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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 September 2010 (30.09.2010)

PCT

(10) International Publication Number
WO 2010/108520 A1

(51) International Patent Classification:
B25J 9/10 (2006.01)

(21) International Application Number:
PCT/EP2009/002277

(22) International Filing Date:
27 March 2009 (27.03.2009)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **ABB AG** [DE/DE]; Kallstadter Str. 1, 68309 Mannheim (DE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **STENGEL, Gregor** [DE/DE]; Haldenwangstr. 2, 76227 Karlsruhe (DE). **HUG, Kuno** [DE/DE]; Steinbachweg 14, 69118 Heidelberg (DE). **SOETEBIER, Sven** [DE/DE]; Vorderer Rindweg 23, 68526 Ladenburg (DE). **WALDI, Wolfgang** [DE/DE]; Ortsstr. 20, 69226 Nussloch-Maisbach (DE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, 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, ST, 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, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

(54) Title: TILT MOTION MODULE

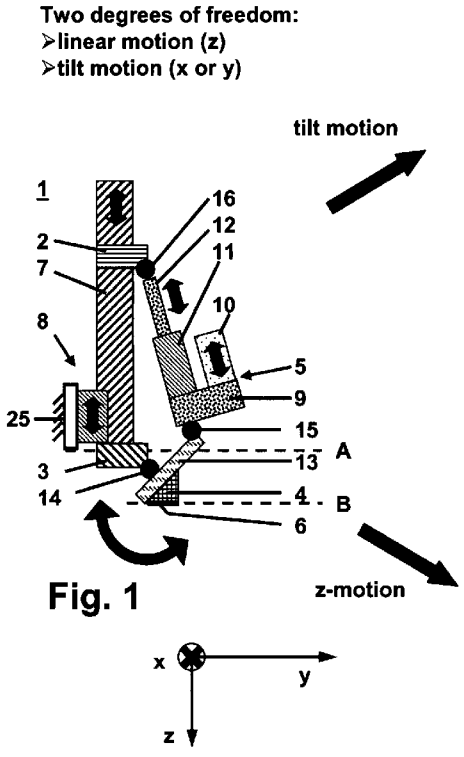


Fig. 1

(57) Abstract: The invention proposes a tilt motion module (1) with a linear cylinder actuator (5) for tilt motion and a linear actuator module (8) for translational movement, • where by the linear actuator module (8) possesses an interface (25) for fastening to a tooling interface (34) of a manipulator module (33) of a manipulator by preference, • where by the linear actuator module (8) possesses a rail (7) for a linear motion compared to interface (25) and a drive (17) for said translational movement, • where by the linear cylinder actuator (5) possesses a cylinder (11), a piston rod (12) and a drive (10) for said tilt motion, • where by this cylinder / piston rod - unit (11/12) possesses a bearing (16, 20) for fastening to the rail (7) via a link unit (2), • where the cylinder / piston rod - unit (11/12) possesses another bearing (15, 19) for fastening to a truss (13, 39, 40) which is equipped with a tilt platform (4) with a flange (6) for fastening to a tool (26) by preference and • where by the truss (13, 39, 40) further possesses a bearing (14, 18) for connection with the rail (7) via a link unit (3).

WO 2010/108520 A1

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

Tilt motion module

Description

The invention relates to a tilt motion module which is foreseen to be connected with a tooling interface of a manipulator module (of a tooling device) of a manipulator respectively industrial robot.

It is known, that industrial production processes, for example in the automotive industry, are often based on a wide range of different shaped types of workpieces which have to become mounted together. Due to the increasing plurality of variants of the final product also the workpieces to be mounted together are characterized by an increasing variety.

Normally an industrial production is realized by using industrial robots for the standardized production processes such as gripping platform for a car to be mounted from a staple and moving it to an assembly area. Industrial robots are manipulators with for example five to seven degrees of freedom in movement which are able to perform programmable movements within their working range that enclosures for example a radius of three meters around a belonging rotary base.

Those industrial robots or other manipulators require a tool mounted thereon for securely gripping a workpiece. To handle the high variety of different types of workpieces – such as platforms for cars – it is either possible to handle each type of workpiece with a dedicated (gripper) tool or to design the tool as flexible as possible. The required effort for changing the tool is reduced therewith.

CONFIRMATION COPY

EP 1 839 820 B1 discloses a manipulating device for the handling of workpieces which is foreseen to be mounted on a robot. It comprises several operating modules which are stationary mounted on the same carrier unit on their side and which provide a mounting interface for a gripper tool on their other side. To increase the flexibility of this manipulating device it is foreseen that each mounting interface is moveable within the working range of the belonging working module independently of each other.

In case the workpieces are not flat but shaped as vaulted (convex or concave) planes there appear problems to handle such workpieces with the known (gripper) tools. It is expensive to develop and produce several (gripper) tools adapted to different vaulted planes. Further it is expensive to change these tools in dependence of the workpiece to be handled.

Therefore it is an object of this invention to provide a tooling with increased flexibility.

The problem is solved by a tilt motion module with a linear cylinder actuator for tilt motion and a linear actuator module for translational movement,

- where by the linear actuator module possesses an interface for fastening to a tooling interface of a manipulator module of a manipulator by preference,
- where by the linear actuator module possesses a rail for a linear motion compared to interface and a drive for said translational movement,
- where by the linear cylinder actuator possesses a cylinder, a piston rod and a drive for said tilt motion,
- where by this cylinder / piston rod – unit possesses a bearing for fastening to the rail via a link unit,
- where the cylinder / piston rod – unit possesses another bearing for fastening to a truss which is equipped with a tilt platform with a flange for fastening to a tool by preference and
- where by the truss further possesses a bearing for connection with the rail via a link unit.

It is an advantage of the tilt motion module that a high variety of different types of workpieces – such as a vaulted (convex or concave) plane like vaulted steel plates for cars – can be handled with the proposed tilt motion module. The motion tilt module enables an adjustment of the fastened tool not only with respect to translational movements but with respect to angles of inclination within a great range too. Because of this flexible designed tilt motion module the required effort for changing the tool is reduced.

Further advantageous embodiments of the invention are mentioned in the dependent claims.

The invention will now be further explained by means of an exemplary embodiment and with reference to the accompanying drawings, in which:

Figure 1 - 5 show in side views different possible positions of a tilt motion module,

Figures 6, 7 show in side views the tilt motion possibilities around the x-axis and y-axis,

Figures 8, 9,10 show in side views different positions of a tilt motion module with a curved truss,

Figures 11, 12 show in side views different positions of a tilt motion module with a multiple curved truss,

Figure 13 shows in a side view a tilt motion module with pantograph like truss configuration,

Figure 14 shows in a side view a tilt motion module with fastened tool with gripping tip,

Figure 15 shows a top-view on a tooling device of a manipulator respectively industrial robot having several tilt motion modules,

Figures 16, 17 show two examples of application for the tooling device according Figure 15.

