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(71) Applicant (for all designated States except US): **NEW-SOUTH INNOVATIONS PTY LTD** [AU/AU]; Rupert Myers Building, Gate 14, Baker Street, UNSW, Sydney, NSW 2052 (AU).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **VITTOR, Timothy, Ramford** [AU/AU]; 15 Oklahoma Avenue, Toongabie, NSW 2146 (AU). **WILLGOSS, Richard, Adrian** [AU/AU]; 10 Terranora Place, Bangor, NSW 2234 (AU).

(74) Agent: **GRIFFITH HACK**; GPO Box 4164, Sydney, NSW 2001 (AU).

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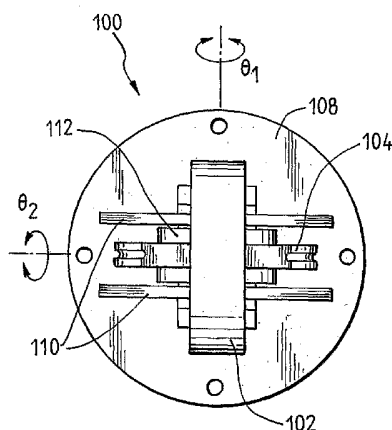
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(54) Title: A MECHANICAL JOINT STRUCTURE



(57) Abstract: A joint (100) arranged to interconnect two elements (102, 104) to allow relative movement to those elements, the joint comprising a first member (102) operative to be connected to one of the elements and a second member (104) operative to be connected to the other element, the second member (104) being coupled to the first member (102) so as to be movable relative to the first member (102) about a first axis, wherein the second member (104) includes first and second parts that are movable relative to each other about a second axis that intersects the first axis so as to allow the joint to rotate through two rotational degrees of freedom around a common point.

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A MECHANICAL JOINT STRUCTUREField of the Invention

5 The present invention relates to a mechanical joint to allow relative movement between two elements. The invention has been developed especially, but not exclusively, to a mechanical joint structure for use in a manipulator. In a further aspect, the invention relates
10 to a manipulator element, or module, incorporating the mechanical joint and to a manipulator that incorporates a plurality of elements interconnected by the joint.

Background of the Invention

15

Joints are commonly employed to connect elements in a mechanical device together and to allow those elements to be moved relative to one another. The range of movement permitted may be defined by means of the degrees of
20 freedom of the joint. For example, a joint may have one degree of freedom (e.g. a hinge on a door) that allows movement solely about one axis, or two or more degrees of freedom (e.g. a universal joint in a vehicle drive train has two degrees of freedom) that allows movement about
25 multiple axes.

Powered mechanical devices that provide articulation of individual elements are generally bulky and cumbersome. Furthermore, devices that permit movement of elements through multiple degrees of freedom often use multiple
30 joints (each allowing a single degree of freedom of movement) that are spaced apart (e.g. the universal joint in a vehicle drive train). These arrangements are preferred over the use of a single joint that can provide

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multiple degrees of freedom (such as a ball and socket type joint) as such joints are difficult to control precisely without the use of elaborate control mechanisms.

5 Summary of the Invention

In a first aspect, the invention provides a joint comprising at least two members attached in a manner to allow the joint structure to rotate through two rotational
10 degrees of freedom around a common point.

In one form, the joint permits relative movement of the members along first and second arcuate paths to permit rotational movement about first and second axes that intersect one another. In this way the members are used
15 to rotate relative to one another through the two rotational degrees of freedom.

In a second aspect, the present invention provides a joint arranged to interconnect two elements to allow relative movement of those elements, the joint comprising
20 a first member operative to be connected to one of the elements and a second member operative to be connected to the other element, the second member being coupled to the first member so as to be movable relative to the first member about a first axis, wherein the second member
25 includes first and second parts that are movable relative to each other about a second axis that intersects the first axis so as to allow the joint to rotate through two rotational degrees of freedom around a common point.

In one form, the first and second axes are
30 orthogonal.

In one form, each of the first and second members includes attachment means enabling the joint to be connected to the elements. In another form, at least one

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of the members is integrally formed with the element to which it is connected, thereby obviating the need for the attachment means.

5 In one form, the first and second members are movable along an arcuate path that constrains the relative movement of the first and second members to movement about the first axis.

10 In one form, the first and second parts of the second member are also movable along an arcuate path that constrains the relative movement of the first and second parts of the second member to movement about the second axis.

In one form, the amount of rotation of the joint about at least one of the respective axes is restricted.
15 In one form, the rotation about one of the axes is less than 180°.

In one form, the first member includes a mounting portion that has an inner surface that defines an aperture in which at least a part of the second member is located.
20 In one form, the arcuate bearing surfaces are formed by portions of the inner surface of the mounting portion and the outer surface of the second member.

In one form, the first part of the second member connects to the other element so that the second part is
25 movable relative to the other element (about the second axis) and is movable relative to the one element (about the first axis).

In one form, the first part of the second member is positioned at the centre of rotation of the joint.

30 In one form, the mounting portion of the first member, and the second member, are generally planar structures. In a particular form, the first part of the second member is positioned at the centre of rotation of

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the joint, with the second part being displaced radially outwardly from the first part in a first plane. The mounting portion of the first member, which is also displaced outwardly from the first part of the second member, lies in a second plane that is orthogonal to the first plane.

In one form, a first actuator is connected to the first member, to provide relative movement of the first and second members about the first axis.

In one form, the second part of the second member is connected to a second actuator that is operative to provide relative movement of the first and second parts of the second member about the second axis.

In a further aspect, the invention relates to a manipulator that incorporates first and second elements that are interconnected by a joint, the joint permitting relative movement of the elements along first and second arcuate paths to permit rotational movement about first and second axes which intersect one another to allow the elements to rotate through two rotational degrees of freedom around a common point.

In one form, the joint is in accordance with the second aspect described above, with the first member connected to one of the elements, and the second member connected to the other element.

It is to be appreciated that the connection between either or both of the joint members and the manipulator elements may be such that those parts are integrally formed together, or the parts may be formed separately and be subsequently interconnected.

In yet a further aspect, the invention relates to a manipulator module comprising a body having spaced apart first and second ends, a joint connected to the body at or

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adjacent the first end and incorporating attachment means allowing connection of the module with the second end of another said module, wherein when so connected, the joint allows the connected modules to rotate relative to one
5 another through two rotational degrees of freedom.

In one form, the joint is in accordance with any form described above. In a particular embodiment, the second member of the joint is connected to the module body, and the first member incorporates the attachment means that
10 allows for connection of the module with another said module.

In one form, the attachment means is in the form of a plate that is spaced from the first end of the module body.

