

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
12 August 2004 (12.08.2004)

PCT

(10) International Publication Number  
**WO 2004/067233 A1**

(51) International Patent Classification<sup>7</sup>: **B25J 15/00**,  
13/08

(21) International Application Number:  
PCT/CA2004/000135

(22) International Filing Date: 30 January 2004 (30.01.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/443,886 31 January 2003 (31.01.2003) US

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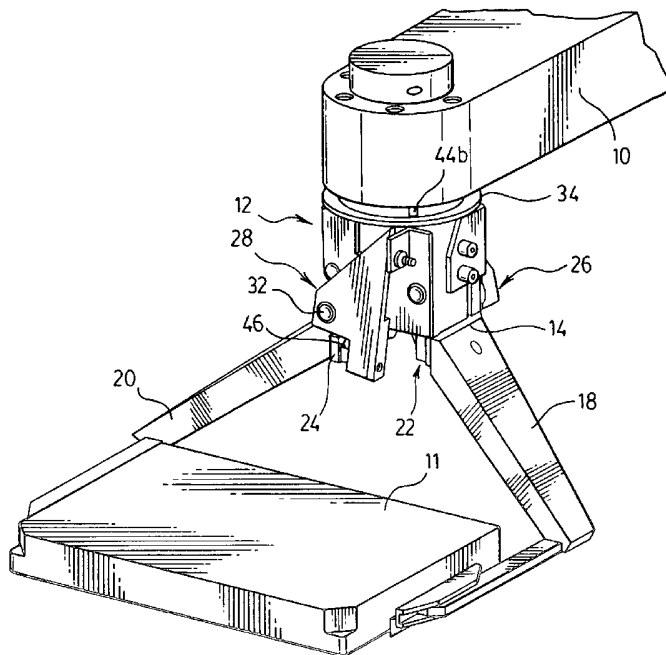
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(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,  
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,  
GB, GD, GE, GH, GM,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

(84) Designated States (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), Euro-  
pean (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR,  
GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK,  
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: A GRIPPING ERROR DETECTION MECHANISM FOR ROBOT GRIPPER



(57) Abstract: An apparatus, associated with a gripping device (12) attached to a robotic arm (10), the gripping device (12) being adapted to engage an object (11), the apparatus being adapted for sensing an error during the gripping step. The apparatus includes a trigger (34), to activate an error sensor (36), and cams (26), pivotally attached to the gripping device (12) and associated with the gripping members (18, 20) of the gripping device (12), the cams (26) being able to activate the trigger (34) in the event the object (11) is not engaged by the gripping device (12).

WO 2004/067233 A1



**Published:**

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## **AN ERROR DETECTION MECHANISM FOR ROBOT GRIPPER**

### **CROSS REFERENCE TO PRIOR APPLICATIONS**

**[0001]** This application claims priority from US application number 60/443,886, filed on January 31, 2003.

### **BACKGROUND OF THE INVENTION**

#### **1) FIELD OF THE INVENTION**

**[0002]** The present invention relates to gripper devices associated with robotic arms and, more particularly, to an error detection mechanism associated with a robotic gripper for signalling an error during the gripping function.

#### **2) DESCRIPTION OF THE PRIOR ART**

**[0003]** Material handling devices such as robots and laboratory movers are normally provided with a gripping device for grasping their payload. An example of such a gripping (or grasping) device is provided in US patent number 5,588,688.

**[0004]** A common strategy in material handling system design incorporating gripping devices as indicated above, is to include some form of sensor to verify that the robot or mover successfully grasps the desired payload when commanded. The sensor is usually a proximity switch or optical sensor. Typically, the sensor is placed on the gripper and wiring is routed from the gripper to the body of the robot or mover.

**[0005]** It is commonly known that wiring between the gripper and robot body continually flexes as the robot moves and, therefore, is susceptible to fatigue over time. To mitigate the risk of wire failure, careful routing and generous bend radii are required to prevent fatigue of the wire conductors.

**[0006]** Various systems and mechanisms have been proposed to sense positioning and applied force of gripping devices. Examples of systems for sensing positioning and force are

provided in US patent numbers 4,682,805 and 4,600,357, respectively. One of the drawbacks with these known systems is the lack of an efficient grip error detection mechanism that does not require wiring as described above. Grip error occurs where the gripping device fails to grasp the desired article, which may be, for example, a container or a microtitre plate etc.