Figures 1 - 5 show in side views different possible positions of a tilt motion module. The tilt motion module 1 consists of the following main components:

- a linear actuator module 8 with an interface 25 – preferably fastened to a tooling interface 34 of a manipulator module 33 (see Fig. 15) –, a rail 7 for a linear motion in z-direction compared to interface 25 and a drive 17 (for instance an electrical motor) for this translational movement in z-direction (see Fig. 11),
- a linear cylinder actuator 5 with a base plate 9, a cylinder 11, a piston rod 12, so called cylinder / piston-rod – unit 11/12, and a drive 10 (for instance an electrical motor) for tilt motion,
  - whereas a bearing 16 is connected with the free end of the piston rod 12,
  - whereas this bearing 16 is connected with a first link unit 2 fastened to the rail 7,
- a tilt platform 4 with a flange 6, preferably fastened to a tool 26 with gripping tip (gripper tool, see Fig. 15), whereas a truss 13 of the tilt platform 4 is connected with two bearings 14, 15 at its opposite sides,
  - whereas the bearing 14 is connected with a second link unit 3 fastened to the rail 7,
  - whereas the bearing 15 is connected with the base plate 9.

A reference area A marks an area defined by the x/y-axes and the interface 25. A reference area B for the flange 6 marks the actual z-position and inclination of the tilt platform 4 of the tilt motion module 1. The tilt motion module 1 realizes two degrees of freedom:

- linear motion in z-direction,
- tilt motion around x-axis or y-axis, whereas the bearings 14, 15, 16 according Fig. 1 – 5 enable a tilt motion around the x-axis.

Figures 2 and 3 show the tilt motion around the x-axis – see the different tilt angles between the reference areas A und B in Figures 1, 2 and 3. In Fig. 2 the linear

cylinder actuator 5 becomes shorter compared to Fig. 1, therefore the tilt platform 4 executes an anticlockwise rotation. In Fig. 3 the linear cylinder actuator 5 becomes longer compared to Fig. 1, therefore the tilt platform 4 executes a clockwise rotation. In both cases the linear actuator module 8 remains unchanged.

Figures 4 and 5 show the linear motion in z-direction. In both cases the rail 7 with the two link units 2, 3 moves downwards, see reference area B, which enlarges its distance to reference area A. Both reference areas A, B remain parallel to each other. In both cases the linear cylinder actuator 5 remains unchanged.

Figures 6 and 7 show in side views the tilt motion possibilities around the x-axis and y-axis. Fig. 6 corresponds to Figures 1 – 5 and shows the tilt motion around the x-axis with the bearings 14, 15 and 16, so that the following two degrees of freedom are realized:

- tilt motion around the x-axis,
- linear motion in z-direction.

Fig. 7 shows the tilt motion around the y-axis with a bearing 18 for connection between tilt platform 4 / truss 13 and second link unit 3, with a bearing 19 for connection between tilt platform 4 / truss 13 and base plate 9 of the linear cylinder actuator 5 and with a bearing 20 for connection between piston rod 12 of the linear cylinder actuator 5 and first link unit 2, so that the following two degrees of freedom are realized:

- tilt motion around the y-axis,
- linear motion in z-direction.

Figures 8, 9, 10 show in side views different positions of a tilt motion module with a curved truss 39 mounted between second link unit 3 (via bearing 14) and piston rod 12 (via bearing 15). Compared with the structures according to Figures 1 – 7 the cylinder / piston-rod – unit 11/12, i. e. the arrangement of the linear cylinder actuator 5 is opposite, that means, cylinder 11 and piston rod 12 exchange their positions. Such a curved truss 39 enables different tilt angles between the position of the linear cylinder actuator 5 (with cylinder 11 and piston rod 12) and the tilt platform 4 (with flange 6) compared with a straight truss 13. In dependence of the intended tilt angles

such a curved truss 13 is advantageous with regard to the required space caused by movements of the cylinder 11 because of the reduced lateral deflections of the linear cylinder actuator 5. Figures 9 and 10 show the tilt motion around the x-axis, see the different tilt angles between the reference areas A und B in Figures 8, 9 and 10. In Fig. 9 the linear cylinder actuator 5 becomes longer compared to Fig. 8, therefore the tilt platform 4 executes a clockwise rotation around bearing 14. In Fig. 10 the linear cylinder actuator 5 becomes shorter compared to Fig. 8, therefore the tilt platform 4 executes an anticlockwise rotation around bearing 14. In both cases the linear actuator module 8 remains unchanged.

Figures 11, 12 show in side views different positions of a tilt motion module with a multiple curved truss 40 mounted between second link unit 3 (via bearing 14) and piston rod 12 (via bearing 15). Again – like explained to the Figures 8, 9, 10 – such a multiple curved truss 40 is advantageous with regard to the required space because of the reduced lateral deflections of the linear cylinder actuator 5, but this depends on the intended tilt angles of the tilt motion module 1. Further the Figures 11 and 12 show the drive 17 of linear actuator module 8 for translational movement in z-direction and the drive 10 for tilt motion.

Figure 13 shows in a side view a tilt motion module with pantograph like truss configuration. Compared to the structure according Fig. 1 the version according Fig. 13 comprises two additional bearings 21, 22 and two additional trusses 23, 24, so that bearing 15 is connected with the two trusses 23, 24, where by truss 23 is connected with truss 13 via bearing 22 and truss 24 is connected with the second link unit 3 via bearing 21. Further the second link 3 is connected with the truss 13 via bearing 14. This pantograph like truss configuration leads to a very compact tilt motion module 1 because the movements of the linear cylinder actuator 5 are parallels to the rail 7 without any lateral deflections. In addition to the first degree of freedom "linear motion in z-direction" the second degree of freedom alternatively can be "tilt motion around x-axis" or "tilt motion around y-axis".

Figure 14 shows in a side view a tilt motion module with fastened tool with gripping tip. This tool with gripping tip 26 (gripper tool) is connected to the flange 6 of the tilt platform 4.

Fig. 15 shows a top-view on a tooling device of a manipulator respectively industrial robot having four tilt motion modules 1.1, 1.2, 1.3, 1.4 in all. Two parallel and opposed guide rails 31, 32 are attached to a base unit 29 which is foreseen to be connected to an industrial robot with a connection interface 30. On each guide rail 31 respectively 32 two movable manipulator modules 33.1, 33.2 respectively 33.3, 33.4 are mounted, which can linearly become moved along those rails, what is marked with an arrow with reference sign 37. Actuators 36.1, 36.2, 36.3, 36.4 are attached to the base unit 29 to drive this linear movement individually for each manipulator module 33.1, 33.2, 33.3, 33.4, whereas a not shown spindle drive is foreseen as movement transmission interface between each actuator 36.1, 36.2, 36.3, 36.4 and each related manipulator module 33.1, 33.2, 33.3, 33.4.

