(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 June 2009 (04.06.2009)

PCT

(10) International Publication Number
WO 2009/069154 A1

(51) International Patent Classification:
B25J 5/04 (2006.01) *B66C 17/06* (2006.01)
B25J 9/04 (2006.01) *B65B 53/06* (2006.01)
G21C 19/10 (2006.01)

(21) International Application Number:
PCT/IT2007/000821

(22) International Filing Date:
26 November 2007 (26.11.2007)

(25) Filing Language: Italian

(26) Publication Language: English

(71) Applicants *(for all designated States except US)*: **MECHATRONIC SYSTEM COMPANY S.R.L.** [IT/IT]; Via Leonardo da Vinci, 3, 42024 Castelnovo Di Soto (Reggio Emilia) (IT). **MOTOR POWER COMPANY S.R.L.** [IT/IT]; Via Leonardo da Vinci, 4, Castelnovo Di Sotto (Reggio Emilia) (IT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MIGNANO, Paolo** [IT/IT]; Via Astrologo, 6, 420 Correggio (Reggio Emilia) (IT). **IMMOVILLI, Fabio** [IT/IT]; Via Asiago, 9, 42100 Reggio Emilia (IT).

(74) Agent: **COLLI, Alfonso**; Via P. Borsellino, 22, 42100 Reggio Emilia (IT).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,

[Continued on next page]

(54) Title: A DEVICE FOR HANDLING AND/OR PERFORMING WORK OPERATIONS ON OBJECTS

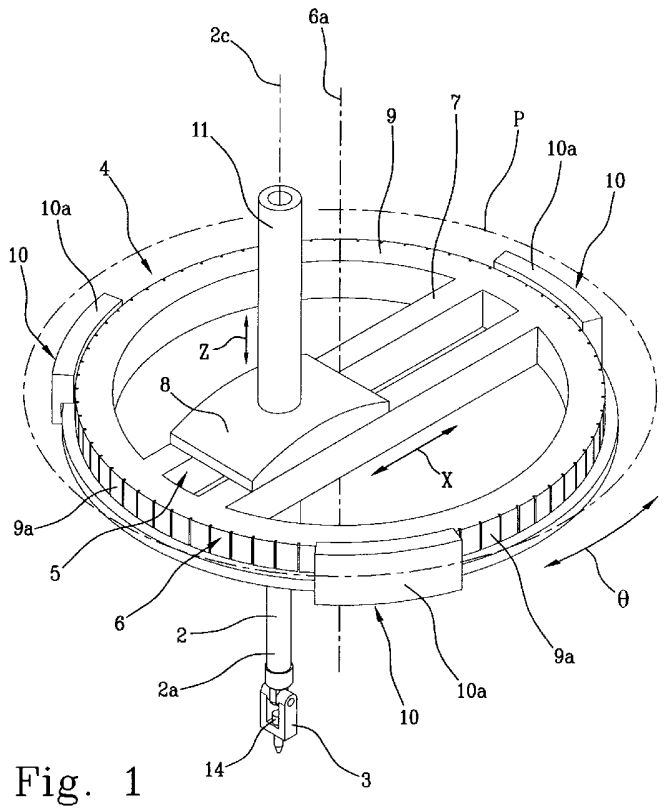

Fig. 1

(57) Abstract: A device for handling and/or performing work operations on objects comprises: at least a first arm (2) comprising a first end (2a) for supporting a tool (3) for picking or working; means for supporting and moving (4) the first arm (2); a first linear electric motor (5) connected to the first arm (2) for promoting a translation of the first arm (2) along a straight trajectory (X), preferably horizontal, and a second linear electric motor (6), associated to the first linear electric motor (5), developing along a closed path (P), which sets in rotation the first arm (2) about at least a circular trajectory (9).

WO 2009/069154 A1

FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

Description

A Device for Handling and/or Performing Work Operations on Objects

Technical Field

The invention relates to a device for handling and/or performing work operations on objects.

