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(54) Title: A COMPACT PARALLEL KINEMATICS ROBOT

(57) Abstract: A parallel kinematics robot (10) has a first drive arm (80) and a second drive arm (90), the two drive arms (80, 90) being crossed when the robot (10) operates within its normal work area. The drive arms (80, 90) thereby occupy less space in a horizontal direction compared with a situation where the two drive arms (80, 90) point away from each other.

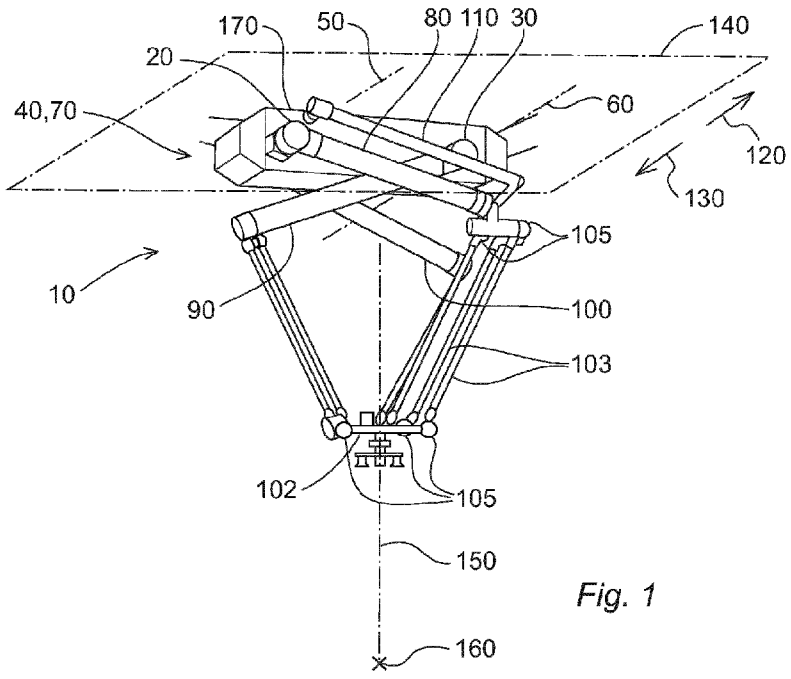

Fig. 1

WO 2015/139730 A1

A compact parallel kinematics robot

TECHNICAL FIELD

The present invention relates to a parallel kinematics robot that is compact in that its drive arms do not extend over a great width.

BACKGROUND ART

Conventional parallel kinematics robots comprise a plurality of drive arms each connected, directly or via a gearbox, to a respective shaft of a servo motor at one end. At the opposite end the drive arms are attached to proximate ends of rods via ball joints having three degrees of freedom (DOF). The rods transmit the rotating movement of the drive arms to a respective movement of an end effector that is attached to distal ends of the rods via ball joints. The servo motors and the respective drive arms are thereby working in parallel in the sense that manipulation of one drive arm does not affect the position of the remaining drive arms.

A delta robot is one well known type of parallel kinematics robot that can comprise three drive arms. Each drive arm is connected to an end effector with two rods having a ball joint at each end. The drive arms rotate about respective servo motor axes, the servo motors being arranged symmetrically such that their axes intersect at 60 degrees angles. Because the drive arms of a delta robot are relatively long and point in different directions the robot construction needs a lot of space. US7188544 discloses one type of a delta robot comprising three drive arms. Delta robots can also comprise four or more drive arms.

WO200366289 discloses other and less well known types of parallel kinematics robots comprising three or more drive arms. The robots according to WO200366289 differ from delta robots in that the rotational axes of the drive arms are parallel, and in many embodiments the drive arms even have one common rotational axis. The number of rods between the drive arms and the end effector vary from one to three depending on a drive arm and a robot embodiment. Also the drive arms of the robots according to WO200366289 need to be relatively long and well spread, and consequently need a lot of space.

There remains a desire to provide a more compact parallel kinematics robot.

SUMMARY OF THE INVENTION

One object of the invention is to provide a compact parallel kinematics robot.

These objects are achieved by the device according to appended claim 1.