[0007] When a grip status detection sensor is placed on the gripper itself, traditional methods of routing electrical signals back to the robot or mover body include: use of a slip ring; and, direct wiring designed and routed for dynamic motion.

[0008] Slip rings tend to be expensive, sometimes large, and must be placed in the center of the joint of the robotic arm. Dynamic wiring must have adequate space available to bend or flex without fatiguing significantly. The larger the range of motion of the rotating gripper, the more space that is required. Furthermore, the sliding contact of brush type slip rings produces electrical noise, and can result in false readings. Wet contact slip rings have fewer noise problems, but are large and expensive. If the gripper rotate joint does not allow for inclusion of a slip ring or direct wiring because of space constraints, an alternate method of signal passing is necessary.

[0009] In developing a mechanism to pass grip status information to the associated sensor, it is necessary to maximize reliability and Mean Time Between Failure. It is of no value to eliminate the wire fatigue risk in the flexing sensor cable and replace it with similar risk in the new mechanism.

[0010] Apart from the disadvantage of prior art methods using wiring, another problem with known grip detection methods involves the inability to detect the grip signal at any position in the gripper joint rotation. For example, PCT publication number WO/03/037574 (the contents of which are incorporated herein by reference), which shares a common assignee with the present application, describes a robotic arm having a gripping device. The gripping device taught in this reference is provided with a stationary grip status sensor that avoids much of the wiring etc. as described above. However, the grip status detection of this system is able to detect the grip position status at only four specific locations in the range of gripper travel.

1  
2 [0011] Thus, there exists a need for a more efficient and accurate grip status sensor for  
3 robotic devices.  
4

#### 5 SUMMARY OF THE INVENTION

6 [0012] In one aspect, the present invention provides an apparatus for signalling an error  
7 condition, the apparatus being provided on a robotic arm having a gripping device attached  
8 thereto, the gripping device having two or more gripping members adapted to engage an  
9 object, the error condition arising from the gripping device failing to engage the object, the  
10 apparatus comprising:

- 11 - a sensor attached to the robotic arm for signalling the error condition;
- 12 - a trigger attached to the gripping device or the robotic arm, the trigger being adapted  
13 to activate the sensor in the event of an error condition;
- 14 - at least one switch provided on the gripping device for contacting the trigger in the  
15 event of an error condition and urging the trigger to activate the sensor;
- 16 - the at least one switch being adapted to cooperate with the gripping members and  
17 being movable to contact the trigger when the gripping device fails to engage the object.  
18

19 [0013] In another aspect, the at least one switch comprises a cam, the cam being pivotally  
20 attached to the gripping device and having a first end cooperating with at least one of the  
21 gripping members and a second end for contacting the trigger.  
22

23 [0014] In another aspect, the gripping device comprises at least two members moveable  
24 towards each other for engaging the object, and each of the members having an associated  
25 cam.  
26

#### 27 BRIEF DESCRIPTION OF THE DRAWINGS

28 [0015] These and other features of the preferred embodiments of the invention will  
29 become more apparent in the following detailed description in which reference is made to the  
30 appended drawings wherein:

31 [0016] Figure 1 is a front perspective view of a gripping device associated with a robotic  
32 arm.

1 [0017] Figure 2 is a rear perspective view of a gripping device associated with a robotic  
2 arm.

3 [0018] Figure 3 is a detail of the device of Figure 1.

4 [0019] Figure 4 is a schematic diagram illustrating the sensor activating mechanism of  
5 the invention.  
6

## 7 DESCRIPTION OF THE PREFERRED EMBODIMENTS

8 [0020] In one aspect, the present invention provides a grip status sensing device for a  
9 robotic gripping device in a location on the robot, or mover, where wiring to the sensor  
10 remains static as the gripper moves, and provide a mechanism to pass grip status information  
11 to the sensor by some other means.  
12