In particular, the invention is applicable in the industrial sector in movement systems of small-mass objects weighing a few kilograms, and for which fast and precise movement is required.

Background Art

The invention is applicable in systems for gathering and positioning products, known as "pick and place" systems, in lines of packaging or assembly of products, in machines for separating and/or sorting products or in object handling systems.

In the specific case, the present invention can be used in the medical field for moving and handling surgical instruments, or in the field of mechanical working for moving tools such as millers, drill bits, pliers or the like, or for the movement and training of precision instruments in general, such as for example lasers.

As is known, these systems use robot arms composed of a plurality of hinged link mechanisms, which at an end thereof bear a tool, such as pliers, a sucker or a work instrument.

In particular, in pick and place applications, the object, located on a horizontal plane or on a conveyor belt is gathered and moved, parallel to the work plane or with its orientation changed with respect to the plane, to be deposited internally of a special housing or a second conveyor belt.

Robot architectures developed in the prior art are essentially of two types: arms of the traditional type (generally anthropomorphic) or robots having parallel kinematics mechanisms.

Both of these solutions use, in general terms, traditional actuators, typically constituted by an electric motor coupled to a mechanical reducer which adapts the torque-speed characteristics to those required by the application, usually by reducing the number of revolutions and raising the torque value.

The limitations of anthropomorphic structures are essentially constituted by the fact that the actuators are distributed along the kinematic chain constituting the arm, thus involving considerable masses in movement and limiting the dynamics of the operation and consequently the working speed of the whole production line. It is worth remembering that the work speeds required are in the order of 150-200 collections per minute for each arm.

However, the traditional structures exhibit larger work volumes and in general require control algorithms which are simpler to realise.

Parallel kinematics machines obviate the above-described dynamic limitation by concentrating all the actuators in the robot zone which remains fixed, transferring the movement to the object via a complex mechanical structure of mechanical links, often comprising more than one arm, which is however light and rigid.

Though this method gives high dynamic levels, parallel kinematics robots only enable a contained work volume to be carried out. Further, the presence in the work volume of no-go zones to be avoided during functioning in order not to cause the structure to block further reduces the useful working zone. Lastly, the complexity of the structure considerably complicates the realisation of the control algorithms.

For both solutions there is the limitation of having to provide the actuators with mechanical reducers which apart from constituting an additional cost, complicate the maintenance operations, make the structure less rigid, increase noise and vibration in the system, reduce system reliability and complicate control processes.

The aim of the present invention is to obviate the drawbacks encountered in the solutions of the prior art.

In particular, the aim of the present invention is to realise a device for handling and/or performing work operation on objects which combine the work volumes characteristic of anthropomorphic structures with the high-level dynamics and precision of parallel kinematics machines.

In other words, an aim of the present invention is to realise a device for handling and/or the performance of work operations on objects which enables a reduction in the masses in motion, in particular in the zone closest to the object, enabling performance-giving dynamics, a decidedly large work volume and an extremely simple control structure.

Further, another aim of the present invention is to realise a device for handling and/or performing work operations on objects provided with a simplified kinematic structure, being without supplementary mechanical organs such as reducers, screw systems, systems for conversion of motion from circular to straight etc., thus leading to a reduction in costs, greater system reliability, better control of force and torque and extremely simplified control algorithms.

Disclosure of Invention

A description will now be made, by way of non-limiting example, of a preferred but not exclusive embodiment of a handling device for objects, illustrated in the accompanying figures of the drawings, in which:

figure 1 is a perspective view of a device for handling and/or performing work operations on objects, according to the present invention;

figure 2 is a lateral view of the device of figure 1;

figure 3 is a lateral view of a variant of the device for handling and/or performing work operations on objects, in agreement with the present invention.

With reference to the figures of the drawings, 1 denotes a device for handling and/or performing work operations on objects in accordance with the present invention.