Each manipulator module 33.1, 33.2, 33.3, 33.4 comprises on its first end a movable flat skid 35 and on its second end a flat tooling interface 34, which is foreseen to attach a tilt motion module 1.1, 1.2, 1.3, 1.4 thereon (by using interface 25 of the tilt motion module). The tooling interface 34 is movable along a circular path around the related skid 35. Since the degree of freedom in movement of the manipulator module 33.1, 33.2, 33.3, 33.4 is realized by a truss structure in the shape of a tiltable parallelogram, the tooling interface 34 is always in parallel to the belonging skid 35.

The circular movement of each tooling interface 34 is driven by an actuator 38, for instance an electric motor. The tool 26.1, 26.2, 26.3, 26.4 with gripping tip provides a first degree of freedom in movement in the same direction than the axis of rotation of the circular movement (circular path around the related skid 35, z-axis). So it is possible – when also including the linear movement of the manipulator module 33.1, 33.2, 33.3, 33.4 itself – to position the tool interface 34 in any coordinate within a flat virtual movement plane and to adjust the tool 26.1, 26.2, 26.3, 26.4 with gripping tip upright this plane (workpiece). In addition because of the tilt motion possibility of the tilt motion module 1.1, 1.2, 1.3, 1.4 around the x-axis or the y-axis it is possible to adjust the tool 26 with gripping tip upright a vaulted (convex or concave) plane (workpiece).

Summing up the key ideas of the tilt motion module 1 are as follows:

- The tilt motion module 1 will be attached to the linear actuator module 8 and uses the bases structure stiffness of this linear actuator module 8.
- The tilt motion module 1 consists of very few main parts only, a first link unit 2, a second link unit 3, a tilt platform 4 and a linear cylinder actuator 5. The first link unit 2 and the second link unit 3 are attached to interfaces of the linear actuator module 8. The tilt platform 4 is attached to the second link unit 3 and the linear cylinder actuator 5. The linear cylinder actuator 5 connects also to the first link unit 2 and actuates the tilt motion module 1.
- The tilt motion module 1 can be attached in different configurations in order to allow for tilt motion around different axes and/or fulfil packaging and space requirements, preferred are rotations around x- and y-axis.
- Tilt motion of the tilt motion module 1 can be used to adapt to workpiece contact surfaces with different curvature or alternatively to change between different tools. Each tool is sitting on a different angle on the endeffector platform (= tilt platform 4) which can be tilted.
- The interface plate of the tilt motion module 1 is linked directly to the linear actuator module 8 and decouples partially occurring loads from the linear cylinder actuator 5.
- Two different axes of rotation can be configured with the same components by
  a) providing different mounting positions of the whole tilt motion module 1 on the linear actuator module 8 rotated assembly of first link unit 2 and second link unit 3 by 90°,
  b) two different assembly configurations of the tilt motion module 1 itself whereas the first link unit 2 and the second link unit 3 provide two different joint positions where the tilt platform 4 and the linear cylinder actuator 5 can be mounted.
- For increased stiffness
  a) an optional two bar mechanism can be attached between tilt platform 4 and linear cylinder actuator 5 and second link unit 3,
  b) an optional structural element can be attached to the linear actuator module 8 to increase the stiffness and distribute the loads homogenously. Alternatively the structural element can also integrate the first link unit 2 and second link unit 3.
- The design is scalable in the relation / performance / cost:

a) For the joint units either roller bearing or friction bearing can be used.

b) The preferred embodiments used friction sleeve / flange bearings in order to allow for a high overload capacity as well as a compact design.

- The main linkage elements comprise curved or multiple curved truss, beam or space frame structure with light-weighted design features, made from sheet metal, composite plastics, castings.
- The modular design of a tilt motion module can use the stiffness of an already existing linear actuator module base structure which can be optionally equipped with additional stiffeners if needed for certain applications.
- The tilt motion module can be attached to the linear actuator in different angular configurations, rotated by e. g. 90 degrees, around the axis of the linear actuator in order to enable for different rotation axes depending on application needs.
- For a configuration with a tilt motion module which is attached to the linear actuator module the linear actuator module can be mounted via its interface in different angular configurations, rotated by e. g. 90 degrees, around an axis parallel to the axis of the linear actuator module in order to enable for different rotation axes depending on application needs. For this the interface 25 provides a universal mounting flange pattern or alternatively a corresponding adaptor bracket is used.

Figures 16, 17 show two examples of application for the tooling device 28 according Figure 15, schematically showing side views of different shaped vaulted steel planes 41, 42 which have cut outs to insert tools 26.1, 26.2 with gripping tips which are connected with the tilt motion modules 1.1, 1.2 (see Figure 14) in order to move them within a working area. These examples of application show that by means of these tilt modules 1.1, 1.2 the tools 26.1, 26.2 with gripping tip can be adjusted in a very exact manner not only for the tilt motion (around x-axis or y-axis) but for the linear motion (z-axis) too in order to adapt to the existing shape of the workpiece, here the vaulted steel planes 41, 42.

Summing up the ideas expressed in the Figures 15 – 17 other preferred embodiments of the described invention are:

- At least one tilt motion module is part of stationary mounted flexible tooling device comprising different motion modules for different degree of freedom.
- At least one tilt motion module is part of mobile mounted flexible tooling device comprising different motion modules for different degree of freedom.

Then the mobility is provided by a single or multiple degree(s) of freedom positioning device such as single axis servo positioners or industrial robot.

List of reference signs

1	1.1, 1.2, 1.3, 1.4 tilt motion module
2	first link unit
3	second link unit
4	tilt platform
5	linear cylinder actuator
6	flange for tool with gripping tip
7	rail
8	linear actuator module
9	base plate
10	drive for tilt motion
11	cylinder
12	piston rod
13	truss
14	bearing (tilt motion around x)
15	bearing (tilt motion around x)
16	bearing (tilt motion around x)
17	drive of linear actuator module for translational movement (z-direction)
18	bearing (tilt motion around y)
19	bearing (tilt motion around y)
20	bearing (tilt motion around y)
21	additional bearing
22	additional bearing
23	truss
24	truss
25	interface of linear actuator module
26	26.1, 26.2, 26.3, 26.4 tool with gripping tip
27	---
28	tooling device of a manipulator respectively industrial robot
29	base unit
30	connection interface

31	first guide rail of tooling device
32	second guide rail of tooling device
33	33.1, 33.2, 33.3, 33.4 manipulator module of tooling device
34	tooling interface of manipulator module
35	movable skid of manipulator module
36	36.1, 36.2, 36.3, 36.4 actuator
37	moving direction of manipulator modules
38	actuator
39	curved truss
40	multiple curved truss
41	vaulted steel plane
42	vaulted steel plane