The invention is based on the realization that the drive arms occupy less space in a horizontal direction when two of them are arranged to cross each other when the robot is operating within its normal work area.

According to a first aspect of the invention, there is provided a parallel kinematics robot comprising a first shaft rotatable about a first axis, a second shaft rotatable about a second axis, and a third shaft rotatable about a third axis. The robot further comprises a first drive arm attached to the first shaft, a second drive arm attached to the second shaft, and a third drive arm attached to the third shaft, each drive arm being connected to an end

effector by means of at least one rod. The first, second and third axes are parallel and a distance between the first axis and the second axis is at least 30 % of the length of the first drive arm. The first and second axes define a reference plane, the end effector having an extreme position furthest away from the reference plane. A reference axis perpendicular to the reference plane extends between the reference plane and the extreme position. When the end effector is positioned at a middle point of the reference axis, the first and second drive arms are crossed.

According to one embodiment of the invention, the distance between the first axis and the second axis is at least 40 %, such as 50 %, 60 %, 70 % or 75%, of the length of the first drive arm.

According to one embodiment of the invention, the first and second shafts extend from respective actuators in a first direction, and the third shaft extends from a respective actuator in a second direction, the first direction being opposite to the second direction.

According to one embodiment of the invention, the reference plane is inclined in relation to a horizontal plane.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in greater detail with reference to the accompanying drawings, wherein

figure 1 shows a parallel kinematics robot according to one embodiment of the invention,

figure 2 shows the robot of figure 1 at a different position, and

figure 3 shows a schematic view of a parallel kinematics robot according to one embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to figure 1, a parallel kinematics robot 10 according to one embodiment of the invention comprises a first shaft 20 rotatable about a first axis 50, a second shaft 30 rotatable about a second axis 60, and a third shaft 40 rotatable about a third axis 70. A first drive arm 80 is attached to the first shaft 20, a second drive arm 90 is attached to the second shaft 30, and a third drive arm 100 is attached to the third shaft 40, each drive arm 80, 90, 100 rotating along with a respective shaft 20, 30, 40 about a respective axis 50, 60, 70. The first drive arm 80 is connected to an end effector 102 by means of three rods 103, the second drive arm 90 is connected to the end effector 102 by means of two rods 103, and the third drive arm 100 is connected to the end effector 102 by means of one rod 103. Each rod 103 is connected to the respective drive arm 80, 90, 100 and to the end effector 102 by means of joints 105 having three DOF. Parallel with the first drive arm 80 there is a parallel arm 110 the purpose of which is to keep the orientation of the end effector 102 constant.

The first and the second shafts 20, 30 extend in a first direction 120 from respective actuators, and the third shaft 40 extends in a second direction 130 from a respective actuator. All the axes 50, 60, 70 are thereby parallel. The actuators are servo motors including gears housed within a housing 170. When the robot 10 is in the position according to figure 1 the first and the second drive arms 80, 90 are crossed i.e. the longitudinal axis of the first drive arm 80 intersects the longitudinal axis of the second drive arm 90

observed from at least one direction. Indeed, the first and the second drive arms 80, 90 are crossed whenever the robot 10 is operating within its normal work area. For more precisely defining the present invention, a point belonging to the normal work area will now be defined.

For defining a point within the normal work area it is necessary to first define a reference plane 140 and a reference axis 150. The reference plane 140 is a plane defined by the first and second axes 50, 60 i.e. a plane which is parallel with both of these axes 50, 60. There exists an extreme position 160 which is a point at the periphery of the work area where the end effector 102 is furthest away from the reference plane 140. The reference axis 150 extends between the reference plane 140 and the extreme position 160, the reference axis 150 being perpendicular to the reference plane 140. A middle point of the reference axis 150 belongs to the normal work area of the robot 10, and according to the present invention the first and second drive arms 80, 90 shall be crossed when the end effector 102 is positioned at the middle point of the reference axis 150. The first shaft 20 is longer than the second shaft 30 in order to allow the first and the second drive arms 80, 90 to cross each other.