The device 1 comprises at least a first arm 2 exhibiting a first end 2a, which first end 2a bears a tool 3. The tool 3 is advantageously associated to the first end 2a of the arm 2 by means of a hinged connection, preferably jointed, which enables the tool 3 to make a circular and curved movement in all direction in a space defined about the first end 2a of the arm 2.

The tool 3 can advantageously be a gripping instrument, such as pliers or a sucker, or a work tool, such as a drill, a miller, a laser or any other type of mechanical or precision instrument, according to needs.

The device 1 further comprises means for supporting and moving 4 the first arm 2.

The first arm 2 is slidingly mobile at least along a direction X, preferably a straight direction, and at least along a circular trajectory 9.

The means for supporting and moving 4 comprise at least a first linear electric motor 5, directly connected to the first arm 2, to promote the translation of the arm 2 along the direction X.

The means for supporting and moving 4 further comprise at least a second linear electric motor 6, developing in a close path P. The second linear

electric motor 6 is preferably curved and for this reason develops on a circular course lying on a transversal plane to a longitudinal axis 2c of the first arm 2.

The second linear electric motor 6 is preferably associated to the first linear electric motor 5, and in particular supports it. The first linear electric motor 5 advantageously extends internally of the structure of the curved second linear electric motor 6, preferably in a diameter position.

The second linear electric motor 6 sets the first arm 2 in rotation about a preferably circular path ϑ.

By selectively or contemporaneously activating the two linear electric motors 5 and 6, different movements of the first arm 2 can be obtained.

In a case in which only the first linear electric motor 5 is active, the first arm 2 can perform only straight translations along direction X.

Alternatively, if only the second linear electric motor 5 is active, the arm is subject exclusively to a rotating movement, describing circular trajectories which are more or less large according to the position of the first arm 2 with respect to the first linear electric motor 6.

By combining the translational movement along the straight direction X with rotation along the circular trajectory ϑ, the arm 2 is mobile along a plurality of circular trajectories which are concentric with the axis 6a of rotation of the second linear electric motor 6.

The first linear electric motor 5 is preferably a bilateral electric motor, of the type known as ironless. In other words, the motor 5 comprises a stator, defined by a straight guide 7 composed of two facing tracks of permanent magnets. The moving element is defined by a cursor 8, containing the coil, and it is arranged slidably between the two tracks of the straight guide 7. The flow generated by the permanent magnets is almost totally in line with the

spirals of the coils. In an ironless motor the ferromagnetic nucleus is absent, making the motor light.

The first arm 2 is associated to the cursor 8. Thus, according to the position of the cursor 8 along the guide 7 of the first linear electric motor 5, the arm 2, as previously demonstrated, describes larger or smaller circular trajectories about the axis of rotation 6a of the second linear motor 6.

The second linear electric motor 6 can be singly or doubly fed.

In the preferred embodiment the second linear electric motor is singly-fed, and the rotor 9 comprises a plurality of permanent magnets 9a defining a ring, while the stator 10 is identified by at least a block, internally of each of which there is at least a coil 10a.

In a second embodiment, not illustrated, the coils 10a are applied on the rotor 9 and the magnets are applied on the stator 10.

The stator 10 is concentric to the rotor 9.

The first arm 2 can also be axially mobile along a direction Z which is parallel to the longitudinal axis 2c thereof.

The translation is cause by a third linear electric motor 11, directly acting on the first arm 2.

In an alternative configuration, illustrated in figure 3, the device 1 further comprises a second arm 12, cooperating with the first arm 2, for moving the tool 3.

The second arm 12, also preferably arranged in a parallel position to the first arm 2, is connected to the first linear electric motor 5 and runs solidly together with the first arm 2 along the straight direction X.

A fourth linear electric motor 13 is active directly on the second arm 12, to promote axial translation along the axis 12c of the second arm 12.

Thus the first arm 2 and the second arm 12 are slidingly mobile along the same direction Z, alternatingly or in a same direction according to the movements requested.