15 In one form, the module includes an actuation system that is disposed within the module body and is operative to move the module relative to another module to which it is connected through the joint through the two degrees of freedom.

20 In one form, the actuation system comprises first and second actuators operative to move the joint through respective ones of the first and second degrees of freedom.

In one form, the actuators are cable drives and the
25 actuation system further comprises at least one drive mounted within the body and operative to impart translation to the cables to induce relative movement in the joint.

30 Detailed Description of the Drawings

Features of the present invention will be presented in a description of an embodiment thereof, by way of

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example, with reference to the accompanying drawings, in which:

Figures 1a, 1b and 1c are a top view, a side view and a perspective view (respectively) of a joint in accordance with an embodiment of the present invention;

Figures 2a and 2b are a side view and a perspective view (respectively) of a manipulator module frame in accordance with an embodiment of the present invention;

Figures 3a and 3b are a side view and a perspective view (respectively) of the joint structure of Figures 1a, 1b and 1c when located within the manipulator module frame of Figures 2a and 2b;

Figures 4a and 4b are a side view and a perspective view (respectively) of a portion of an actuation means in accordance with an embodiment of the present invention;

Figure 5 is a representative diagram depicting the interconnection between elements of the actuation means in accordance with an embodiment of the present invention;

Figures 6a, 6b and 6c are a top view, a side view and a perspective view (respectively) of a pulley which forms part of the actuation means in accordance with an embodiment of the present invention;

Figures 7a and 7b are a side view and a perspective view (respectively) of a manipulator module in accordance with an embodiment of the present invention; and

Figures 8a and 8b are a side view and a perspective view (respectively) of an assembled manipulator in accordance with an embodiment of the present invention.

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Description of a Specific Embodiment

In the following description of an embodiment of the present invention, the same numeration has been utilised
5 across all Figures, unless indicated otherwise.

Referring to Figures 1a, 1b and 1c in particular, there is shown a joint structure 100 in accordance with an embodiment of the present invention. The joint structure 100 includes at least two members 102 and 104 which are
10 arranged to permit relative movement of the members about first and second axes. This allows the two members to rotate relative to one another through two degrees of freedom. The joint structure is capable of interconnecting two elements (not shown in Figures 1a, 1b
15 and 1c), so that the two elements may move, relative to each other, about a common axis. The joint structure 100, and in particular members 102 and 104, to actuation means (not shown in Figures 1a, 1b and 1c) to provide controlled movement.

20 In more detail, the joint structure 100 includes a first member 102 and a second member 104 which are coupled together so that first member 102 is moveable relative to second member 104. That is, the joint can move in the directions generally denoted by angles θ_1 and θ_2 . The axes
25 of first member 102 and second member 104 intersect so that they provide a joint structure which has two degrees of freedom about a common point. As can be seen in Figures 1a, 1b and 1c, in a particular embodiment, the axes are orthogonal.

30 The first member 102 and the second member 104 are connected through a bearing 106, such that each member may move independently of the other.

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The first member 102 includes attachment first part 108, being a substantially planar structure in the form of a plate. The first part 108 allows the joint to interconnect to a first element (not shown). An

5 attachment second part 110 is also provided to connect the second member 104 to a second element (not shown). This allows the joint to move the first element relative to the second element. The attachment second part 110 may also be substantially planar.

10 It will be understood that the attachment parts may be integrally moulded with the element.

As may be seen from Figures 1a, 1b and 1c, the first and second members 102 and 104 are each movable along an arcuate path that constrains the movement of first and
15 second members 102 and 104 to movement about a first axis θ_1 .

The second member 104 includes a first part 109a and an arcuate second part 109b which are constrained to movement in an arcuate path about a second axis θ_2 . In the
20 embodiment shown, the first part 109a is located at the centre of rotation of the joint 100.

Furthermore, as is apparent from the embodiment disclosed herein, the amount of rotation of the joint about each axis is necessarily limited by interference
25 with the elements. Generally, the total rotation about each one of the axes will be less than 180° , and most likely around 90° .

The first member 102 includes a mounting portion 105, into which the second member 104 is located. The mounting
30 portion has an inner surface 107 in which the bearing 106 resides. The inner surface 107 (in combination with the outer surface of the second member 104) defines the arcuate path through which the two members may move.

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A second attachment part 110 is provided on the first part 109a so that the joint 100 can be connected to the other element. This allows the second attachment part 110 to move relative to the second element about the axis θ_2 and moveable to the first element about the axis θ_2 . The second attachment part 110 is displaced radially outward from the arcuate second part 109b in the direction of the first axis θ_1 . Conversely, the first attachment part 108 is displaced outwardly from the second attachment part 110, and lies in a plane which is orthogonal to axis θ_1 .

In the present embodiment, there is provided a further bearing 112 between the first part 109a and the second member 104.

Figures 2a and 2b depict a body 114 for a manipulator module. The body 114 is arranged to receive the joint structure 100 at an end 116, and is capable of interfacing with another body for a manipulator module (not shown) at another end 118.

Figures 3a and 3b depict the joint structure 100 located within the frame 114 to form a bare manipulator module 120. The frame 114 is also arranged to receive the actuation means 122, a portion of which is depicted at Figures 4a and 4b. A first actuator is connected to the first member 102, to provide relative movement of the first and second members 102 and 104 about the axis θ_1 . Correspondingly, a second actuator is connected to the second member 104, to provide relative movement of the first arcuate part 109 and the attachment second part 110 about the axis θ_2 .

The actuation means 122 includes a motor 124 which drives a gear head 126. The gear head drives a belt drive or a screw drive (not shown in the Figures) which in turn drives a linear actuator in the form of a ball screw 128

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(shown in Figure 5). The linear actuator 128 drives a tension drive 130, which in the present embodiment includes a cable 132. The cable 132 is connected at one end to the arc shaped portion of the joint 134, and at the other end to a pulley 136 (shown in detail in Figures 6a, 6b and 6c), to allow for bidirectional control of the joint.

In other words, when the motor 124 is activated, the gear head 126 is driven, which in turn drives the linear actuator 128, causing the cable drive 130 to move, thereby moving the joint through an angle θ . It will be understood that a similar actuator means is utilised for both arc shaped portions, thereby providing motorised control for both degrees of freedom of the joint structure.

An assembled manipulator module 138 is shown in Figures 7a and 7b. As can be seen, the manipulator module is relatively compact in size, is completely self contained (i.e. all driving parts are contained within the manipulator module), and the attachment plates allow the manipulator module to be easily connected to another module, as shown in Figures 8a and 8b. In another embodiment, the manipulator may be integrally formed, such that the joint is integrally formed with either one or both of the elements on each side of the joint.