13 [0021] The present invention will now be described with reference to a specific example  
14 of its application. The invention is described herein in conjunction with a two jaw parallel  
15 pneumatic gripper as is known in the art and as illustrated in the figures contained herein.  
16 Such grippers are commonly used in systems involving robotic transport of microtitre plates,  
17 for example. It will be appreciated by persons skilled in the art that this particular example is  
18 used purely for the purpose of illustrating the present invention and is not intended to limit  
19 the scope of uses of the invention in any way.  
20

21 [0022] Figures 1 to 3 illustrate a typical robotic arm 10 having at its terminal end, a  
22 typical two jaw parallel pneumatic gripper 12, designed for grasping a microtitre plate 11.  
23 The gripper 12 includes a pair of jaws 14 and 16, each having an associated gripper finger 18,  
24 20, respectively. The gripper fingers are used to grip the payload 11, for example, a  
25 microtitre plate. As is known in the art, gripper fingers are customized for each particular  
26 payload and, as such, various other types of gripper fingers can be used. On the inside, or  
27 facing surface of each jaw, 14, 16, is provided an activator 22 and 24, respectively, which are  
28 used to start the chain of motion of the mechanism of the present invention. The activators  
29 22, 24, are oriented such that each points outward (each in an opposite direction) from the  
30 side of the each gripper jaw. Activators 22 and 24 are designed to bear upon respective cams  
31 26 and 28, which convert the motion applied horizontally by the jaw/activator to a vertical  
32 motion, as will be described further below.

1  
2 **[0023]** Cams 26 and 28 are pivotally secured to the gripper device at pivot points 30 and  
3 32, respectively. The cams are designed to rotate in opposite directions when activated, as  
4 will be described further below. The cams in turn are designed to bear upon on a preferably  
5 circular sensor trigger 34 provided at the joint of the gripping device and the robotic arm 10.  
6 Such joints are generally designed to allow rotation of the gripping device. The trigger 34  
7 may be attached to either the gripping device or the robotic arm. When the cams bear on the  
8 sensor trigger 34, the trigger is lifted vertically and activates the grip status sensor 36, which  
9 is mounted on the housing of the robotic arm 10.

10  
11 **[0024]** The arrangement of the cams, activators and trigger 34 can be seen with reference  
12 to Figure 4 wherein the case of cam 26 is illustrated. As can be seen when the gripper arm 18  
13 (not shown) is moved toward the opposing gripper arm 20 (also not shown), the activator 22  
14 is moved in the direction of arrow A. If movement of the gripper finger 18 is not impeded, as  
15 would be the case where the gripper arms grasp the desired payload, the associated activator  
16 22 moves to bear against an activator bearing surface 38 of cam 26. In the preferred  
17 embodiment, the cam is provided with a travel adjuster 40, which allows for the travel  
18 distance of the activator 22 to be adjustable. A similar travel adjuster 46 is provided on the  
19 opposing activator 24. As shown in Figure 3, the travel adjusters, for example 46, may  
20 optionally extend through the base of the cam and be associated with, for example, a set  
21 screw 50, which can adjust the length of the adjuster 40. Various other means of adjusting  
22 the length of the travel adjuster will be apparent to persons skilled in the art. Once activator  
23 22 bears against the cam surface 38 (either directly or through the adjuster 40), the applied  
24 force causes the cam 26 to rotate about pivot point 30 in the direction of arrow B. This  
25 rotation of the cam in turn causes the cam trigger end 42 to move generally vertically in the  
26 direction shown by arrow C. In doing so, the cam trigger end 42 bears against the sensor  
27 trigger 34, which rises vertically and impinges on sensor 36, which is provided on the robotic  
28 arm 10 housing. At such time, an error condition is signalled. As indicated above, the  
29 activator 22 is provided on the jaw 14 of the associated finger 18. It will be understood that  
30 such arrangement minimizes the travel distance of the activator 22. It will also be  
31 appreciated that the cams 26 and 28 as well as the sensor trigger 34 are provided with springs  
32 or other such apparatus which serve to force each element into a "normal" setting, wherein

1 the sensor 36 is not activated. An example of such a spring, associated with the sensor  
2 trigger 34 is shown as elements 44a and 44b in Figures 1 to 3.