In this way it is possible to vary the height of the work plane of the tool 3.

At the respective first ends 2a, 12a, the arms 2 and 12 exhibit means for supporting and moving 15 the tool 3. In particular, the means for supporting and moving 15 the tool comprise hinged kinematics, such as for example a first 16 and a second 17 con rod, which define, with the first end 2a, 12a of each arm 2, 12, a four-bar link, in order to enable the tool 3 to move on an arc of circumference having a range of between 110° and 140°.

The range of the arc of circumference swept by the tool 3 depends on design choices, and in particular on the distance between the two arms 2, 12 and the length of the con rods 16, 17.

In both the single-arm version, shown in figures 1 and 2, and in the two-arm version, shown in figure 3, the movement of the tool 3 about the rotation axis 3a thereof is powered by a traditional electric motor 14, associated to the tool 3 itself.

The invention offers important advantages since it provides a structure having contained dimensions, which is able to manage work volumes which are characteristics of anthropomorphic structures, with the high dynamics and precision typical of parallel kinematics machines. This is obtained by means of a non-conventional kinematic structure specially designed to be able to exploit direction-motion innovative actuators, which do not require the interposing of supplementary mechanical organs.

Linear electric motors directly command the element to which they are applied, avoiding the presence of kinematic connections which make the

structure heavy, increase the amount of moving parts and slow down the working speed and the overall dynamics of the machine.

The special construction choice of the use of ironless linear electric motors leads to considerable advantages.

The magnetic field is symmetrical, there is an excellent exploitation of the magnetic flow, there are no forces of attraction and the mass of moving parts is small. A similar motor, though not offering high thrust levels, generally not above 2kN, enables rapid and precise movements, optimal for pick and place applications or Cartesian robots.

The carbon arms help to lighten the device and the constructional simplicity of the linear motors simplifies the structural complexity which is typical of the devices of the prior art.

The presence both of straight guides and circular guides makes the whole structure extremely flexible and versatile in any type of motion and technical application required. The absence of supplementary mechanical organs further enables a reduction of costs, a greater system reliability, a better control of torque force, as well as extremely simplified control algorithms.

Claims.

1). A device for handling and/or performing work operations on objects, comprising:

at least a first arm (2) comprising a first end (2a) for supporting a tool (3);

means for supporting and moving (4) the first arm (2);

wherein the means for supporting and moving (4) comprise at least a first linear electric motor (5) for promoting a translation of the first arm (2) along a straight trajectory (X), and a second linear electric motor (6), developing along a closed path (P), which sets the first arm (2) in rotation about at least a circular trajectory (ϑ).

2). The device of claim 1, wherein the second linear electric motor (6) is curved and develops on a circular path (P) which lies on a plane which is transversal to a longitudinal axis (2c) of the first arm (2).

3). The device of one of the preceding claims, wherein the first linear electric motor (5) is associated to the second linear electric motor (6).

4). The device of one of the preceding claims, wherein the first linear electric motor (5) is positioned internally of the closed path (P) defined by the second linear electric motor (6).

5). The device of one of the preceding claims, wherein the first linear electric motor (5) is located at a diameter of the second linear electric motor (6).

6). The device of one of the preceding claims, wherein the first linear electric motor (5) comprises a guide (7), coinciding with a diameter of the second

linear electric motor (6), and a cursor (8) which is mobile slidingly on the guide (7).

7). The device of claim 6, wherein the arm (2) is connected to the cursor (8).

8). The device of one of the preceding claims, characterised in that the second linear electric motor (6) comprises a rotor (9) which is directly connected to the first linear motor (5) and a stator (10) which is concentric of the rotor (9).

9). The device of any one of the preceding claims, wherein the first arm (2) is axially mobile along a direction (Z) which is parallel to the longitudinal axis (2c) of the first arm (2).

