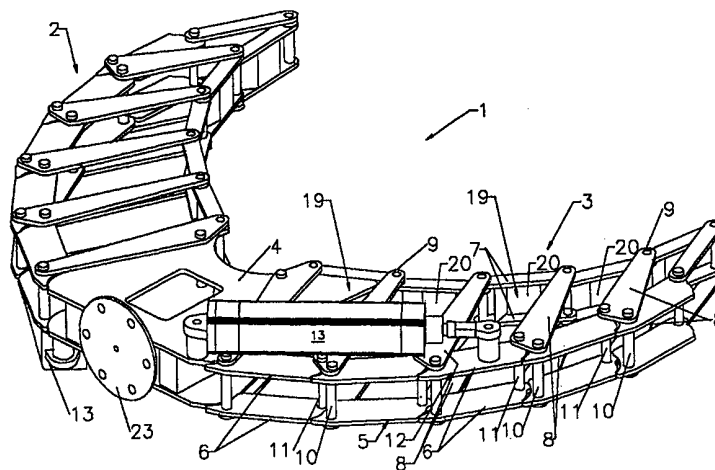


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/SE99/00418 (22) International Filing Date: 17 March 1999 (17.03.99) (30) Priority Data: 9800945-9 20 March 1998 (20.03.98) SE (71)(72) Applicant and Inventor: SYNNELIUS, Sune [SE/SE]; Bangatan 41A, S-722 28 Västerås (SE). (74) Agent: DR. LUDWIG BRANN PATENTBYRÅ AB; P.O. Box 17192, S-104 62 Stockholm (SE).	(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, 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, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>	

(54) Title: GRIPPER WITH SEGMENTED ARMS**(57) Abstract**

A segmented gripper is provided, having two arms (2, 3) which are operated for closing and opening movement in an operational plane. The arms are flexible in way of a finger, i.e. the geometry is variable to adapt to the external shape of the article to be gripped. This is accomplished by providing a structure for the arms, wherein an outer row of rotatably connected links (6) is interconnected with an inner row of rotatably connected links (7), the interconnecting elements (8) being rotatably attached to the link connecting points of each row of links. The lengths of the interconnecting elements are successively decreasing towards the free end of the arm, so that each arm displays a claw-like configuration. The arms are rotatably attached to a support plate, so that when an actuating force is applied tangentially to the outer row of links, the arms are operated for a closing motion. When the exterior of an article is engaged by any of the inner links, continued tangential force causes the inner row of links to bend about the corresponding link connection point, the outer links peripherally overrunning the inner links by rotation of the interconnecting elements about the attachment points (9, 10, 11).

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GRIPPER WITH SEGMENTED ARMS

The present invention relates to a gripper for gripping, holding and transferring articles of varying shapes. More specifically, the invention relates to a gripper having segmented and flexible arms for accommodating to the outer shape of the article to be gripped between the arms of the gripper.

A problem related to lifting and transferring operations, is the varying sizes of articles to be handled by a specific gripper. This is often solved by exchanging the gripper tool of e.g. an industrial robot. Another problem is the often limited ability of some soft, fragile articles like for instance a bag of powder, to resist concentrated loads applied by a non-linked universal gripper tool. The present invention provides a solution to this problem, meeting the object of invention as stated below.

The present invention has for its object to provide a segmented gripper with one or more flexible arms, having the ability to accommodate to the outer shape of an article, so as to be operable for handling articles of different form and shape. In the case of handling soft articles, like e.g. the bag of powder, the applied load will not be concentrated but distributed over the surface, thereby limiting in comparison with a non-linked gripper, the requirement for the article to resist concentrated loads.

This object is met in a gripper according to the invention, having the features of claim 1. Advantageous embodiments of the invention are defined in the subclaims 2 to 10, and suitable applications of the inventive gripper are defined in the subclaims 11 to 16.

The present invention provides a gripper having two arms which are operated for closing and opening movements, resp., in an operational plane. The arms are flexible in way of a finger, i.e. the geometry is variable to adopt to the external shape of the article to be gripped. This is accomplished by providing a structure for the arms, wherein an outer row of rotatably connected links is interconnected with an inner row of rotatably connected links, the interconnecting elements being rotatably attached to the link connecting points of each row of links. The length of the interconnecting elements is successively decreasing towards the free end of the arm, so that each arm displays a claw-like configuration. The arms are rotatably attached

to a support plate, so that when an actuating force is applied tangentially to the outer row of links, the arms are operated for a closing motion.. When the exterior of an article is engaged by any of the inner links, continued tangential force causes the inner row of links to bend about the corresponding link connection point, the outer links peripherrally overrunning the inner links by rotation of the interconnecting elements about the attachment points.