The manipulator module may include communication means, which may take the form of an electronic interface (i.e. an electronic bus) that interfaces the motors to a control means. The control means may use any type of communication technology, such as wireless, electrical wired or optical wired interfaces. The control means may be a control pad (such as a joystick) in the case of a manually controlled manipulator module, or it may be a

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computing means (such as a microcontroller or a computer)
in the case of a programmable manipulator module. In
other embodiments, the communication means and the
microcontroller (or equivalent) may be wholly contained
5 within each module, such that each module may operate
independently of other modules.

The control means may also be assisted by any one or
more of a variety of external sensors or other input
devices. The manipulator module may also incorporate
10 appropriate sensors which may be required to sense the
surrounding environment, to avoid obstacles or to provide
information on some external condition, such as
temperature, humidity, etc. In one particular embodiment,
the sensor may be an optical encoder or a camera, which
15 may be used to measure the proximity of obstacles.
Another possible sensor could be a pressure sensor, which
may be used to determine whether the manipulator module
has come into contact with an external object.

Whilst the joint structure described herein is shown
20 located within a conventional manipulator module, it will
be understood that the joint can find use in any suitable
application where such a joint is required.

It will also be understood that whilst manipulator
modules of a similar size are depicted in the Figures,
25 modules of different sizes may be coupled together, as
required for particular applications. For example, a
larger module may be used at the base of the manipulator,
to improve stability. Such variations and modifications
are contemplated by embodiments of the present invention.

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CLAIMS:

1. A joint comprising at least two members attached in a manner to allow the joint structure to rotate through two rotational degrees of freedom around a common point.
5
2. The joint in accordance with Claim 1, wherein the joint permits relative movement of the members along first and second arcuate paths to permit rotational movement about first and second axes that intersects one another.
10
3. A joint arranged to interconnect two elements to allow relative movement of those elements, the joint comprising a first member operative to be connected to one of the elements and a second member operative to be connected to the other element, the second member being coupled to the first member so as to be movable relative to the first member about a first axis, wherein the second member includes first and second parts that are movable relative to each other about a second axis that intersects the first axis so as to allow the joint to rotate through two rotational degrees of freedom around a common point.
15
20
4. A joint in accordance with Claim 3, wherein the first and second axes are orthogonal.
25
5. A joint in accordance with Claim 4, wherein each of the first and second members includes attachment means enabling the joint to be connected to the elements.
30
6. A joint in accordance with Claim 5, wherein the first and second members are movable along an arcuate path that

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constrains the relative movement of the first and second members to movement about the first axis.

7. A joint in accordance with Claim 6, wherein the first
5 and second parts of the second member are also movable along an arcuate path that constrains the relative movement of the first and second parts of the second member to movement about the second axis.

10 8. A joint in accordance with Claim 7, wherein the amount of rotation of the joint about at least one of the respective axes is restricted.

9. A joint in accordance with Claim 8, wherein the
15 rotation about one of the axes is less than 180°.

10. A joint in accordance with Claim 9, wherein the first member includes a mounting portion that has an inner surface that defines an aperture in which at least a part
20 of the second member is located. In one form, the arcuate path is defined by portions of the inner surface of the mounting portion and the outer surface of the second member.

25 11. A joint in accordance with Claim 10, wherein the first part of the second member connects to the other element so that the second part is movable relative to the other element (about the second axis) and is movable relative to the one element (about the first axis).

30 12. A joint in accordance with Claim 11, wherein the first part of the second member is positioned at the centre of rotation of the joint.

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13. A joint in accordance with Claim 12, wherein the mounting portion of the first member, and the second member, are generally planar structures.

5

14. A joint in accordance with Claim 13, wherein the first part of the second member is positioned at the centre of rotation of the joint, with the second part being displaced radially outwardly from the first part in
10 a first plane.

15. A joint in accordance with Claim 14, wherein the mounting portion of the first member, which is also displaced outwardly from the first part of the second
15 member, lies in a second plane that is orthogonal to the first plane.

16. A joint in accordance with Claim 15, wherein a first actuator is connected to the first member, to provide
20 relative movement of the first and second members about the first axis.

17. A joint in accordance with Claim 16, wherein the second part of the second member is connected to a second
25 actuator that is operative to provide relative movement of the first and second parts of the second member about the second axis.

18. A manipulator comprising first and second elements
30 that are interconnected by a joint, the joint permitting relative movement of the elements along first and second arcuate paths to permit rotational movement about first and second axes which intersects one another to allow the

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elements to rotate through two rotational degrees of freedom around a common point.

19. A manipulator in accordance with Claim 18, including
5 the joint in accordance with Claim 3, wherein the first member is connected to one of the elements, and the second member is connected to the other element.

20. A manipulator module comprising a body having spaced
10 apart first and second ends, a joint connected to the body at or adjacent the first end and incorporating attachment means allowing connection of the module with the second end of another said module, wherein when so connected, the joint allows the connected modules to rotate relative to
15 one another through two rotational degrees of freedom.

21. A manipulator module in accordance with Claim 20,
wherein the second member of the joint is connected to the module body, and the first member incorporates the
20 attachment means that allows for connection of the module with another said module.

22. A manipulator module in accordance with Claim 21,
wherein the attachment means is in the form of a plate
25 that is spaced from the first end of the module body.

23. A manipulator module in accordance with Claim 22,
including an actuation system that is disposed within the module body and is operative to move the module relative
30 to another module to which it is connected through the joint through the two degrees of freedom.

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24. A manipulator module in accordance with Claim 23,
wherein the actuation system further comprises first and
second actuators operative to move the joint through
respective ones of the first and second degrees of
5 freedom.

25. A manipulator module in accordance with Claim 24,
wherein the actuators are tension drives and the actuation
system further comprises at least one drive mounted within
10 the body and operative to impart translation to the cables
to induce relative movement in the joint.

26. A manipulator module in accordance with Claim 25,
further comprising a proximity sensor arranged to detect
15 the distance between the manipulator module and at least
one external object.

27. A manipulator module in accordance with any one of
Claims 20 to 26, further comprising means to communicate
20 with a control source.

28. A manipulator module in accordance with Claim 27,
wherein the control source is a computational means.

25 29. A manipulator module in accordance with Claim 28,
wherein the computational means is a microprocessor housed
within the manipulator module.