10). The device of any one of the preceding claims, wherein it comprises a third linear electric motor (11), which is directly active on the first arm (2), in order to promote translation of the first arm (2) along a direction (Z) which is parallel to a longitudinal axis (2c) of the first arm (2).

11). The device of any one of the preceding claims, wherein the tool (3) is connected articulatedly to the first end (2a) of the first arm (2), in order to move in a plurality of directions.

12). The device of any one of the preceding claims, wherein it comprises a second arm (12), cooperating with the first arm (2), for moving the tool (3).

13). The device of claim 12, wherein the first arm (2) and the second arm (12) are parallel to one another and are connected to the first linear electric motor (6).

14). The device of claim 12 and 13, wherein the first arm (2) and the second arm (12) are slidably mobile along a direction (Z) which is parallel to the respective longitudinal axes (2c, 12c).

15). The device of one of claims from 12 to 14, wherein it comprises a fourth linear electric motor (13), directly acting on the second arm (12), for

promoting translation of the second arm (12) along a direction (Z) which is parallel to a longitudinal axis (12c) of the second arm (12).

16). The device of one of claims from 1 to 15, wherein the first arm (2) and the second arm (12) support, at respective first ends (2a, 12a) thereof, means for supporting and moving (15) a tool (3).

17). The device of claim 16, wherein the means for supporting and moving (15) are articulated.