Below, a representative embodiment of the invention is described more in detail with reference to the attached drawings, of which

Fig. 1 discloses a gripper of the invention, in a schematical, perspective view,

Fig. 2 shows the gripper of fig. 1 in an elevational view from above, and

Fig. 3 shows an alternative embodiment of the inventive gripper.

In fig. 1, the invention is generally referred to as a gripper 1. The gripper 1 comprises two opposing gripper arms 2,3, the inner ends of which are rotatably journalled in a central support plate 4. Actuating means, such as a pair of cylinder units 13 are disposed to act between the support plate 4 and each one of the gripper arms 2,3. The actuating means are operative to impart a reciprocating movement in an operative plane of the gripper arms 2,3 for gripping and transferring an article, e.g. between working stations in a production line. As used herein, the expression reciprocating movement refers to the closing and opening motions, resp., of the arms 2,3. The actuating means 13 are controllable for securing the arms in a closed position around the article, for transferring operation. The actuating means 13 may be controlled for simultaneous and coordinated operation of the arms 2,3, and may optionally be controlled for individual operation of the arms. In this aspect, the cylinder units 13 may be conventionally equipped with lock function on the piston rods, which may be an advantageous feature

in the case where the gripped article is revolved so that load is mainly absorbed by one of the arms.

The two gripper arms are identical in construction, and in the following, reference is being made solely to the gripper arm 3 on the right hand side of the drawings of figs 1 and 2. The gripper arm 3 comprises a set of segments 5, each segment being defined by an outer link 6, an inner link 7 and interconnecting spacing elements 8, forming the interconnecting sides of adjacently disposed segments 5. The inner links 7 of any two adjacent segments 5 are rotatably journalled on a common axis 9 in one end of the spacing element 8, and the outer links 6 of said two segments are rotatably journalled on separate axis 10 and 11 in the other end of the spacing element 8.

Reference being made to fig. 2, the abutting ends of the outer links 6 are formed with first restriction means 14 and 15 for delimiting in one direction the reciprocating movement of the gripper arm 3. To this purpose, the outer links 6 may be formed with a heel 14 in its one end, co-acting with a seat 15 formed in the other end of an adjacently disposed outer link 6 for providing a positive stop in a contact position between heel 14 and seat 15 in an end position of the opening movement of the arm 3.

Optionally, a second restriction means 16 may be provided on the support plate 4. To this purpose, the support plate 4 is formed to have a knee 16, extending into an inner, first segment 5 of the gripper arm 3. The knee 16 is formed with a forward edge 17, providing a positive stop in the opening direction of the reciprocating movement of the gripper arm 3, by engaging the inner link 7 of said inner, first segment 5.

The restriction means 14,15 and 16 provide stability and rigidity of the gripper arm 3 in its maximum opened position. Design parameters for the restriction means 14,15 and 16 may preferably, as in the illustrated embodiment of fig. 2, be chosen to secure that the outer link 6 is rotatable about the axis 10, so that an angle α is greater than 0. In the resting or opening end position of gripper arm 3, the rows of connected outer links 6 and connected inner links 7 thereby displaying a bowshaped configuration, defined by the angle α .

In an advantageous and presently preferred embodiment as illustrated in figs 1 and 2, a second set of segments 5 is disposed in parallel alignment to the first set of segments. The spacing of the two sets of segments is dimensioned through the length or height of the axis 9, 10 and 11, so that the two sets of segments have a box-like configuration. An engagement member 19 is formed on the inner links 7, resp., to project a contact surface 20 to the article to be gripped by the arm 3. In the preferred embodiment, engagement member 19 connects the inner links 7 of two superimposed segments 5. Engagement members 19 may be bow-shaped in the closing direction of the arm 3, or may be angularly formed with one or more planar contact surfaces 20 as in the preferred embodiment. Optionally, the contact surface 20 may have any suitable form and operation adapted to a specific application, and may e.g. comprise friction means such as teeth or serrations etc.

