



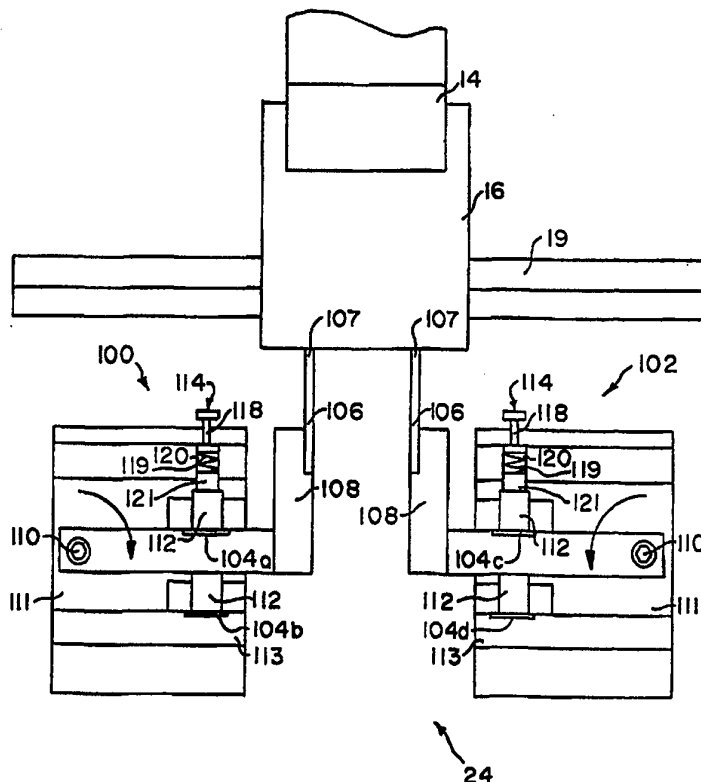
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(15) International Patent Classification <sup>6</sup> : <b>B21D 5/00, 5/02, 11/22, 43/00, B25J 9/16, 19/02, G05B 19/00</b></p>	<p><b>A3</b></p>	<p>(11) International Publication Number: <b>WO 96/14949</b></p> <p>(43) International Publication Date: 23 May 1996 (23.05.96)</p>
<p>(21) International Application Number: PCT/JP95/02289</p> <p>(22) International Filing Date: 9 November 1995 (09.11.95)</p> <p>(30) Priority Data: 08/338,153 9 November 1994 (09.11.94) US 08/385,829 9 February 1995 (09.02.95) US</p> <p>(71) Applicants: AMADA COMPANY, LIMITED [JP/JP]; 200, Ishida, Isehara-shi, Kanagawa 259-11 (JP). U.S. AMADA, LTD. [US/US]; 7025 Firestone Boulevard, Buena Park, CA 90621 (US).</p> <p>(72) Inventors: MOORE, Richard, M., Jr.; 2344 Sherbrook Street, Pittsburgh, PA 15217 (US). BOURNE, David, Alan; 209 Kearsarge Street, Pittsburgh, PA 15211 (US). ELKINS, Kerry, L.; 2652 country Squire N.W., Uniontown, OH 44685 (US). MURRAY, Anne, Marie; P.O. Box 551, Onalaska, TX 77360 (US). STURGES, Robert, H., Jr.; 134 Markham Drive, Mt. Lebanon, PA 15228 (US). HAZAMA, Kensuke; U.S. Amada, Ltd., 7025 Firestone Boulevard, Buena Park, CA 90621 (US).</p> <p>(74) Agent: MIYOSHI, Hidekazu; Toranomon Daiichi Building, 3rd floor, 2-3, Toranomon 1-chome, Minato-ku, Tokyo 105 (JP).</p>	<p>(81) Designated States: CA, CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p> <p>(88) Date of publication of the international search report: 5 December 1996 (05.12.96)</p>	

