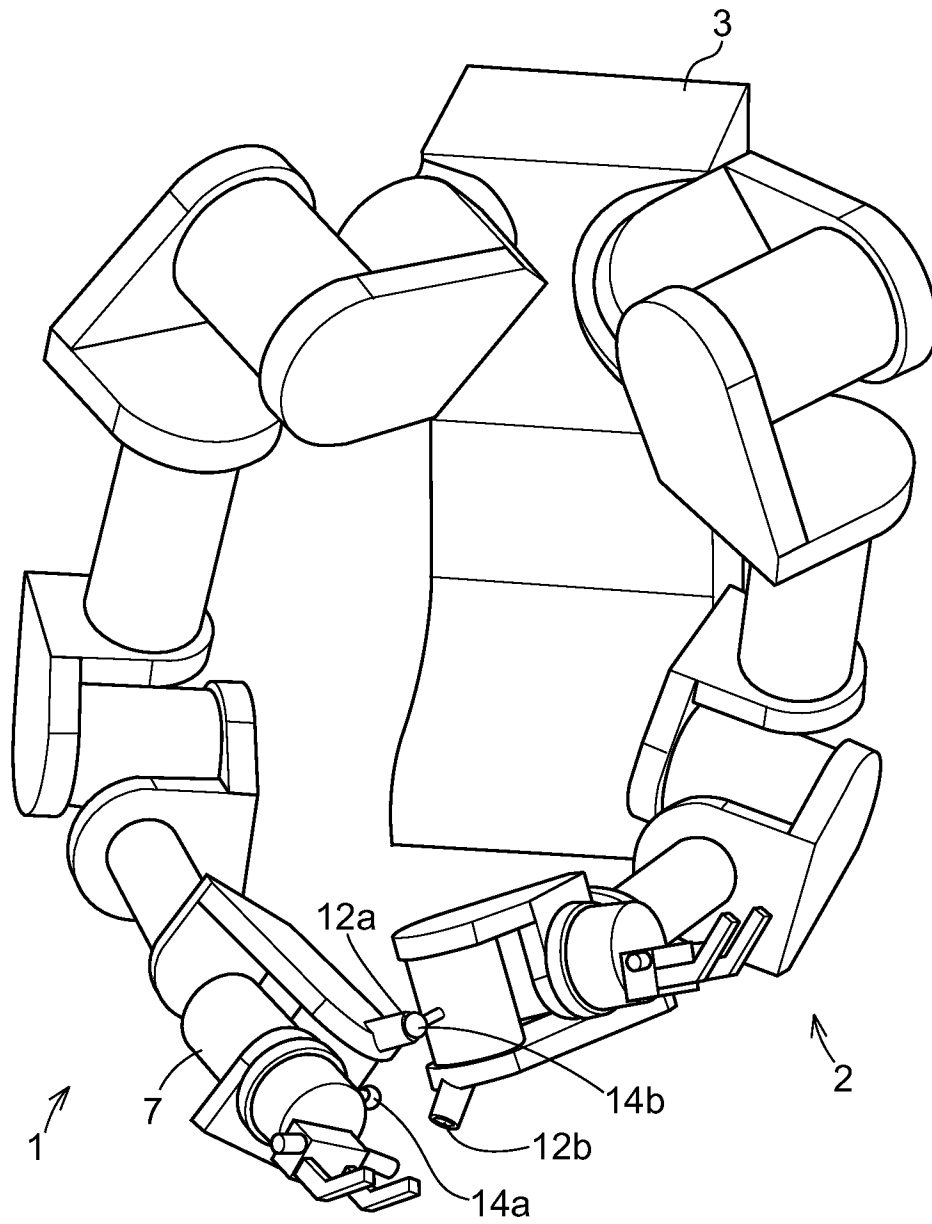
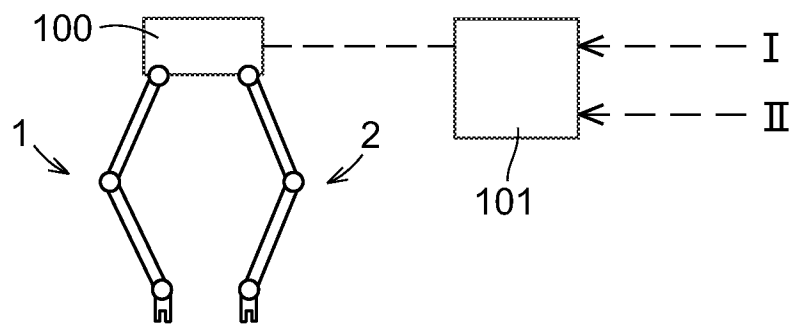
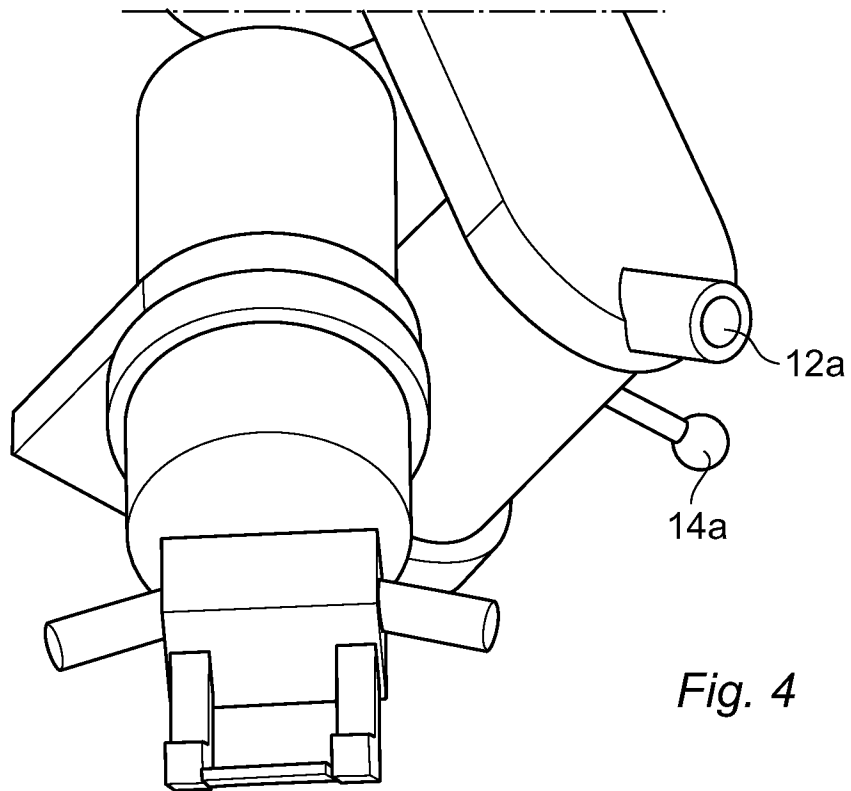