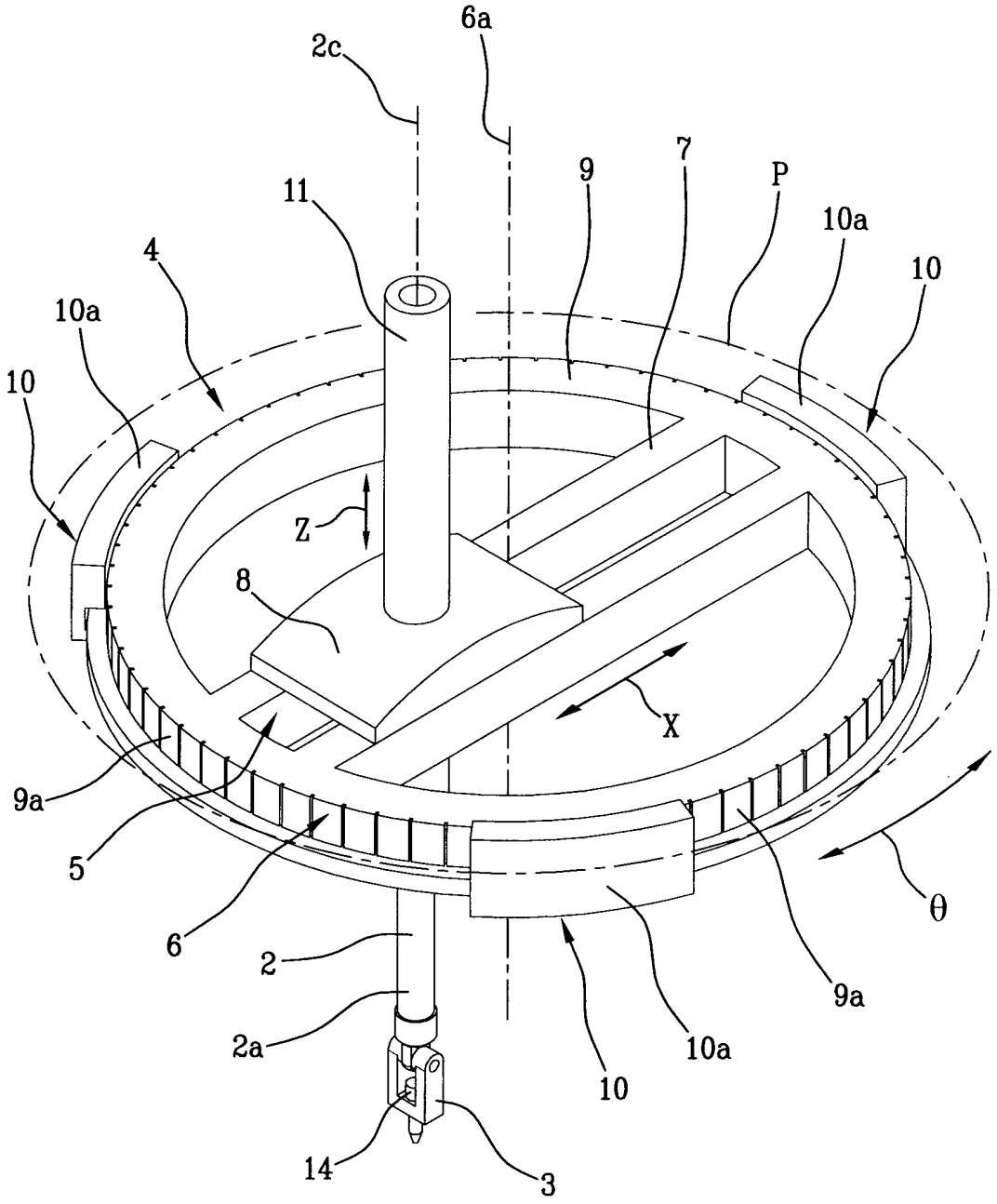

Fig. 1

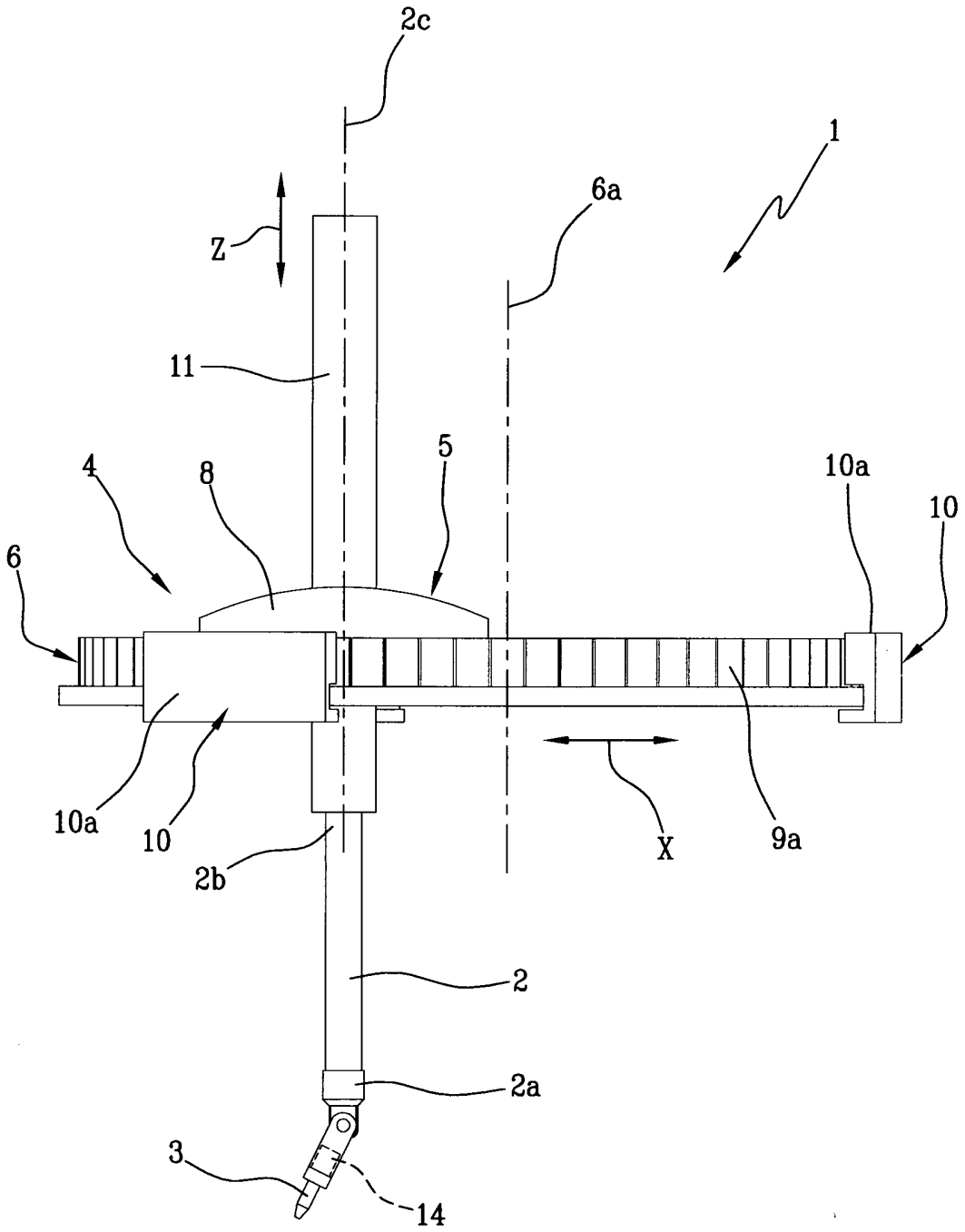

Fig. 2

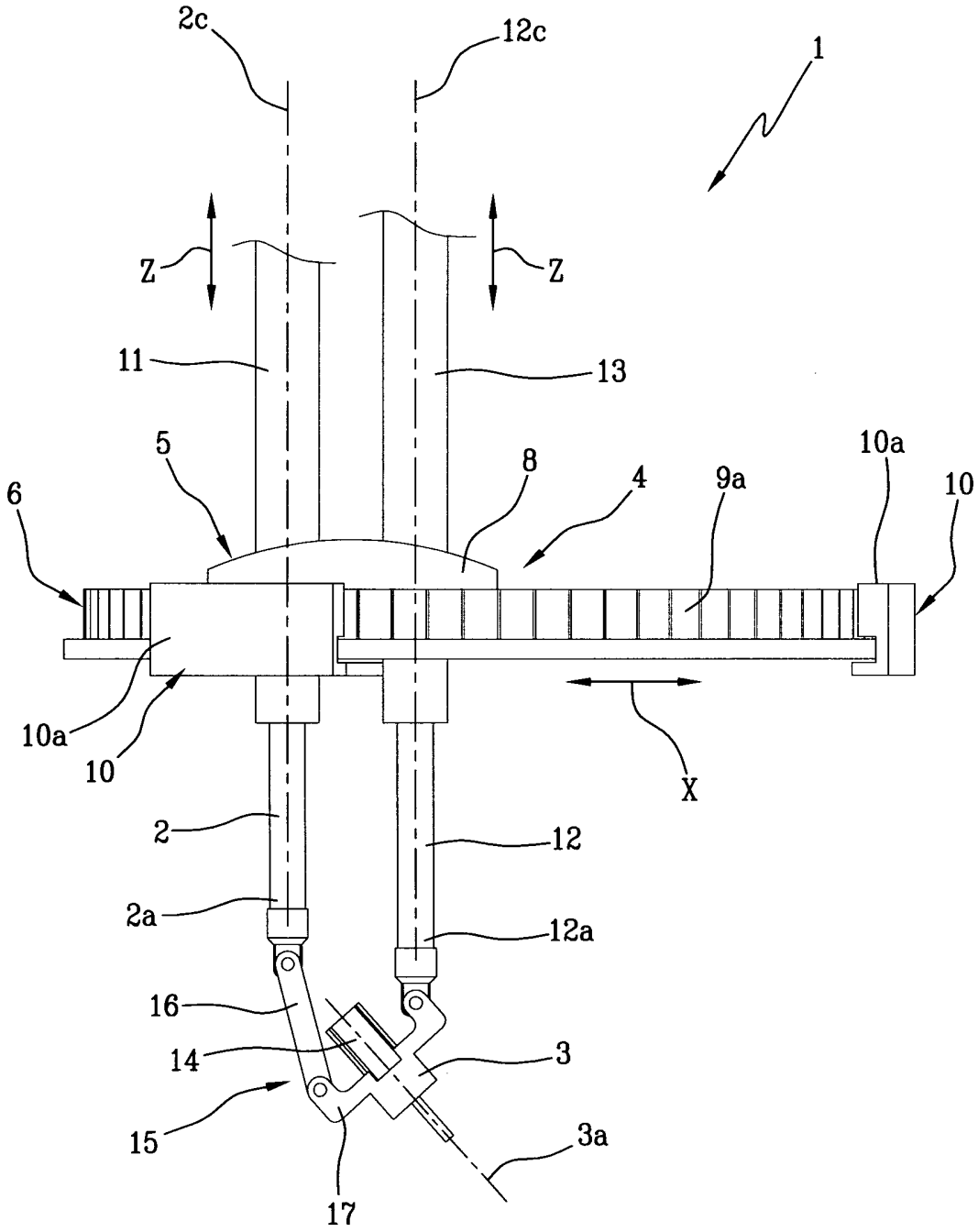

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2007/000821

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J5/04 B25J9/04 G21C19/10 B66C17/06 B65B53/06

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 G21C B66C B65B

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.
Y	US 5 369 676 A (ORTEGA FRANK [US] ET AL) 29 November 1994 (1994-11-29) abstract	1-12
Y	WO 2006/036669 A (KULICKE & SOFFA IND INC [US]; FRASCH WALTER E [US]; BEATSON DAVID T [U) 6 April 2006 (2006-04-06) abstract	1-11
Y	EP 1 419 851 A (DECKEL MAHO PFRONTEN GMBH [DE]) 19 May 2004 (2004-05-19) paragraphs [0007], [0009]	12