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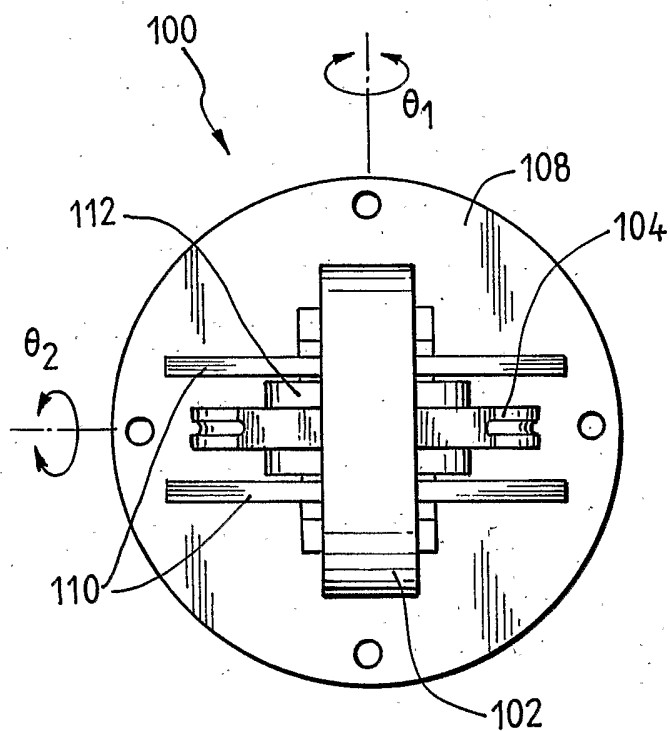