In closing and gripping motion, the cylinder 13 is operated to expand and thereby rotate the arm 3 about an axis 18, by which the arm 3 is rotatably journalled in the support plate 4. When one engagement member 19 or inner link 7 engages the article to be gripped, the closing movement of the corresponding segment and of previous segments in the row of segments 5 is stopped. Continued operation of the cylinder 13 provides a tangential displacement of the row of outer links 6, that will cause all spacing elements 8 to rotate about the corresponding axis 9, thereby bending the arm 3 in way of a finger about that axis 9 which is connecting the engaged inner link 7 and adjacent inner link 7 of the successive segment in the row of segments 5. Still continued operation of the cylinder 13 will cause the arm 3 to bend further around the article in the manner described, until the last or outmost inner link 7 is in engagement with the article to be gripped.

In opening motion, cylinder 13 is operated to retract and thereby successively disconnecting the engagement members 19 or inner links 7 from engagement with the article, beginning with the inner link 7 of the outmost segment 5.

In the reciprocating motion of closing and opening the arm 3, the geometries of the segments 5 vary in response to the engagement or disengagement, resp., with the gripped article. In the closing motion, the continued expansion of cylinder 13 causes the outer links 6 to overrun peripherally the inner links 7 in a bowshaped path, changing the relative angularity within the segments 5 individually in relation to the successive engagement with the article's exterior shape.

The length of the spacing elements 8 is successively decreasing towards the outer, free end of the arm 3. The rows of outer and inner links 6 and 7, resp., thereby having substantially a semicircular shape, the centres of which are offset so that the centre of the inner link circle is disposed in front of the outer link circle, as viewed in a direction towards the operational area of the gripper 1.

The spacing elements 8 are substantially triangular in shape, rotatably journalled in one inner end to the axis 9, connecting rotatably two inner links 7. The second, outer end of the spacing elements 8 which forms the base of the triangle, is rotatably journalled to successively coupled outer links 6, through the axis 10 and 11, resp. The axis 10 and 11 are disposed in the triangle corners of spacing element 8, so that axis 10 is placed peripherally outside of the axis 11, thereby providing added momental force in the end of the opening movement for securing a resting position with the restriction means 14 and 15 in active engagement.

To add constructive rigidity to the arm 3, the outer links 6 are formed with sliding faces 21 and 22, resp., in the abutting ends of the outer links 6. The sliding faces 21 and 22 may be bowshaped to allow for sliding engagement between adjacent outer links 6 in the relative displacement during operation of the gripper 1. Elements 21 and 22 are designed to present additional restriction means for preventing an unlimited opening movement of the gripper arm, by having a radius, resp., which causes an interception between contacting surfaces 21 and 22 in the opening end position.

In the drawing of fig. 3, an angle β (beta) is introduced to define the relative angular positions of the inner links 7, resp. in the opening end position. The angles α and β are related in effect

of the geometry of the gripper arm, preferably both to be greater than 0, so that the gripper arm 3 in resting position displays a bowshaped configuration.

In the course of development, other embodiments have been contemplated for the inventive gripper. E.g. a gripper, having three or more arms in parallel to the operational plane (drawing plane of fig. 2), or a gripper having one or several segmented and linked gripper arms, and one or several fixed or rigid arms or counter acting supports or surfaces. Likewise, embodiments wherein the angles a and b may adopt the value 0, the gripper arm thereby displaying a straight line configuration in a resting position, or a negative value whereby the gripper arm is bent outwardly in the resting position, have been contemplated.

The restriction means, dimensioning the angles a and b and limiting the opening movement of the gripper arm 3, may be alternatively constructed as shown in fig. 3. The engagement member 19 is here formed to have an extension 34, constituting a restriction 34 and providing a positive stop in the opening direction of the reciprocating movement of the gripper arm 3 by engaging the inner link 7 of the adjacently disposed segment 5. In a similar manner, the outer link 6 may be provided with an extension 35 constituting a restriction 35, operating similarly to the restriction 34 to provide a positive stop when contacting the outer link 6 of the adjacently disposed segment 5. The restriction means 34 and 35 may be separately applied or applied in combination, with or without one or both of the abovesaid restriction means 14/15 and 21/22.

The embodiment of fig. 3 further differs from the embodiment of figs. 1 and 2, in that the connecting point between inter connecting spacing elements 8 and outer links 6 is a single axis 31 due to the alternatively formed restriction means 34 and 35.

The inventive gripper is contemplated for many useful and industrial applications.

E.g., the flexible gripper can be attached to the arm of an industrial robot included in a production line for transferring work pieces between work stations for machining, welding, mo-

unting , surface treatment such as polishing, painting etc., but also for packaging, weighing and storing etc.