A	reference area
B	reference area for flange of tilt platform

Claims

1. Tilt motion module (1, 1.1, 1.2, 1.3, 1.4) with a linear cylinder actuator (5) for tilt motion and a linear actuator module (8) for translational movement,

- where by the linear actuator module (8) possesses an interface (25) for fastening to a tooling interface (34) of a manipulator module (33, 33.1, 33.2, 33.3, 33.4) of a manipulator by preference,
- where by the linear actuator module (8) possesses a rail (7) for a linear motion compared to interface (25) and a drive (17) for said translational movement,
- where by the linear cylinder actuator (5) possesses a cylinder (11), a piston rod (12) and a drive (10) for said tilt motion,
- where by this cylinder / piston rod – unit (11/12) possesses a bearing (16, 20) for fastening to the rail (7) via a link unit (2),
- where the cylinder / piston rod – unit (11/12) possesses another bearing (15, 19) for fastening to a truss (13, 39, 40) which is equipped with a tilt platform (4) with a flange (6) for fastening to a tool (26, 26.1, 26.2, 26.3, 26.4) by preference and
- where by the truss (13, 39, 40) further possesses a bearing (14, 18) for connection with the rail (7) via a link unit (3).

2. Tilt motion module according to claim 1, characterized in that the truss is designed as a curved truss (39) or as a multiple curved truss (40).

3. Tilt motion module according to claim 1 or 2, characterized in that main linkage elements comprise curved or multiple curved truss, beam or space frame structure with light-weighted design features.

4. Tilt motion module according claim 3, characterized in that the main linkage elements are made from sheet metal.

5. Tilt motion module according claim 3, characterized in that the main linkage elements are made from composite plastics.

6. Tilt motion module according claim 3, characterized in that the main linkage elements are made as castings.

7. Tilt motion module according to any of the proceeding claims, characterized in that the truss is designed as a pantograph like truss configuration with two additional bearings (21, 22) and two additional trusses (23, 24) so that the movements of the linear cylinder actuator (5) are parallels to the rail (7).

8. Tilt motion module according to any of the proceeding claims, characterized in that cylinder (11) and drive (10) of the linear cylinder actuator (5) are fastened to a base plate (9) which is equipped with bearing (15, 19) for fastening to the truss (13).

9. Tilt motion module according to any of the proceeding claims, characterized in that its modular design uses the stiffness of an already existing linear actuator module base structure which can be optionally equipped with additional stiffeners if needed for certain applications.

10. Tilt motion module according to any of the proceeding claims, characterized in that it can be attached to the linear actuator module (8) in different angular configurations around the axis of the linear actuator module in order to enable for different rotation axes depending on application needs.

11. Tilt motion module according to claim 10, characterized in that the different angular configurations are rotated by 90 degrees.

12. Tilt motion module according to any of the proceeding claims, which is attached to the linear actuator module (8), characterized in that the linear actuator module (8) can be mounted via its interface (25) in different angular configurations around an axis parallel to the axis of the linear actuator module (8) in order to enable for different rotation axes depending on application needs.

13. Tilt motion module according to claim 12, characterized in that the interface (25) of the linear actuator module (8) provides a universal mounting flange pattern.

14. Tilt motion module according to any of the proceeding claims, characterized in that the tool (26, 26.1, 26.2, 26.3, 26.4) is designed as a tool with gripping tip.

15. Device with tilt motion module according to any of the proceeding claims, characterized in that at least one tilt motion module is part of stationary mounted flexible tooling device comprising different motion modules for different degree of freedom.

16. Device with tilt motion module according to any of the proceeding claims, characterized in that at least one tilt motion module is part of mobile mounted flexible tooling device comprising different motion modules for different degree of freedom.

17. Device with tilt motion module according to claim 16, characterized in that the mobility is provided by a single or multiple degree(s) of freedom positioning device such as single axis servo positioners or industrial robot.