Figure 1a

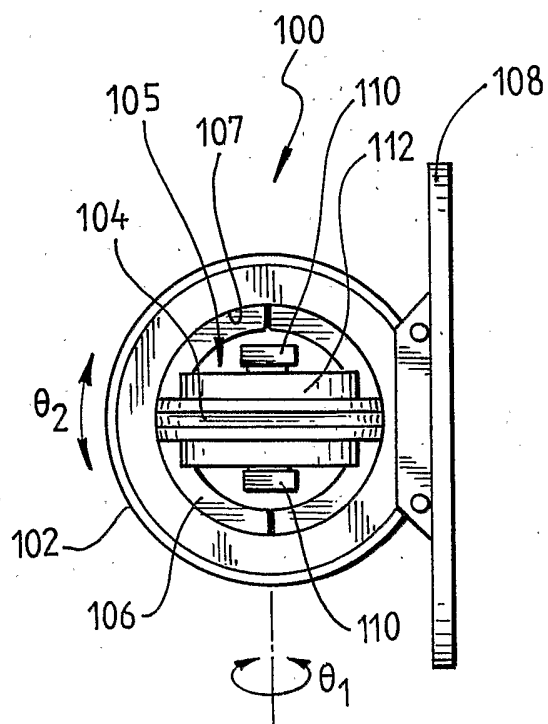


Figure 1b

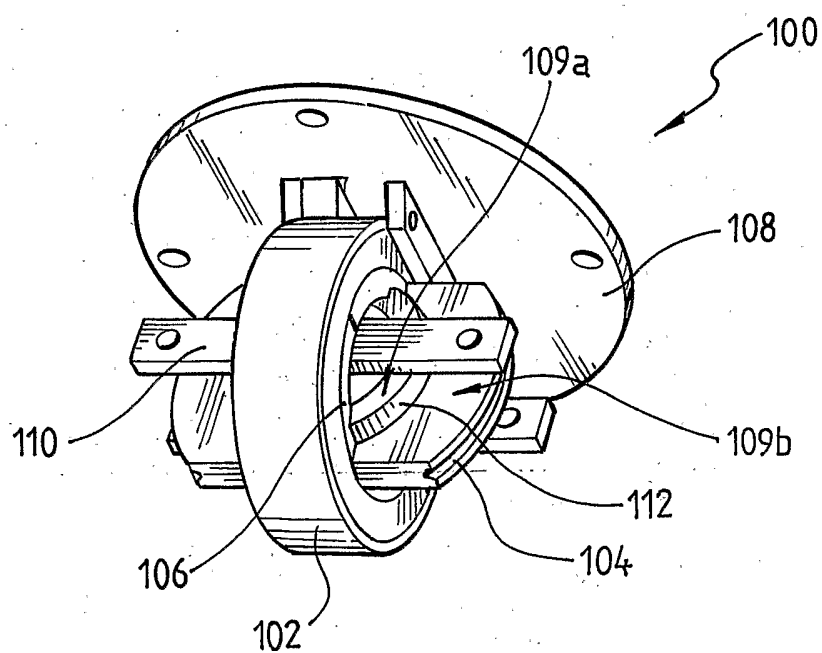


Figure 1c

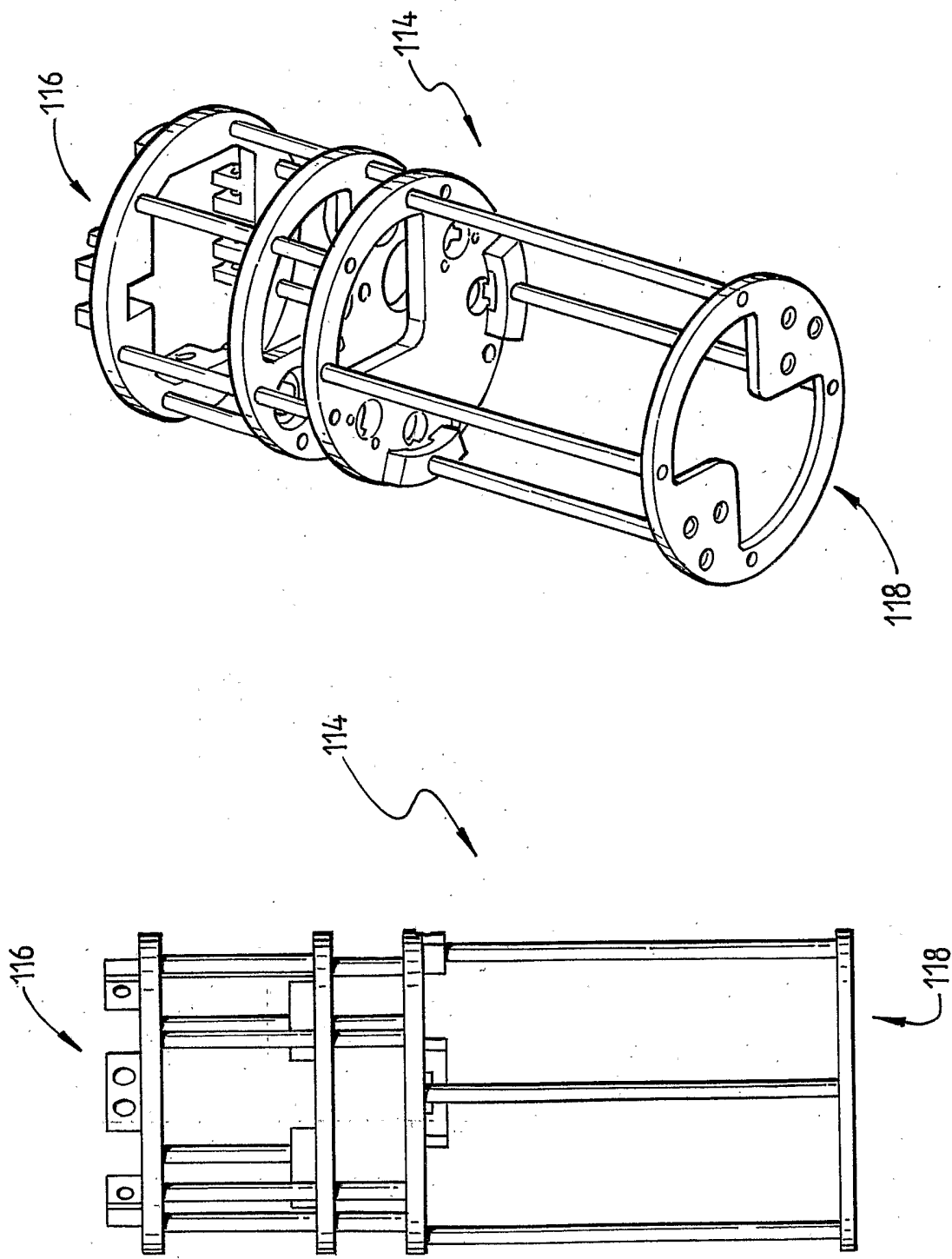


Figure 2b

Figure 2a

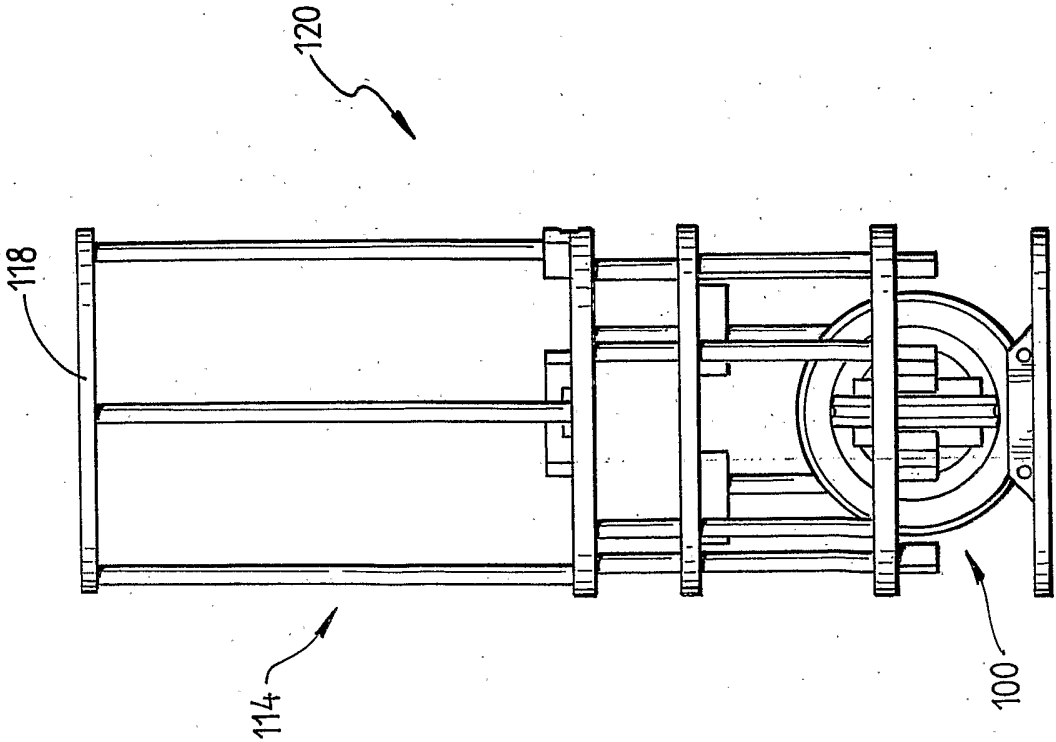


Figure 3a

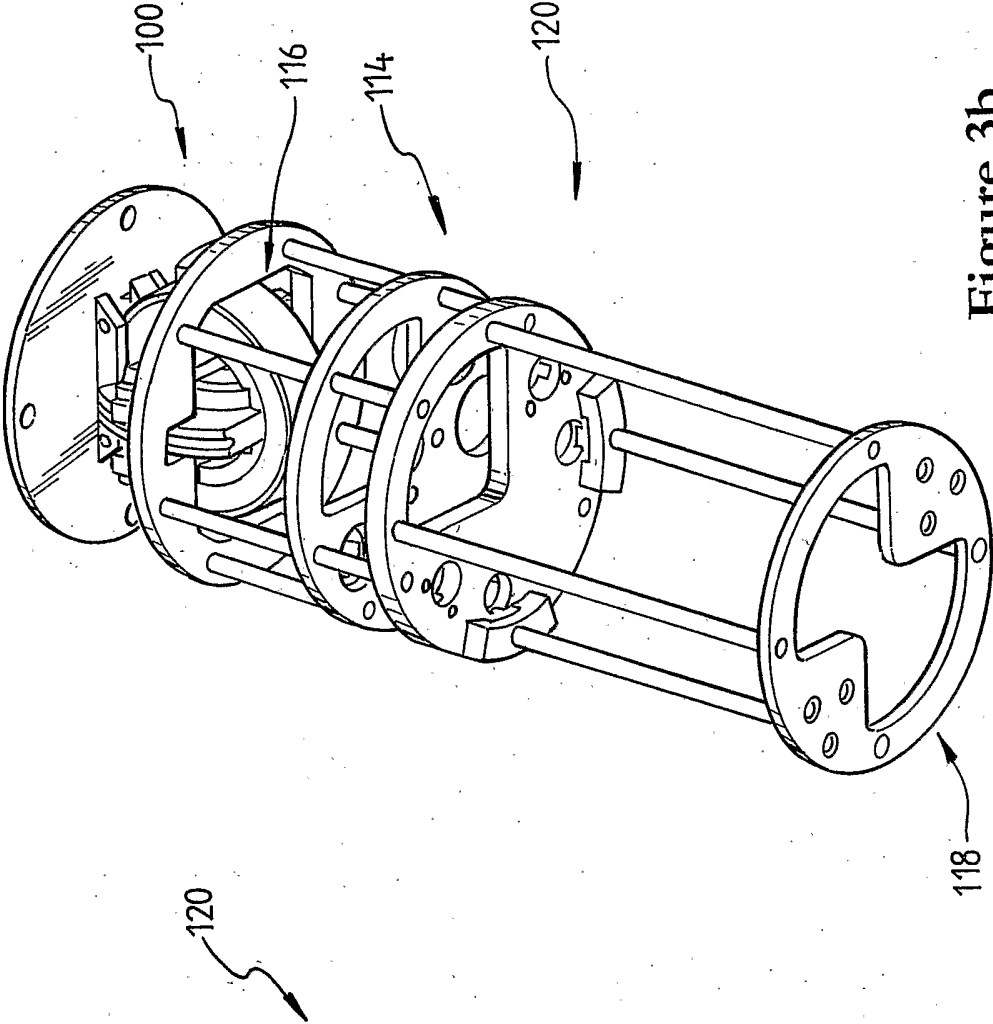