A distance between the first and second shafts 20, 30 is relatively long in order to draw advantage from the crossed drive arms 80, 90. Namely, when the first and second shafts 20, 30 are far from each other the respective first and second drive arms 80, 90 occupy in horizontal direction areas that largely overlap each other. The robot 10 can thereby be construed much more compact in the horizontal direction compared with a situation where the two drive arms 80, 90 point away from each other. According to the embodiment of figure 1 the distance between the first axis

50 and the second axis 60 is about 72 % of the length of the first drive arm 80. For measuring the length of the first drive arm 80 a distance from the first axis 50 to a joint 105 attached to the first drive arm 80 and being furthest away from the first axis 50 shall be considered.

The robot 10 according to figure 1 is mounted such that the reference plane 140 is horizontal. However, the robot 10 can be mounted in any appropriate orientation for example in order to affect the shape of a useful work area.

Referring to figure 2, the robot 10 of figure 1 is shown in a position where the end effector 102 is closer to the extreme position 160.

Referring to figure 3, a schematic drawing of a robot 10 according to the invention schematically shows the main elements of the robot 10.

The invention is not limited to the embodiments shown above, but the person skilled in the art may modify them in a plurality of ways within the scope of the invention as defined by the claims.

CLAIMS

1. A parallel kinematics robot (10) comprising:
a first shaft (20) rotatable about a first axis (50), a second shaft (30) rotatable about a second axis (60), a third shaft (40) rotatable about a third axis (70),
a first drive arm (80) attached to the first shaft (20),
a second drive arm (90) attached to the second shaft (30), a third drive arm (100) attached to the third shaft (40), each drive arm (80, 90, 100) being connected to an end effector (102) by means of at least one rod (103),
the first, second and third axes (50, 60, 70) being parallel and a distance between the first axis (50) and the second axis (60) being at least 30 % of the length of the first drive arm (80),
the first and second axes (50, 60) defining a reference plane (140), the end effector (102) having an extreme position (160) furthest away from the reference plane (140),
a reference axis (150) being perpendicular to the reference plane (140) and extending between the reference plane (140) and the extreme position (160),
characterized in that when the end effector (102) is positioned at a middle point of the reference axis (150), the first and second drive arms (80, 90) are crossed.

2. A parallel kinematics robot (10) according to claim 1, wherein the distance between the first axis (50) and the second axis (60) is at least 40 %, such as 50 %, 60 %, 70 % or 75%, of the length of the first drive arm (80).

3. A parallel kinematics robot (10) according to any of the preceding claims, wherein the first and second shafts

(20, 30) extend from respective actuators in a first direction (120), and the third shaft (40) extends from a respective actuator in a second direction (130), the first direction (120) being opposite to the second direction (130).

4. A parallel kinematics robot (10) according to any of the preceding claims, wherein the reference plane (140) is inclined in relation to a horizontal plane.