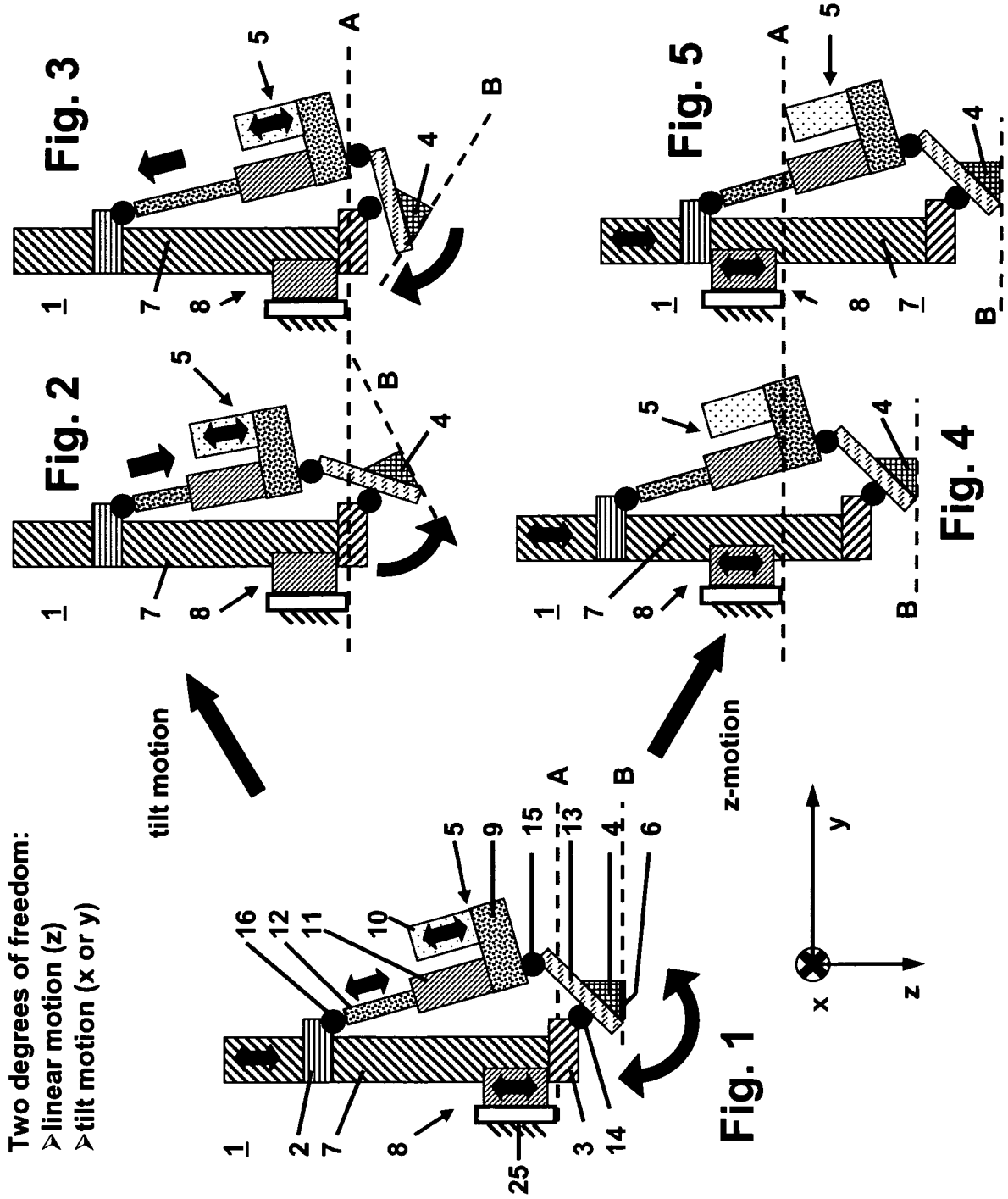


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

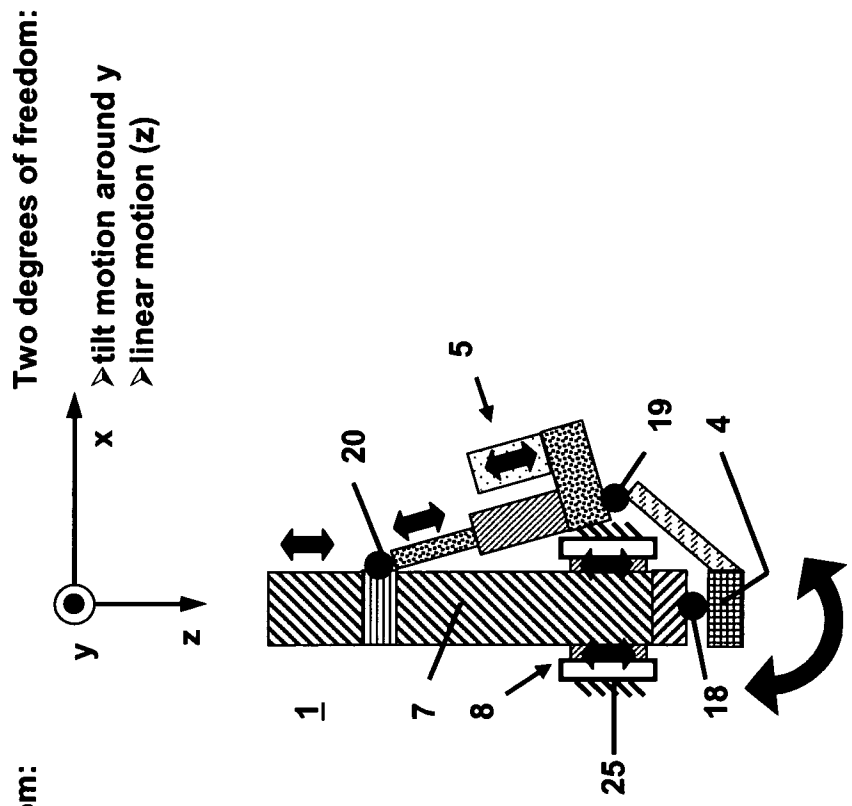

Two degrees of freedom:
➢tilt motion around y
➢linear motion (z)
x
y
z
5
20
19
4
1
7
8
18
25

Fig. 7

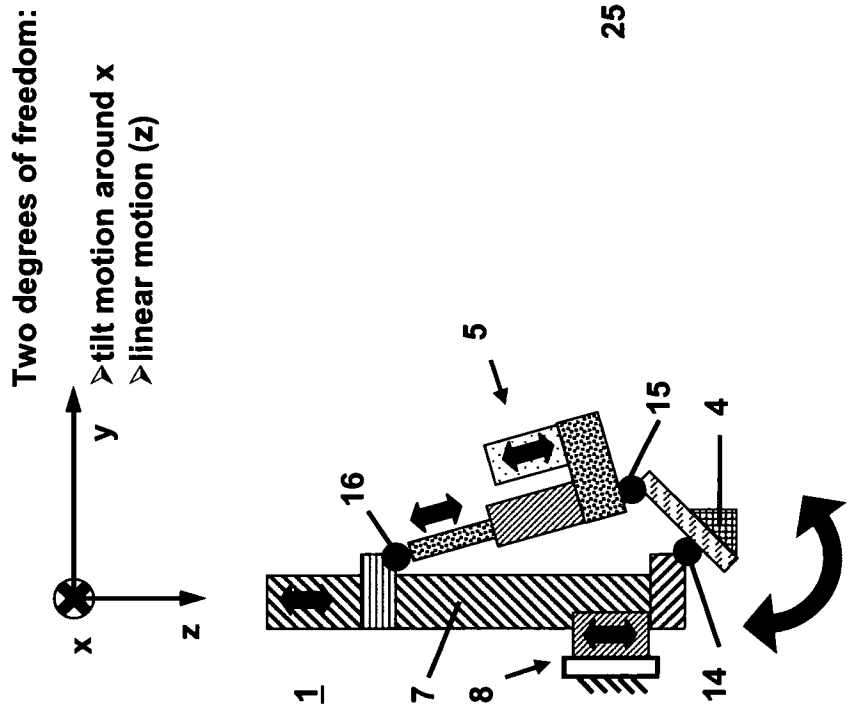

Two degrees of freedom:
➢tilt motion around x
➢linear motion (z)
y
x
z
5
16
15
4
1
7
8
14