3  
4 **[0025]** In a typical gripping sequence, the gripper fingers 18, 20 close on the payload 11.  
5 The gripper jaws 14, 16 do not travel far enough to rotate the cams if the grip is successful.  
6 Thus, the mechanism is not engaged so the sensor 36 does not receive a signal. If the gripper  
7 is commanded to close and there is no payload in place, the gripper jaws and activators travel  
8 farther. This time, the travel is far enough to contact the cams and rotate them as described  
9 above, lifting the circular sensor trigger. The trigger activates the grip status sensor 36,  
10 which may be an inductive proximity sensor as known in the art. When the gripper opens  
11 again, sensor trigger return springs 44 (shown as 44a and 44b in the figures) press on the  
12 sensor trigger 34, driving it away from the grip status sensor 36. This opens the sensing  
13 circuit, clearing the error condition. The sensor trigger 34 also pushes the cams back to their  
14 neutral position, ready for the next detection.

15  
16 **[0026]** As described above, the sensor trigger 34 is preferably circular. As such, it will  
17 trigger the grip status sensor at any angle of gripper rotation. In other words, by having a  
18 circular trigger, the cams 26 and 28 can activate the trigger in any position of rotation of the  
19 gripping device. Persons skilled in the art will appreciate that various embodiments of the  
20 invention may be possible without a trigger 34 in the form of a continuous ring while still  
21 achieving the benefits of the present invention.

22  
23 **[0027]** As indicated above, in one aspect of the invention, two cams 26 and 28 are  
24 provided. This type of arrangement serves to balance the force on the sensor trigger 34 at  
25 opposite sides of the ring, preventing binding or other such deformation.

26  
27 **[0028]** The logic for detecting a failure according to the invention is as follows:  
28 - issue command for gripper to close: if no sensor triggered, grip is successful  
29 - issue command for gripper to close: if sensor triggered, no payload in  
30 gripper.

1   **[0029]**   Using this invention, the gripper status detection sensor can be located on the  
2   section of the robot arm which supports the gripper rotate axis. As the gripper rotates, the  
3   sensor undergoes no motion, hence the sensor wiring remains static and would not be  
4   subjected to the strains as described above with respect to prior art devices.

5  
6   **[0030]**   Because the gripper status detection sensor is not located on the gripper, no  
7   provision needs to be made for moving wires. This allows for a more compact gripper rotate  
8   joint design.

9  
10   **[0031]**   The mechanism developed to pass grip status information to the sensor is designed  
11   such that it is only activated when a failed attempt to grasp a payload occurs. Because the  
12   frequency of failed grip attempts is typically fairly low, the actual operating time of the  
13   mechanism relative to the time of operation of the robot or mover is also fairly low. This  
14   increases the overall life of the mechanism.

15  
16   **[0032]**   Eventually, the mechanism may begin to show evidence of wear leading to  
17   improper activation. Provision is made in the design of the mechanism to adjust the  
18   activation range to compensate for wear. This feature is achieved, for example, by means of  
19   the travel adjusters 40 and 46 described above.

20  
21   **[0033]**   The mechanism of the present invention allows for detection of an error signal at  
22   any position in the gripper joint rotation. Because the invention is capable of detection at any  
23   position in the range of gripper travel, the mechanism design is very different.

24  
25   **[0034]**   The principal advantages and differences of the present invention over existing  
26   devices are as follows:

- 27       ◦ no grip status sensor wire fatigue (due to the use of “static” wiring)
- 28       ◦ more compact gripper rotate axis design
- 29       ◦ can detect at any point in the rotation of the gripper axis
- 30       ◦ adjustment can be made to compensate for wear of the mechanism

1 [0035] Although the invention has been described with reference to certain specific  
2 embodiments, various modifications thereof will be apparent to those skilled in the art  
3 without departing from the spirit and scope of the invention as outlined in the claims  
4 appended hereto.  
5