Figure 3b

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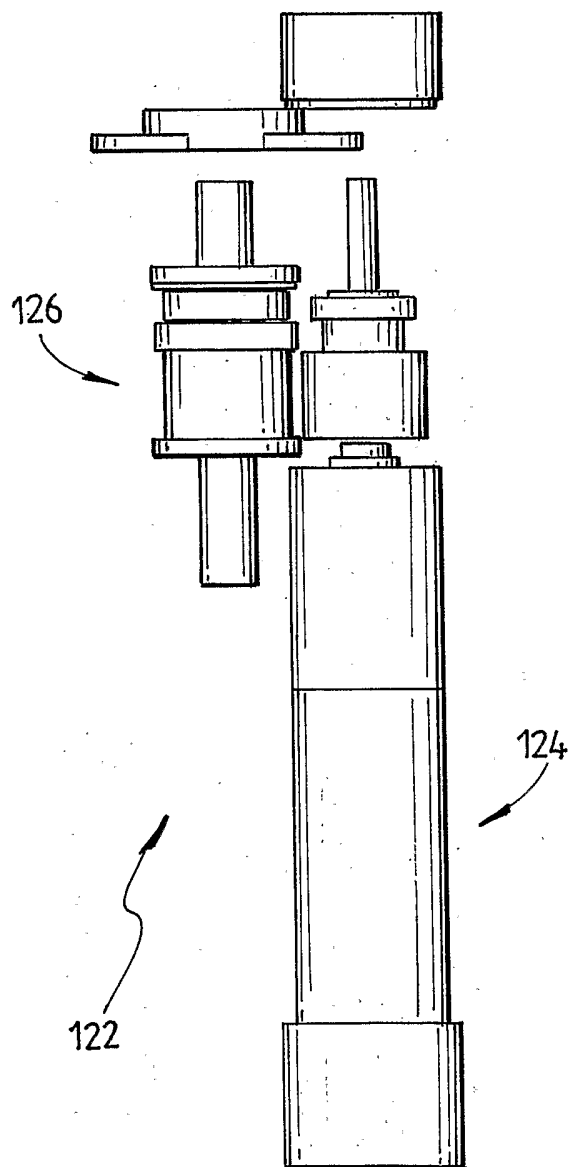


Figure 4a

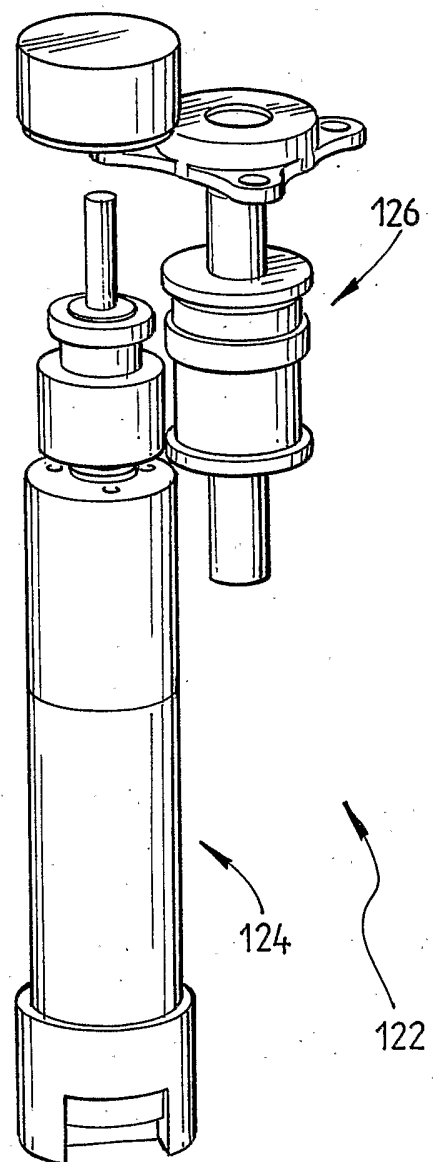


Figure 4b

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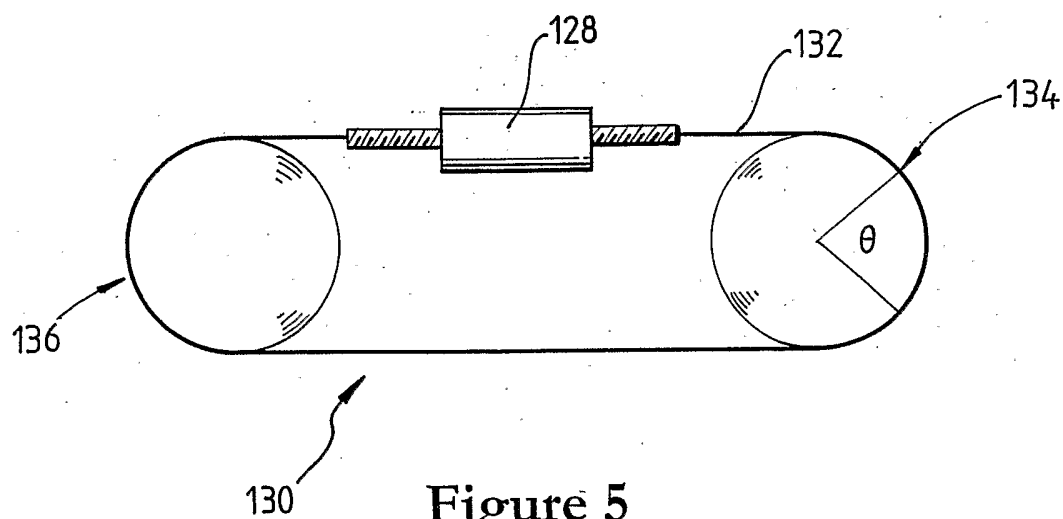