Other contemplated applications may be the use of the flexible gripper on transport trucks, lifting cranes and other building construction vehicles, or for e.g. in agriculture and forest industry vehicles.

The inventive gripper has also been contemplated for use in artificial hands and limbs.

The support plate 4 is advantageously equipped with mounting means 23 for rotatably mounting the gripper 1 to a carrier. In this way, the gripper 1 is able to grip, lift and transfer the article while turning it a full 360 degrees so as to be operable in all spatial planes.

Thus there is provided a gripper for holding, lifting and transferring articles, with substantial flexibility to adopt to the outer shape of an article. The gripper arms 2,3 are structured with an outer row of rotatably connected links, the row of outer links being interconnected with an inner row of rotatably connected links, wherein the interconnecting elements are rotatably attached to the link connecting points of each row of links. The arms are rotatably attached to an intermediate common support, so that when an actuating force is applied tangentially to the outer row of links, the arms are operated for a closing motion. When the exterior of an article is engaged by any of the inner links, continued tangential force causes the inner row of links to bend about the corresponding link connection point, the outer links peripherrally overrunning the inner links by rotation of the interconnecting elements about the attachment points.

CLAIMS

1. A gripper for gripping, holding and transferring articles, comprising arms (2,3) pivotally attached to an intermediately disposed common support and actuated for closing and opening movements, resp., each arm comprising an outer row of pivotally connected links (6), the row of outer links being interconnected with an inner row of pivotally connected links (7), wherein the interconnecting elements (8) are pivotally attached to the link connecting points (9,10,11; 9,31) of each row of links, and actuating means (13) are operable to apply a tangential force to the outer row of links and having restrictions (14,15 or 34,35) designed to provide a stop in the opening direction of the reciprocating movement of the gripper arm (3) at an angle (α) between connected outer links (6) or/and at an angle (β) between connected inner links (7), **characterized in** that the relative length of the spacing elements (8) being successively reduced in the longitudinal direction towards the free end of the gripper arm.

2. Gripper of claim 1, wherein the inner end of each arm (2,3) being pivotally journaled in a support plate (4), each arm having three or more interconnected, four sided first set of segments (5) disposed in a side by side relationship in the longitudinal direction of the gripper arm, each segment having an inner link (7) and an outer link (6), resp., operative for movement in the operative plane of the gripper arm, said inner and outer links being spaced by a spacing element (8) forming an interconnecting side of two adjacent segments (5), the inner links (7) of said two adjacent segments being pivotally journaled on a common axis (9) in one end of the spacing element (8), and the outer links (6) of said two adjacent segments being pivotally journaled on a common axis (31) or on separate axis (10,11) in the opposite end of said spacing element (8).

3. Gripper of claim 2, wherein a second set of segments (5) is aligned in parallel to the first set of segments (5), the spacing between said first and second sets of segments being dimensioned through the length of said common (9,31) axis or said common (9) and said separate (10,11) axis, the gripper arm segments thereby having a box-like configuration.

4. Gripper of claim 2, wherein actuating means (13) are arranged between the support plate (4) and each of the gripper arms (2,3), resp., said actuating means being controllable to operate the gripper arms for coordinated reciprocating movements in the operative plane.

5. Gripper of claim 4, wherein said actuating means (13) are separately controllable for individual movements of the gripper arms.

6. Gripper of claim 2, wherein the inner links (7) are formed with surfaces for contact (20) with an article to be gripped, said surfaces connecting the inner links of said first and second segments, resp.

7. Gripper of claim 2, wherein the abutting ends of said outer links (6) are formed with restriction means (14,15) for delimiting in an opening direction the reciprocating movement of the gripper arm.

8. Gripper of claim 2, further comprising restriction means (16) on said support plate (4), cooperating with the one of said inner links (7) for delimiting in said opening direction the reciprocating movement of the gripper arm.

9. Gripper of claim 2, wherein the abutting ends of said outer links (6) are formed with sliding faces (21,22), providing a stop in the end position of the opening movement of the gripper arm (3).

10. Gripper of claim 2, wherein said support plate (4) comprises mounting means (23) for pivotally mounting the gripper to a carrier, thereby making

the gripper operative for gripping, holding and transferring operation in any desired spatial plane.