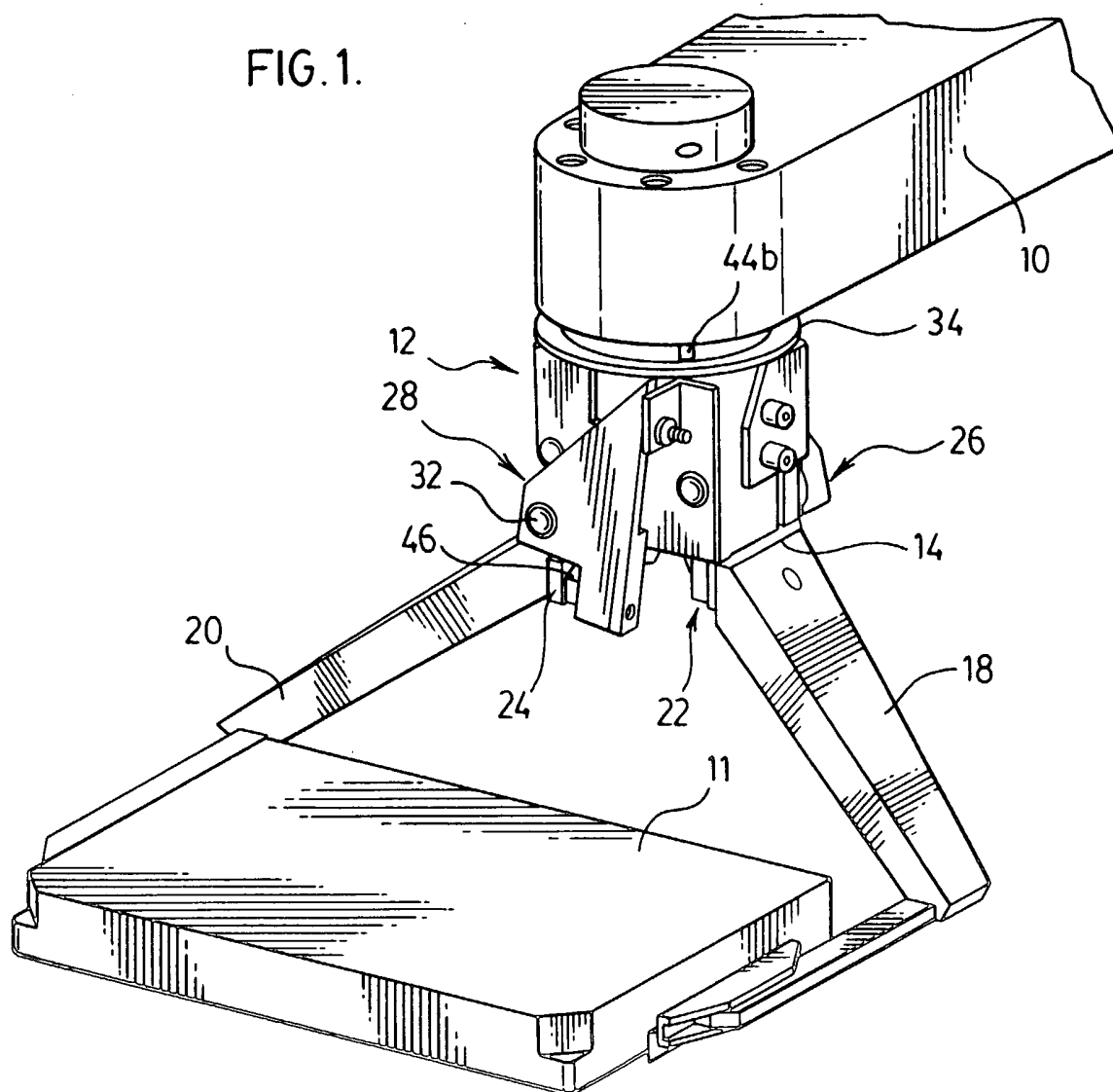
**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE  
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. An apparatus for signalling an error condition, said apparatus being provided on a robotic arm having a gripping device attached thereto, said gripping device having two or more gripping members adapted to engage an object, said error condition arising from the gripping device failing to engage said object, the apparatus comprising:
  - a sensor attached to said robotic arm for signalling said error condition;
  - a trigger attached to said gripping device or said robotic arm, said trigger being adapted to activate said sensor in the event of an error condition;
  - at least one switch provided on said gripping device for contacting said trigger in the event of an error condition and urging said trigger to activate said sensor;
  - said at least one switch being adapted to cooperate with said gripping members and being movable to contact said trigger when said gripping device fails to engage said object.
2. The apparatus of claim 1 wherein said gripping device is rotatably attached to said robotic arm and said trigger comprises a ring coaxial with the axis of rotation of the gripping device.
3. The apparatus of claim 2 wherein said at least one switch comprises a cam, said cam being pivotally attached to said gripping device and having a first end cooperating with at least one of said gripping members and a second end for contacting said trigger.
4. The apparatus of claim 3 wherein said gripping members are adapted to contact and activate said at least one cam when said gripping device fails to engage said object.
5. The apparatus of claim 4 wherein said trigger is maintained separated from said sensor by means of a first resilient device.
6. The apparatus of claim 5 wherein said at least one cam is maintained separated from said trigger by means of a second resilient device.