Figure 5

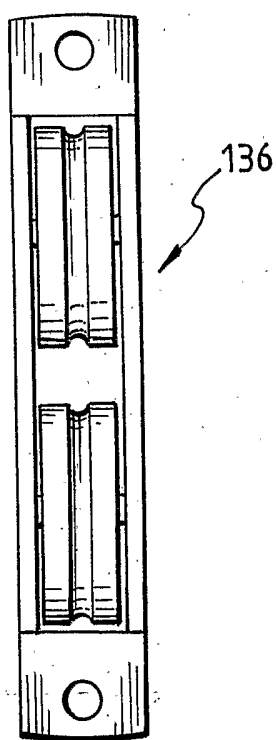


Figure 6a

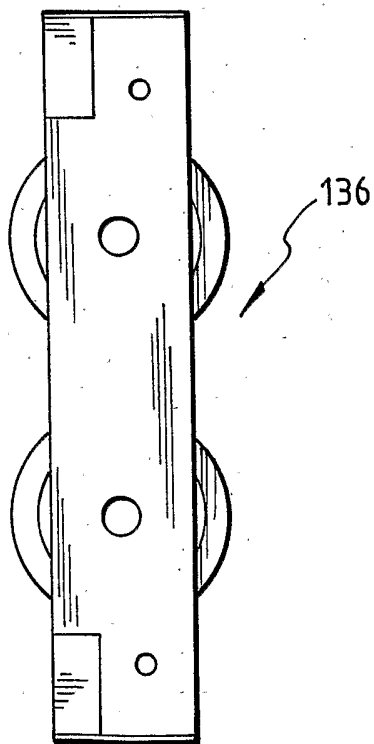


Figure 6b

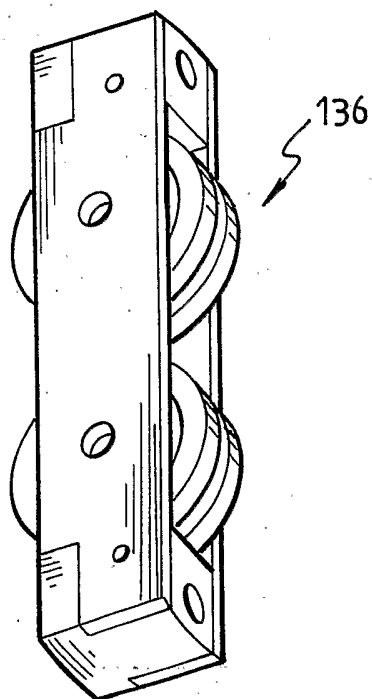


Figure 6c

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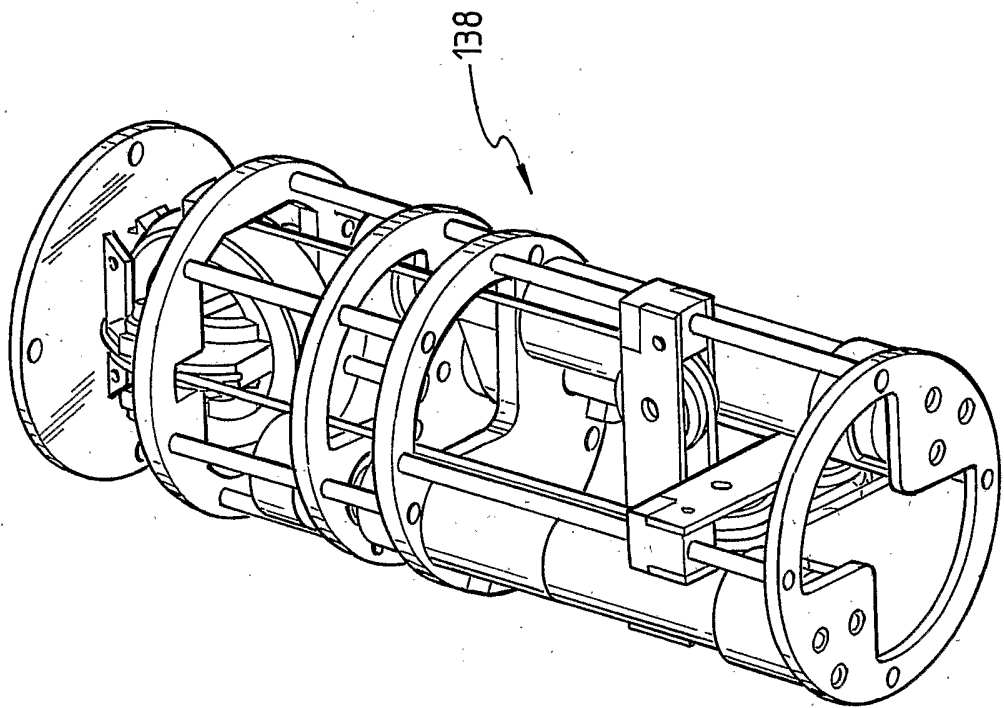