Fig. 6

Fig. 10

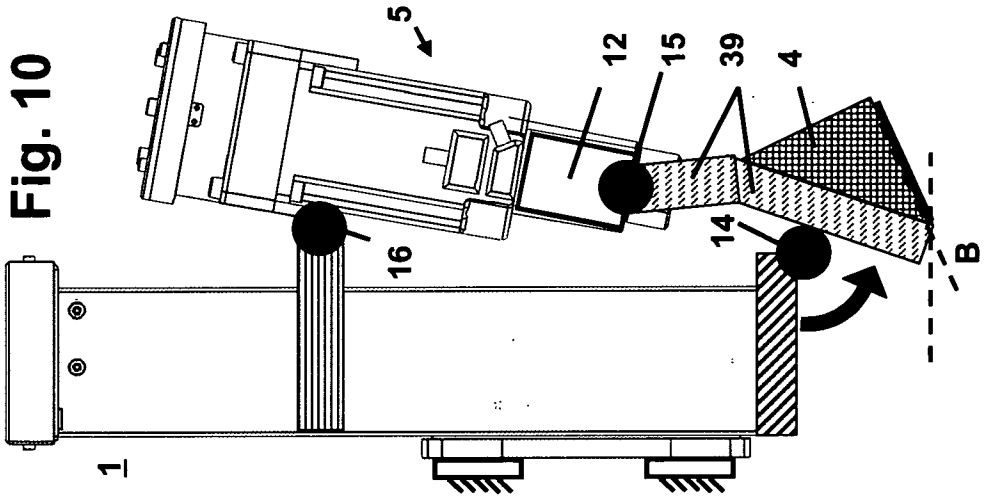


Fig. 9

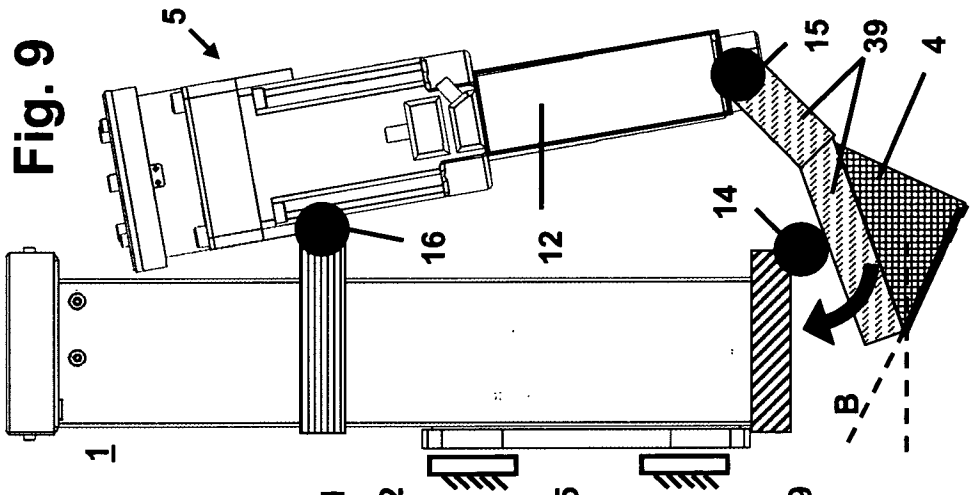
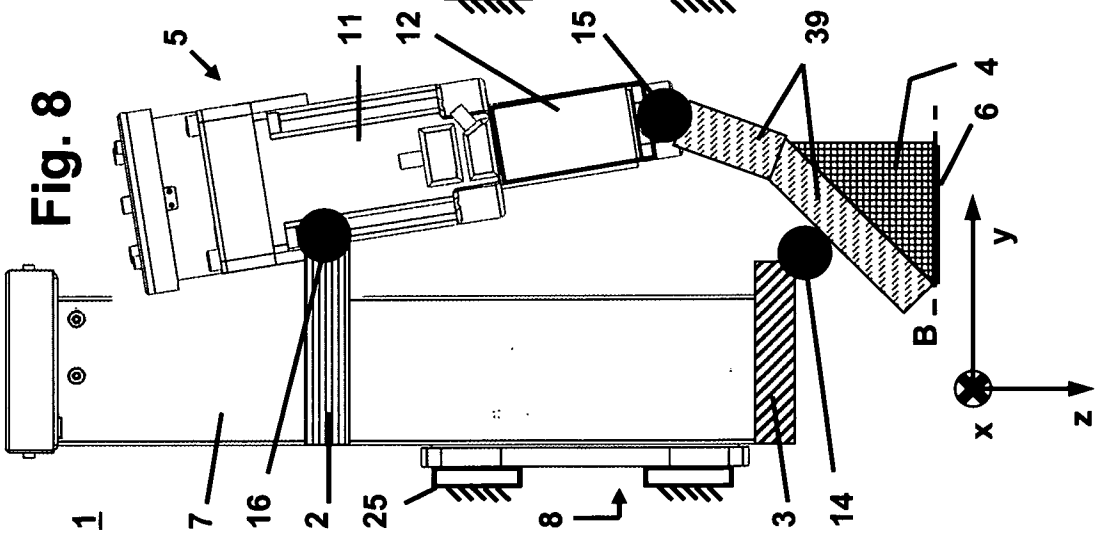