A	EP 0 320 436 A (NOELL GMBH [DE]) 14 June 1989 (1989-06-14) figure 1	1-11

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 June 2008	04/07/2008

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Meyer, Thomas

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2007/000821

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2007/131686 A (EEW MASCHB GMBH [DE]; MEYER PETER [DE]) 22 November 2007 (2007-11-22) abstract	1-11
A	US 3 771 666 A (FOURNIER O) 13 November 1973 (1973-11-13) abstract	1-11
A	US 5 873 214 A (MOORE PHIL [US] ET AL) 23 February 1999 (1999-02-23) abstract	1-11
A	FR 2 800 659 A (PROCESS CONCEPTION INGENIERIE [FR]) 11 May 2001 (2001-05-11) abstract	12-17
A	DE 44 13 625 A1 (HERMANN HEUSS GMBH & CO KG ING [DE]; STRASSER INGBUERO GMBH [DE]; INTR) 18 April 1996 (1996-04-18) abstract	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IT2007/000821

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5369676 A	29-11-1994	JP 7151897 A	16-06-1995
WO 2006036669 A	06-04-2006	CN 101052493 A	10-10-2007
EP 1419851 A	19-05-2004	CN 1511674 A	14-07-2004
		DE 10252824 A1	03-06-2004
		ES 2257629 T3	01-08-2006
		ES 2281035 T3	16-09-2007
		JP 2004284007 A	14-10-2004
		US 2004115019 A1	17-06-2004
EP 0320436 A	14-06-1989	DE 3741632 A1	22-06-1989
		JP 1216789 A	30-08-1989
		US 4941106 A	10-07-1990
WO 2007131686 A	22-11-2007	NONE	
US 3771666 A	13-11-1973	NONE	
US 5873214 A	23-02-1999	NONE	
FR 2800659 A	11-05-2001	NONE	
DE 4413625 A1	18-04-1996	NONE	