Figure 7b

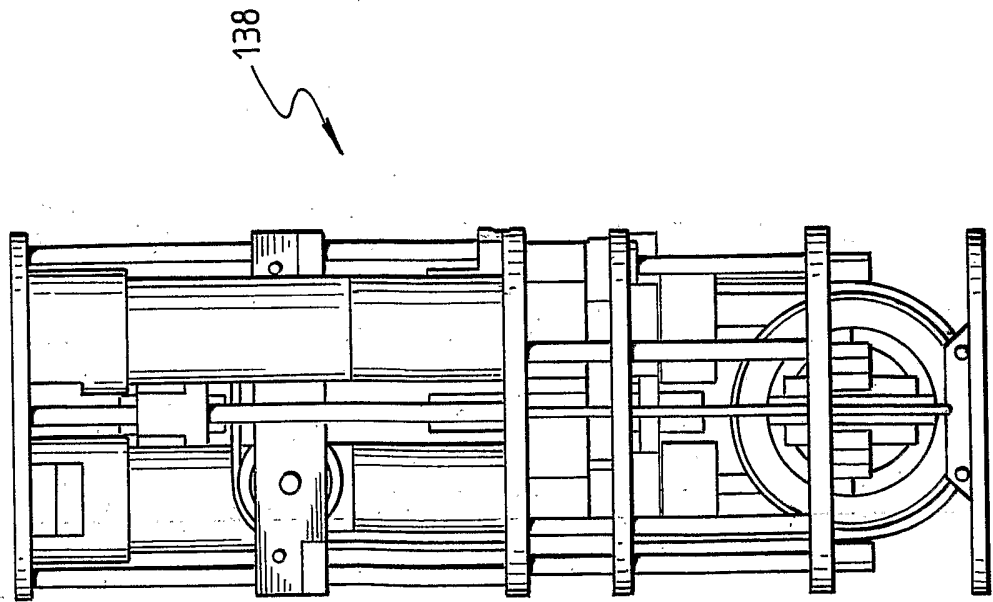


Figure 7a

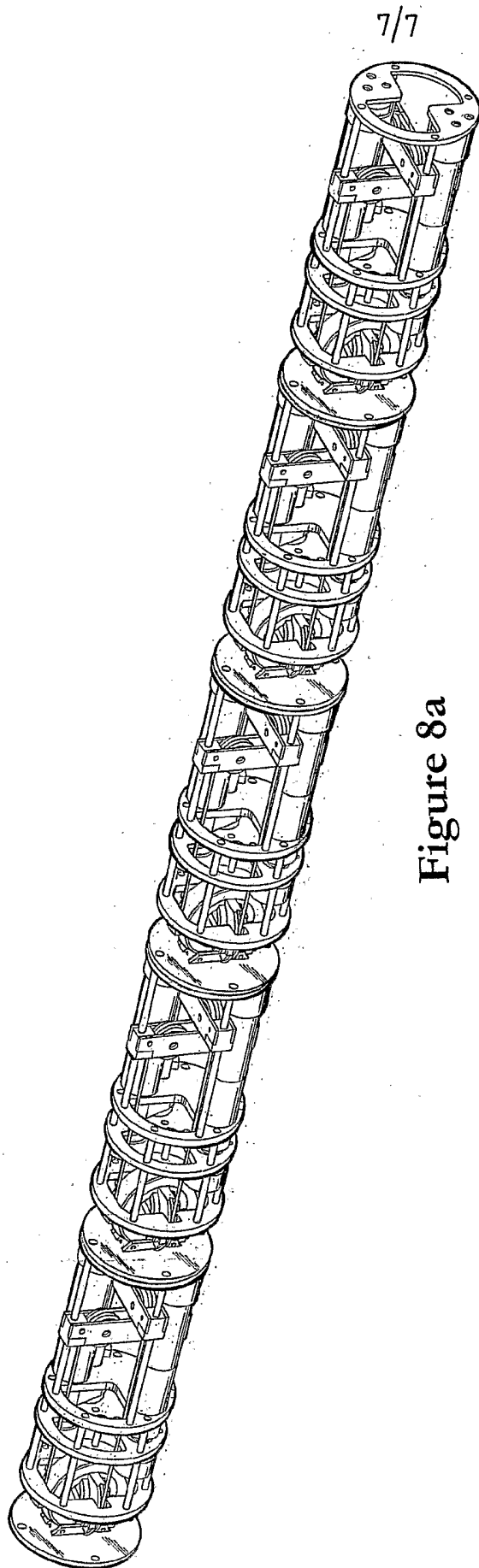


Figure 8a

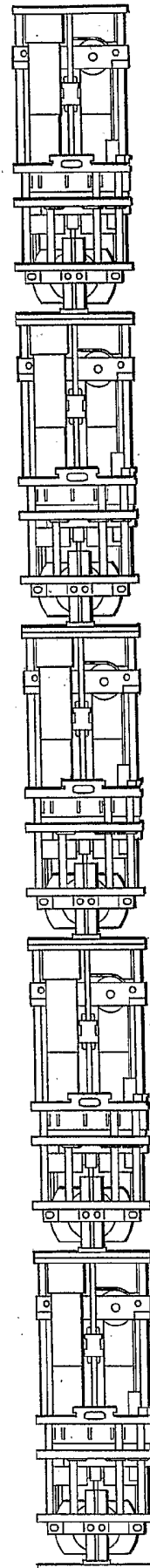


Figure 8b

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2005/001710

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

E05D 7/085 (2006.01) **B25J 17/00** (2006.01) **B25J 17/02** (2006.01).

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)

IPC: **E05D 7/085**, **B25J 17/00**, **B25J 17/02**.

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

AU IPC: **E05D 7/085**, **B25J 17/00**, **B25J 17/02**.

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

DWPI: IPC **E05D 7/085**, **B25J 17/00**, **B25J 17/02**, (HINGE+ OR E05D/IC) AND (TWO OR 2) AND (DEGREE+) AND (FREEDOM+).

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5692412 A (ROSHEIM) 2 December 1997. See entire specification.	1-9,18-21, 27-29.
X	US 5740699 A (BALLANTYNE ET AL.) 21 April 1998. See entire specification.	1-9,18-21, 27-29.
A	US 5101681 A (SHPIGEL) 7 April 1992. See entire specification.	

☒ Further documents are listed in the continuation of Box C

☒ See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
10 May 2006

Date of mailing of the international search report 17 MAY 2006

Name and mailing address of the ISA/AU
AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustalia.gov.au
Facsimile No. (02) 6285 3929

Authorized officer

R. WEBER

Telephone No : (02) 6283 2546

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001710

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 4729253 A (ROSHEIM) 8 March 1988. See entire specification.	1-12, 18-21, 27-29.
X	US 4911033 A (ROSHEIM ET AL.) 27 March 1990. See entire specification.	1-9, 18-21, 27-29.
X	US 5036724 A (ROSHEIM) 6 August 1991. See entire specification.	1-12, 18-21, 27-29.
X	US 5239883 A (ROSHEIM) 31 August 1993. See entire specification.	1-12, 18-21, 27-29.
X	US 5243873 A (DEMERS) 14 September 1993. See entire specification.	1-12, 18-21, 27-29.
X	DE 2732559 A (E.I. DU PONT DE NEMOURS AND CO.) 26 January 1978. See entire specification.	1-9.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2005/001710

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member		
US	5692412	NIL			
US	5740699	JP	9029681		
US	5101681	AU	19918/88	AU	39263/93
		EP	0316445	EP	0534982
		US	4845603	US	4976468
		US	5314425	WO	8809882
		WO	9319410	WO	9114220
US	4729253	CA	1273666	EP	0295244
		WO	8704539	US	4686866
US	4911033	CA	2045487	EP	0452415
US	5036724	EP	0393024	WO	8905216
US	5239883	NIL			
US	5243873	NIL			
DE	2732559	JP	53024954	US	4140024
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
END OF ANNEX					