Fig. 8



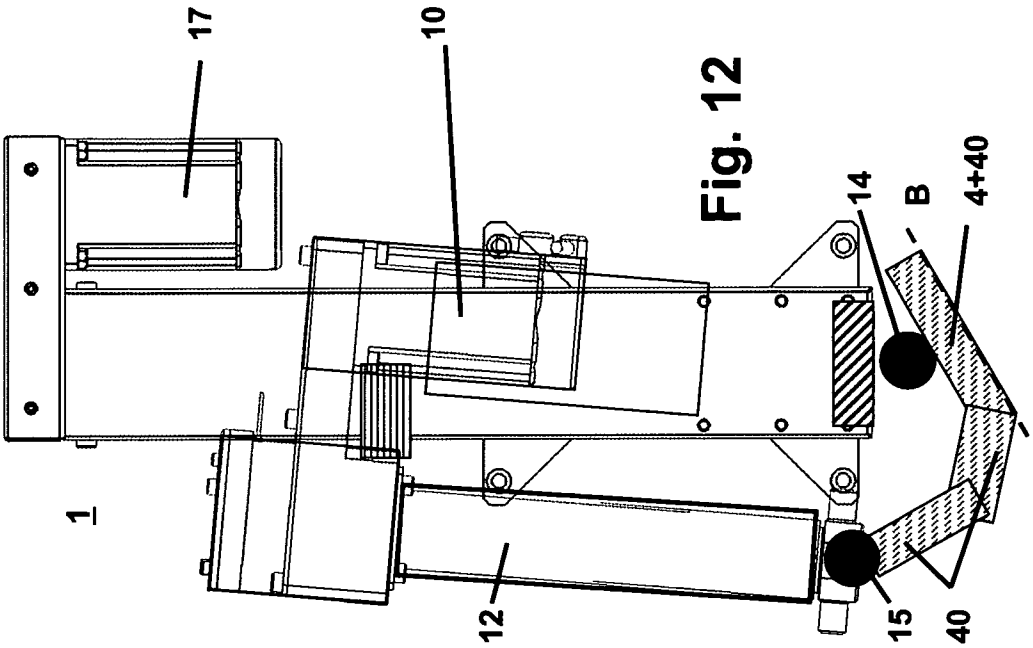


Fig. 12

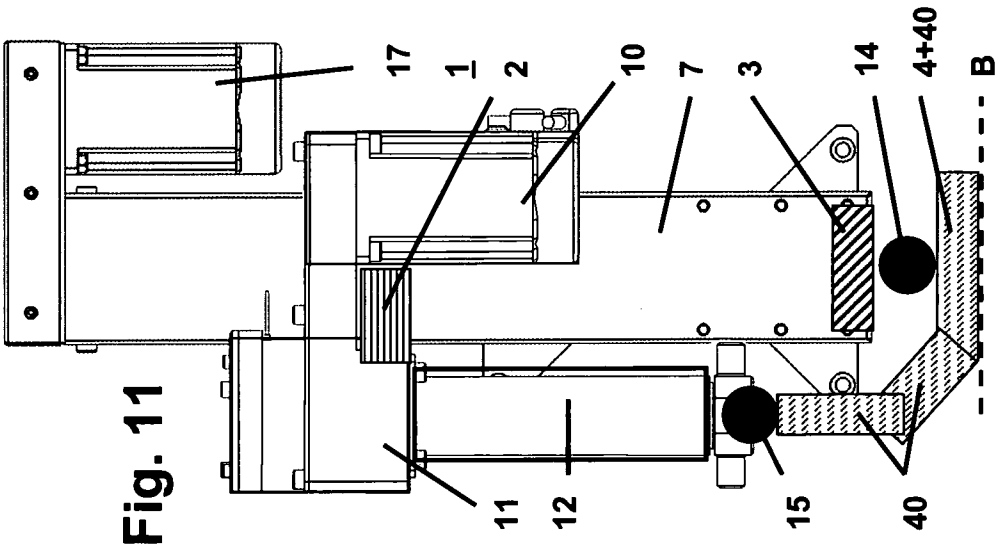


Fig. 11

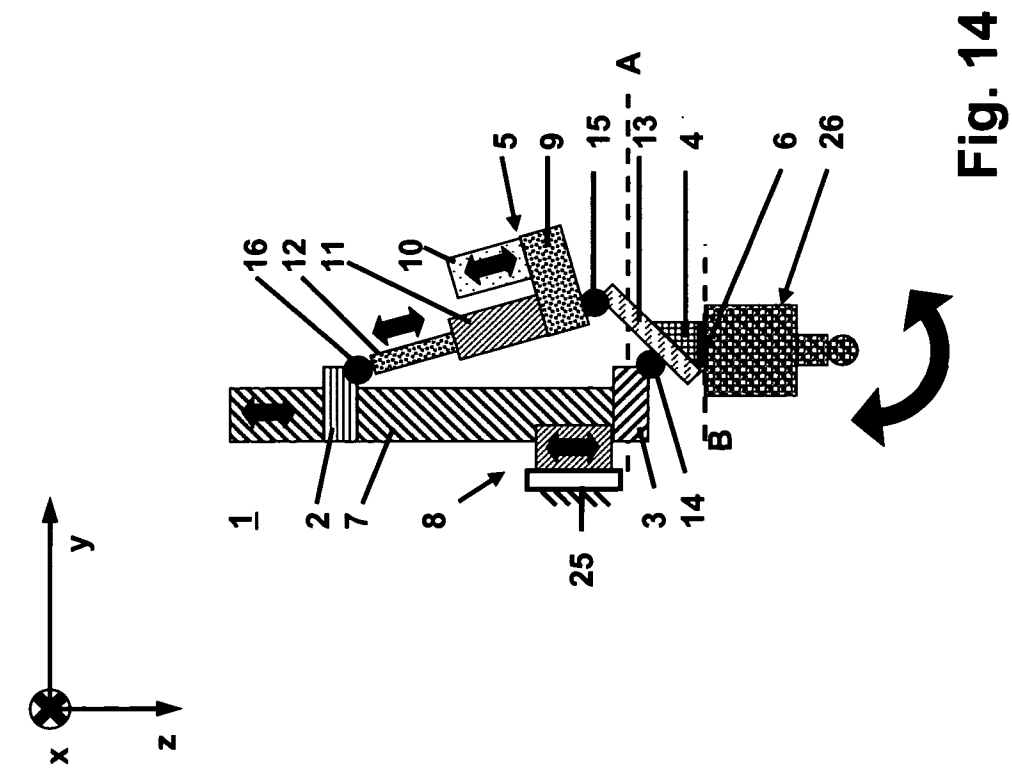


Fig. 14

Two degrees of freedom:

- linear motion (z)
- tilt motion (x or y)