7. The apparatus of claim 6 wherein said first and second resilient devices comprise at least one spring.
8. The apparatus of claim 6 wherein said trigger is circular.
9. The apparatus of claim 8 wherein said gripping device comprises at least two members moveable towards each other for engaging said object, and each of said members having an associated cam.
10. The apparatus of claim 9 wherein said cams are arranged equidistantly around the circumference of said trigger.
11. The apparatus of claim 10 wherein said at least one cam includes an adjusting device to adjust the distance between said gripping members

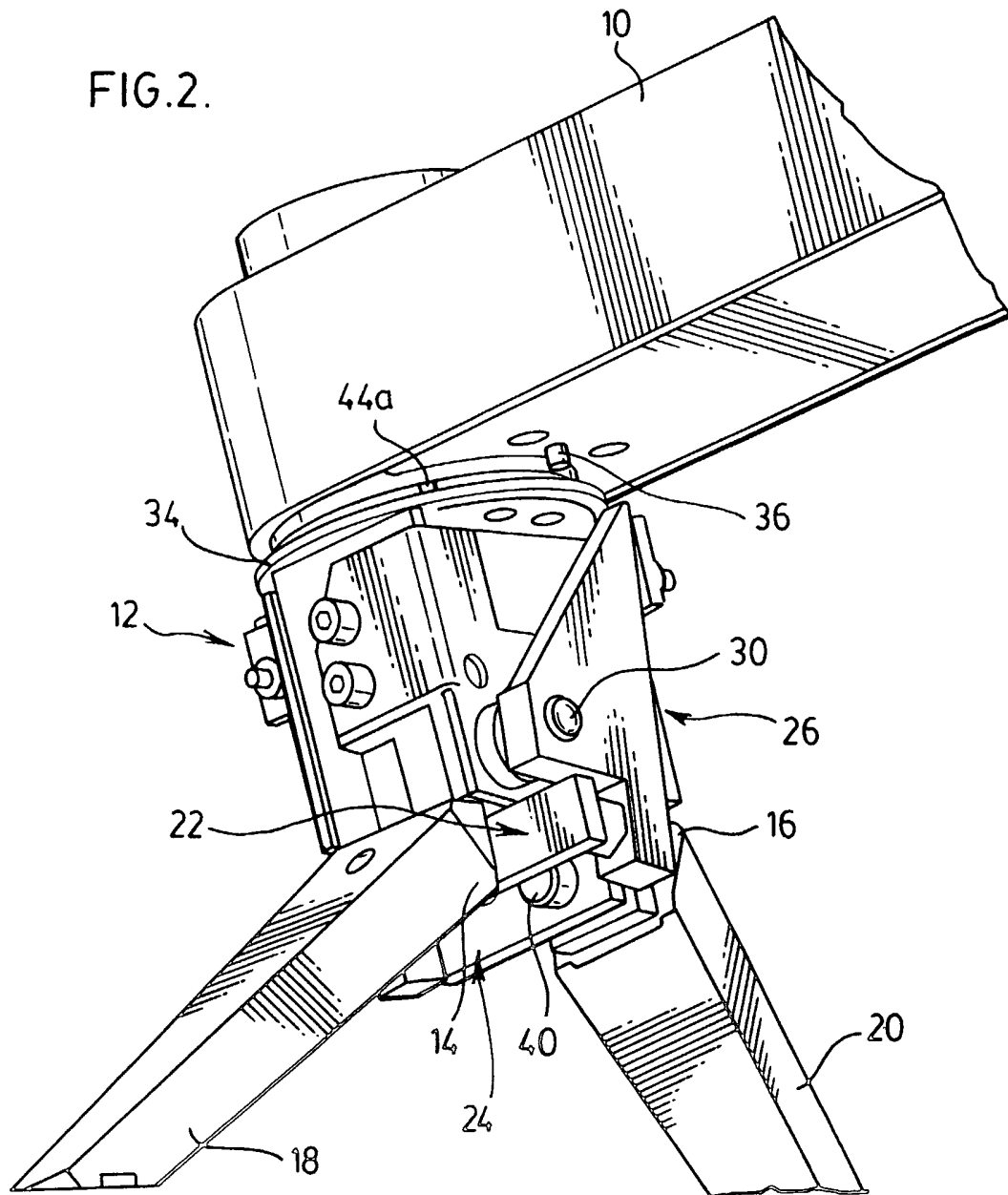
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FIG. 1.