Fig. 3

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/051551

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J9/00 B25J9/16

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25J

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 402 599 A (HITACHI LTD [JP]) 19 December 1990 (1990-12-19) abstract; figure 5	1, 9, 10, 13-16
Y	-----	11
X	JP 59 064239 A (HITACHI LTD) 12 April 1984 (1984-04-12) abstract	1-4, 6, 8-10, 12-16
X	WO 2005/087451 A (DAIMLER CHRYSLER AG [DE]; ALONSO GARCIA ALEXANDER [DE]; MACK PETER [DE] 22 September 2005 (2005-09-22) page 10, line 18; claim 5; figure 2	1, 5, 13
X	JP 05 111897 A (FANUC LTD) 7 May 1993 (1993-05-07) abstract	1, 13
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

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22/04/2009

Name and mailing address of the ISA/

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Meyer, Thomas

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/051551

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 894 901 A (SODERBERG MARK S [US]) 23 January 1990 (1990-01-23) abstract -----	1,13
Y	EP 1 468 791 A (KAWASAKI HEAVY IND LTD [JP]) 20 October 2004 (2004-10-20) abstract -----	11
A	JP 2003 159683 A (RICOH KK) 3 June 2003 (2003-06-03) cited in the application abstract -----	1,13
A	US 4 260 941 A (ENGELBERGER JOSEPH F ET AL) 7 April 1981 (1981-04-07) cited in the application the whole document -----	1,13
A	US 4 826 392 A (HAYATI SAMAD A [US]) 2 May 1989 (1989-05-02) cited in the application the whole document -----	1,13
A	DE 39 32 013 A1 (BERLIN OBERBEKLEIDUNG [DD]) 31 May 1990 (1990-05-31) cited in the application the whole document -----	1,13
A	JP 08 185218 A (NISSAN MOTOR) 16 July 1996 (1996-07-16) cited in the application the whole document -----	1,13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/051551

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0402599	A	19-12-1990	CA 2015245 A1 JP 2284884 A	26-10-1990 22-11-1990
JP 59064239	A	12-04-1984	JP 1492054 C JP 63036894 B	07-04-1989 22-07-1988
WO 2005087451	A	22-09-2005	DE 102004012592 A1	29-09-2005
JP 5111897	A	07-05-1993	NONE	
US 4894901	A	23-01-1990	NONE	
EP 1468791	A	20-10-2004	WO 03039817 A1 JP 3577028 B2 JP 2003145462 A US 2005055132 A1	15-05-2003 13-10-2004 20-05-2003 10-03-2005
JP 2003159683	A	03-06-2003	NONE	
US 4260941	A	07-04-1981	NONE	
US 4826392	A	02-05-1989	NONE	
DE 3932013	A1	31-05-1990	CS 8906591 A2 DD 277230 A1	15-10-1991 28-03-1990
JP 8185218	A	16-07-1996	JP 3235385 B2	04-12-2001