(54) Title: METHODS AND APPARATUSES FOR BACKGAGING AND SENSOR-BASED CONTROL OF BENDING OPERATIONS

## (57) Abstract

Several methods and subsystems are disclosed for aligning a workpiece (16) as it is being loaded into a die space of a bending apparatus (29), and for performing sensor-based control of a robot as it moves a workpiece from one location to another within a bending apparatus environment. A backgaging mechanism is provided with finger gaging mechanisms (100, 102) having force sensors (104) for sensing forces in directions perpendicular to and parallel to a die (19). In addition, a robot gripper sensor (128) is provided for sensing either or both of shear forces and normal forces created by movement of a workpiece being held by the gripper (14). Several sensor-based control modules are disclosed, including a bend-following control module, a speed control module, a module for actively damping vibrations in a workpiece, a module for controlling active compliance/contact between a workpiece and an obstacle, a module for performing a guarded move to intentionally bring a workpiece into contact with an obstacle, and a module for detecting unintentional impacts between a workpiece and an obstacle. Several droop sensing methods and systems are also disclosed, including methods for performing droop sensing and compensation with the use of a vision-based droop sensor, a compound break-beam droop sensor, and a single break-beam droop sensor. In addition, an angle sensor is disclosed, along with a springback control method utilizing the disclosed angle sensor.



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INTERNATIONAL SEARCH REPORT

Intern. Application No  
PCT/JP 95/02289

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 B21D5/00 B21D5/02 B21D11/22 B21D43/00 B25J9/16  
B25J19/02 G05B19/00

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 6 B21D

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 91 09696 A (AMADA CO LTD) 11 July 1991 see the whole document ---	1
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 126 (M-1381), 17 March 1993 & JP 04 309414 A (DAIKIN IND LTD), 2 November 1992, see abstract ---	1
X	JP 04 309 414 A (DAIKIN IND LTD) 2 November 1992 see figures ---	1
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 298 (M-1141), 29 July 1991 & JP 03 110022 A (KOMATSU LTD;OTHERS: 01), 10 May 1991, see abstract ---	1
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Further documents are listed in the continuation of box C.  Patent family members are listed in annex.

\* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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.</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search <b>19 June 1996</b>	Date of mailing of the international search report <b>22. 10. 96</b>
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Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Authorized officer <b>RIS M.</b>
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## INTERNATIONAL SEARCH REPORT

Intern. Application No

PCT/JP 95/02289

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 03 110 022 A (KOMATSU LTD;OTHERS: 01) 10 May 1991 see figures	1
A	<p style="text-align: center;">---</p> PATENT ABSTRACTS OF JAPAN vol. 015, no. 298 (M-1141), 29 July 1991 & JP 03 110018 A (AMADA CO LTD), 10 May 1991, see abstract	2
A	<p style="text-align: center;">---</p> JP 03 110 018 A (AMADA CO LTD) 10 May 1991 see figures	2
A	<p style="text-align: center;">---</p> PATENT ABSTRACTS OF JAPAN vol. 018, no. 239 (M-1601), 9 May 1994 & JP 06 031345 A (AMADA CO LTD), 8 February 1994, see abstract	2
A	<p style="text-align: center;">---</p> PATENT ABSTRACTS OF JAPAN vol. 015, no. 325 (M-1148), 19 August 1991 & JP 03 124318 A (AMADA CO LTD), 27 May 1991, see abstract	2
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP 95/02289

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

- 1.- claim 1
- 2.- claim 2
- 3.- claims 3-20

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:  
  
1,2
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

information on patent family members

Intern. Application No

PCT/JP 95/02289

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9109696	11-07-91	IT-B- 1237750 AT-T- 119440 DE-D- 69017670 DE-T- 69017670 EP-A- 0462286 JP-T- 4504821 US-A- 5187958	15-06-93 15-03-95 13-04-95 06-07-95 27-12-91 27-08-92 23-02-93
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JP-A-04309414	02-11-92	NONE	
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JP-A-03110022	10-05-91	NONE	
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JP-A-03110018	10-05-91	NONE	
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