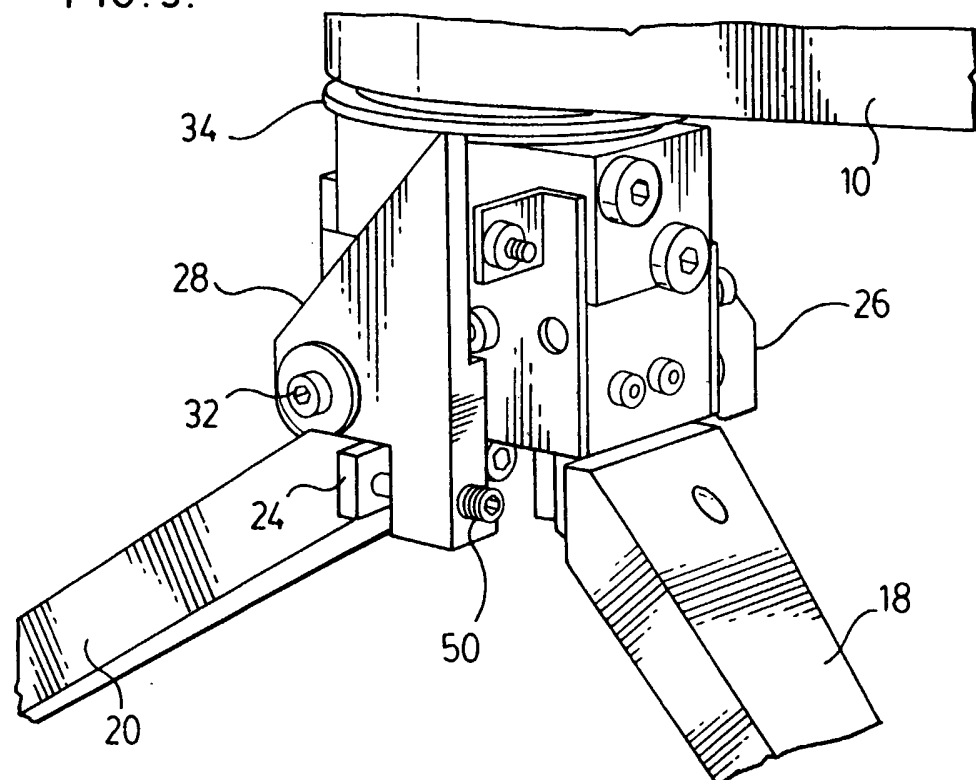
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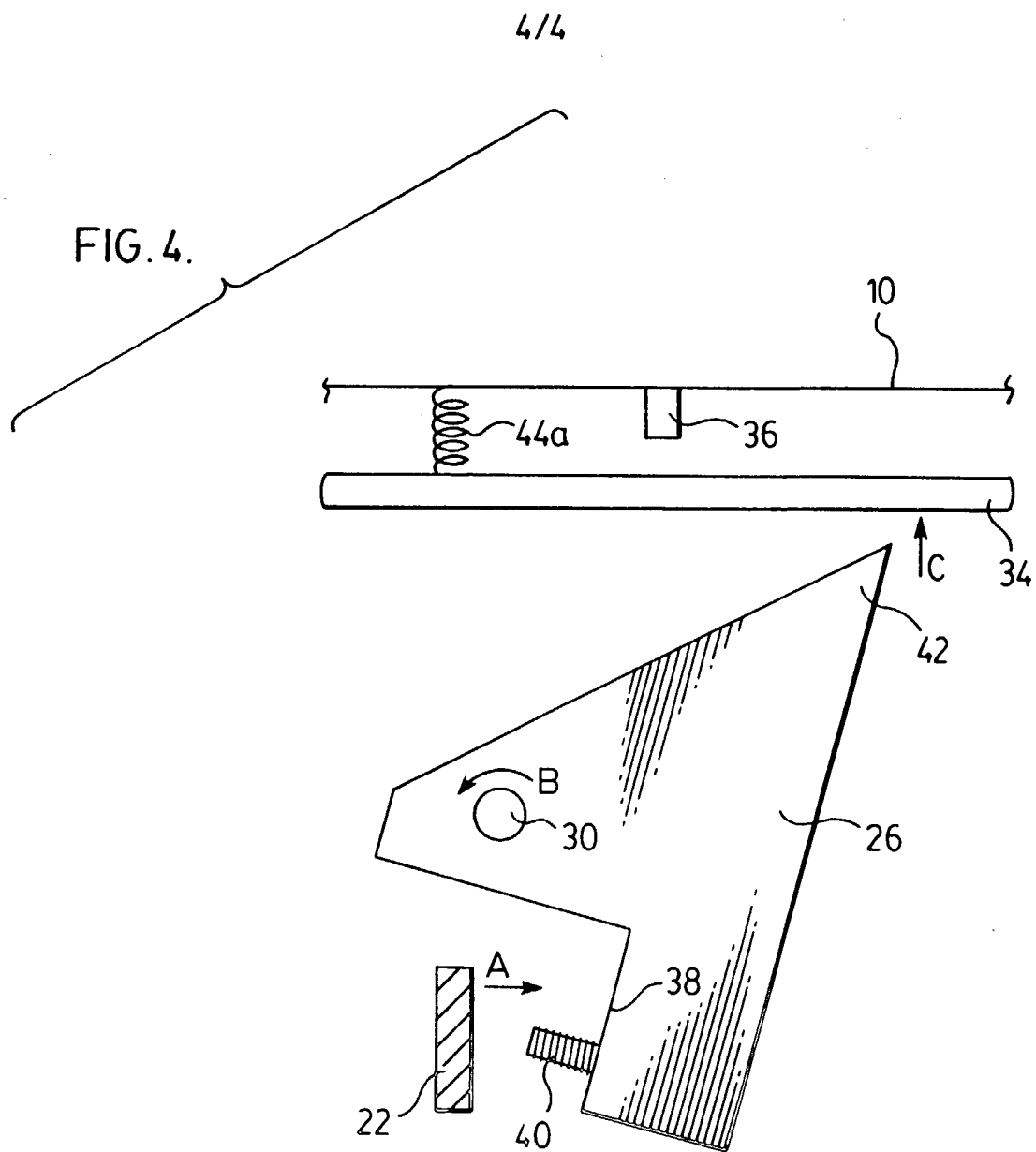
FIG.2.



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FIG. 3.





# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/CA2004/000135

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B25J15/00 B25J13/08

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 7 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, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                        | Relevant to claim No. |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A          | PATENT ABSTRACTS OF JAPAN<br>vol. 018, no. 151 (M-1576),<br>14 March 1994 (1994-03-14)<br>-& JP 05 329790 A (CANON INC),<br>14 December 1993 (1993-12-14)<br>abstract; figures 1-3<br>--- | 1-11                  |
| A          | PATENT ABSTRACTS OF JAPAN<br>vol. 016, no. 526 (E-1286),<br>28 October 1992 (1992-10-28)<br>-& JP 04 196458 A (SEIKO EPSON CORP),<br>16 July 1992 (1992-07-16)<br>abstract<br>-----       | 1-11                  |

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

☐ Patent family members are listed in annex.

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Date of mailing of the international search report

1 June 2004

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CA2004/000135

| Patent document<br>cited in search report |   | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---|---------------------|----------------------------|---------------------|
| JP 05329790                               | A | 14-12-1993          | NONE                       |                     |
| JP 04196458                               | A | 16-07-1992          | NONE                       |                     |