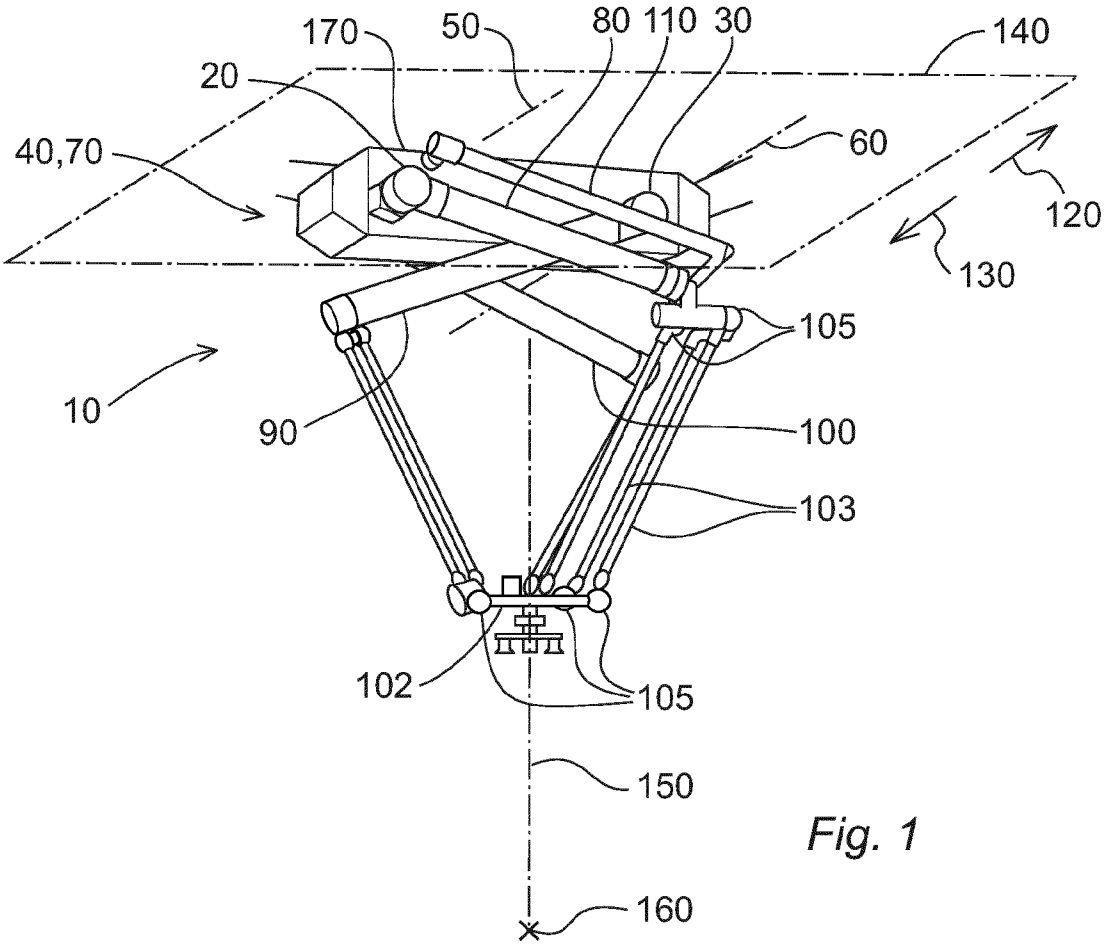
170
50
80
110
30
140
20
40,70
60
120
130
105
10
90
100
103
102
105
150
160