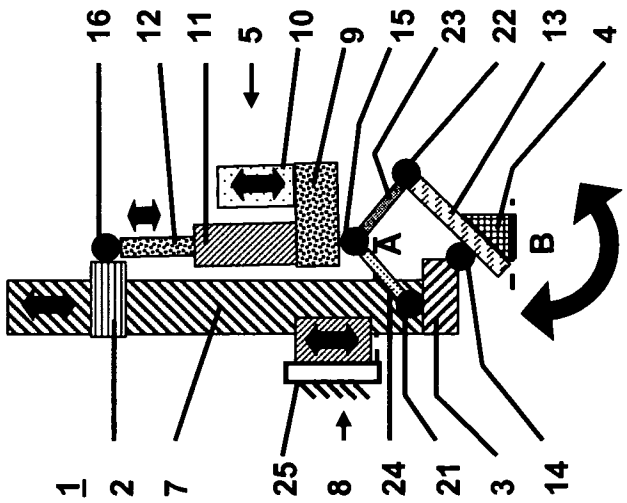


Fig. 13

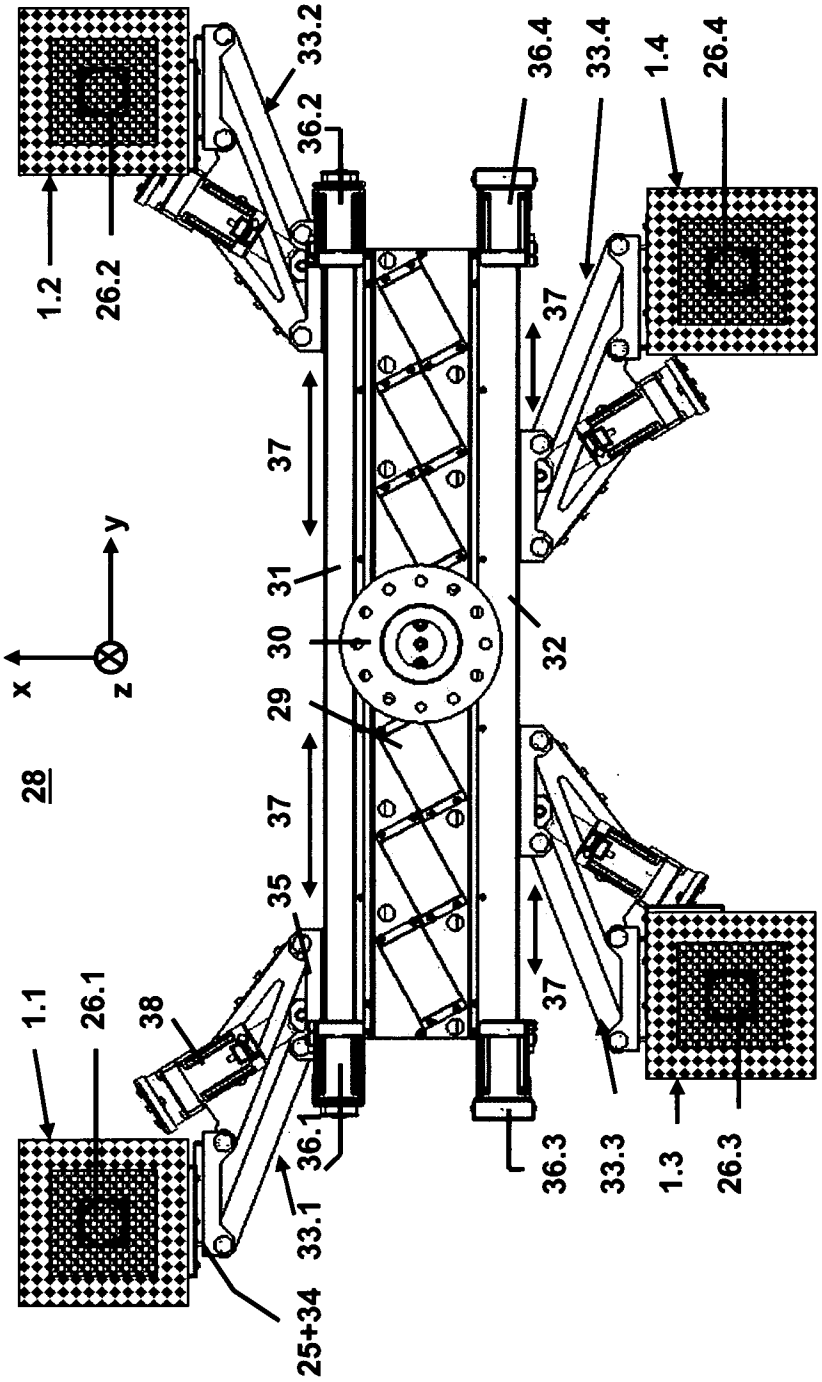

1.2
26.2
33.2
36.2
36.4
33.4
1.4
26.4
37
37
31
30
29
37
35
37
32
28
y
x
z
1.1
26.1
38
36.1
33.1
25+34
36.3
33.3
1.3
26.3

Fig. 15

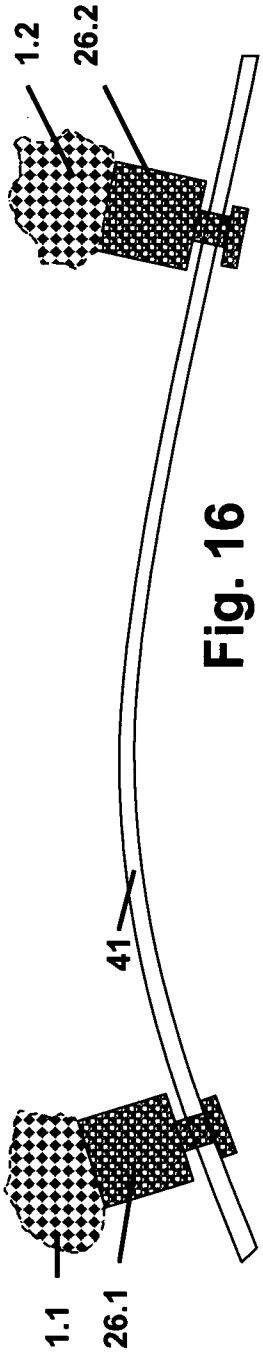


Fig. 16

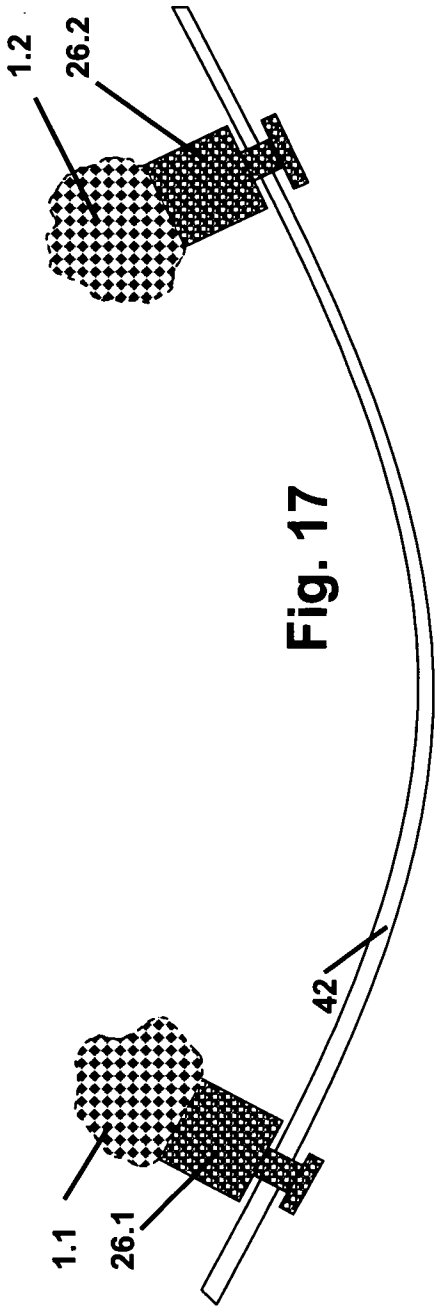


Fig. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/002277

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J9/10

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.
A	JP 11 123687 A (TSUBAKIMOTO CHAIN CO) 11 May 1999 (1999-05-11) abstract; figures	1-17
A	DE 101 28 185 A1 (FRAUNHOFER GES FORSCHUNG [DE]) 19 December 2002 (2002-12-19) paragraph [0054]; figure 4	1-17
A	EP 1 839 820 A1 (FESTO AG & CO [DE]) 3 October 2007 (2007-10-03) cited in the application paragraph [0018] - paragraph [0028]; figures	1-17
A	WO 2007/108343 A1 (HONDA MOTOR CO LTD [JP]; KATSUTANI YOSHIO [JP]) 27 September 2007 (2007-09-27) figures 1,2	1-17

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

☒ 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
20 January 2010	03/02/2010

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
PCT/EP2009/002277

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 11123687 A	11-05-1999	NONE	
DE 10128185 A1	19-12-2002	NONE	
EP 1839820 A1	03-10-2007	AT 398508 T	15-07-2008
		CN 101045296 A	03-10-2007
		ES 2306316 T3	01-11-2008
		JP 2007260897 A	11-10-2007
		KR 20070097371 A	04-10-2007
		PT 1839820 E	03-07-2008
		US 2007233320 A1	04-10-2007
WO 2007108343 A1	27-09-2007	CN 101454126 A	10-06-2009
		JP 2007253249 A	04-10-2007
		US 2009206216 A1	20-08-2009