Fig. 1

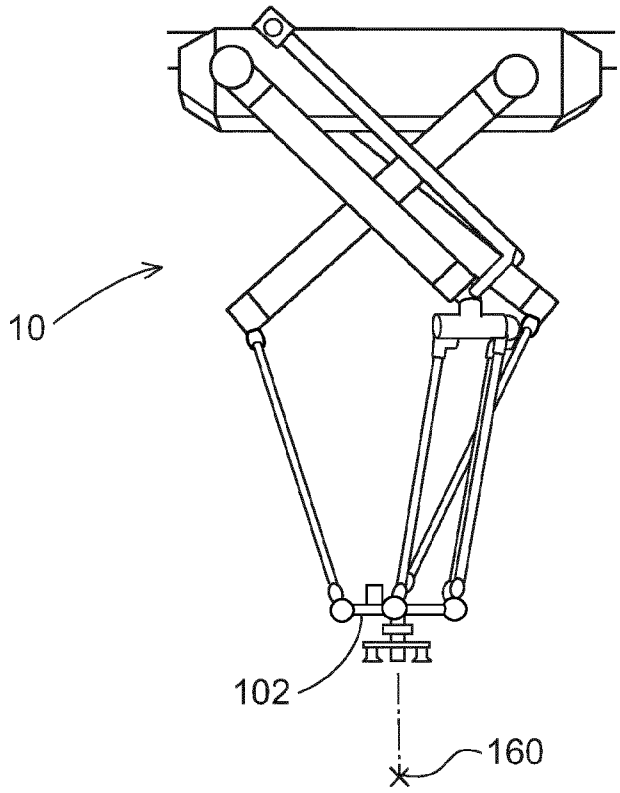
10
102
160

Fig. 2

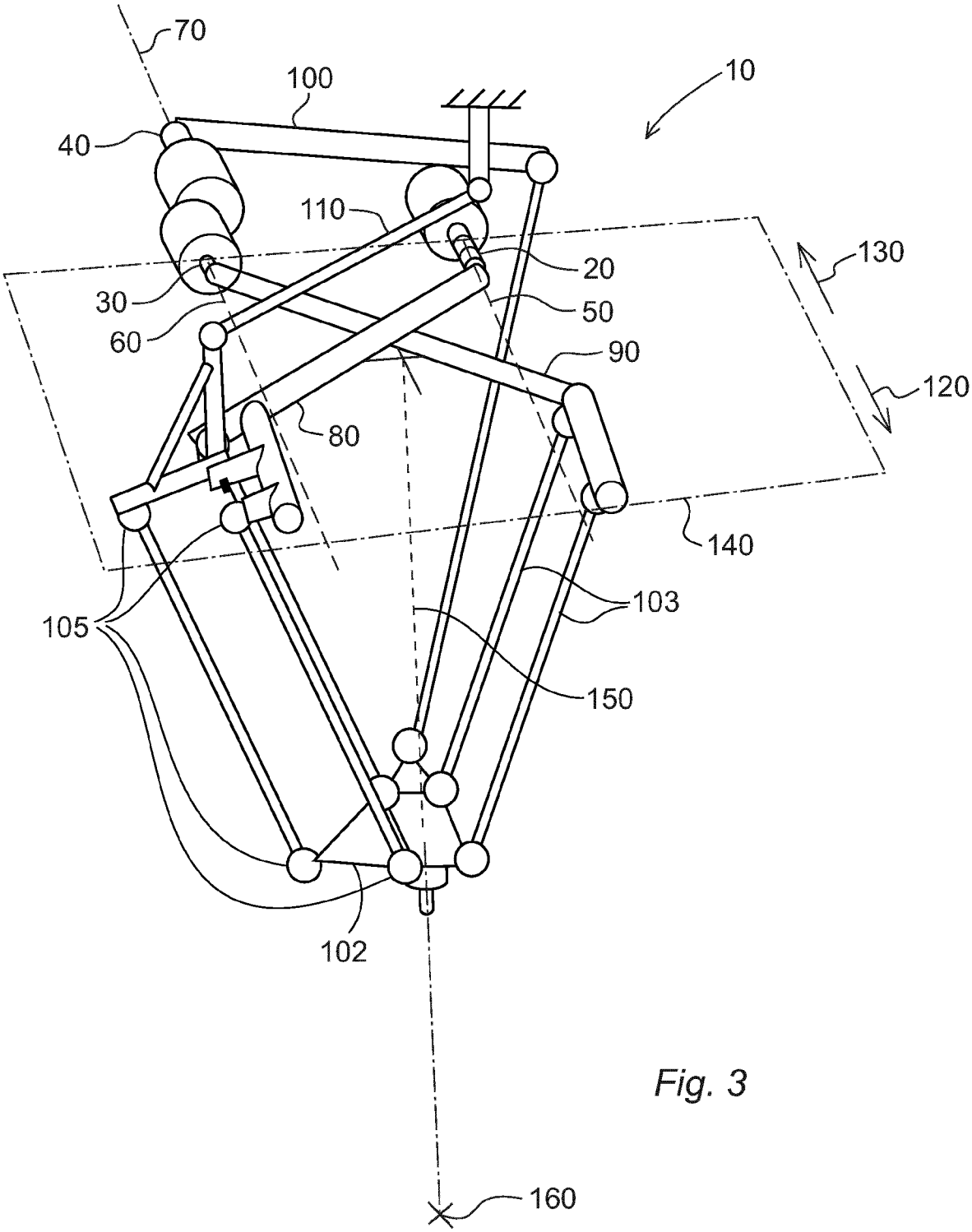

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/055356

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

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 practicable, 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.
A	WO 2012/031635 A1 (ABB RESEARCH LTD [CH]; BROGAARDH TORGNY [SE]) 15 March 2012 (2012-03-15) page 9, line 17 - page 12, line 6 figures 1-4	1-4
A	US 2013/189063 A1 (BROGARDH TORGNY [SE] ET AL) 25 July 2013 (2013-07-25) figures 4,5	1-4
A	US 2008/295637 A1 (LESSARD SIMON [CA] ET AL) 4 December 2008 (2008-12-04) figures	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 2014	27/11/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Grenier, Alain

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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