11. Gripper substantially as described in claims 1 to 10, mounted for operation in an industrial robot.

12. Gripper substantially as described in claims 1 to 10, mounted for operation in a production line.

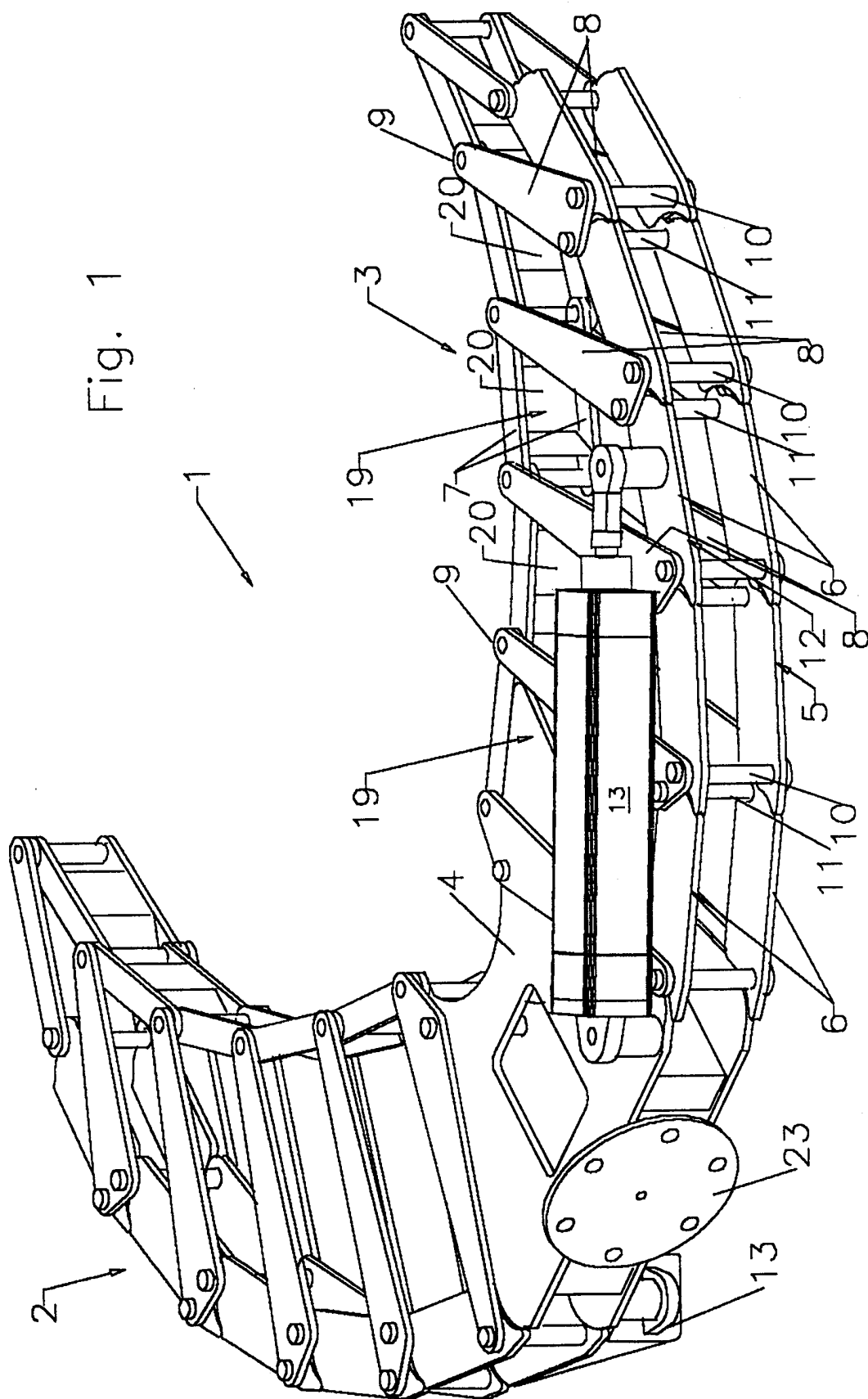
13. Gripper substantially as described in claims 1 to 10, mounted for operation in a transport truck.

14. Gripper substantially as described in claims 1 to 10, mounted for operation in a lifting arrangement.

15. Gripper substantially as described in claims 1 to 10, mounted for operation in an artificial limb.

16. Gripper substantially as described in claims 1 to 10, having at least one moveable arm (3) cooperating with a support or supporting surface for holding an article.

1/3



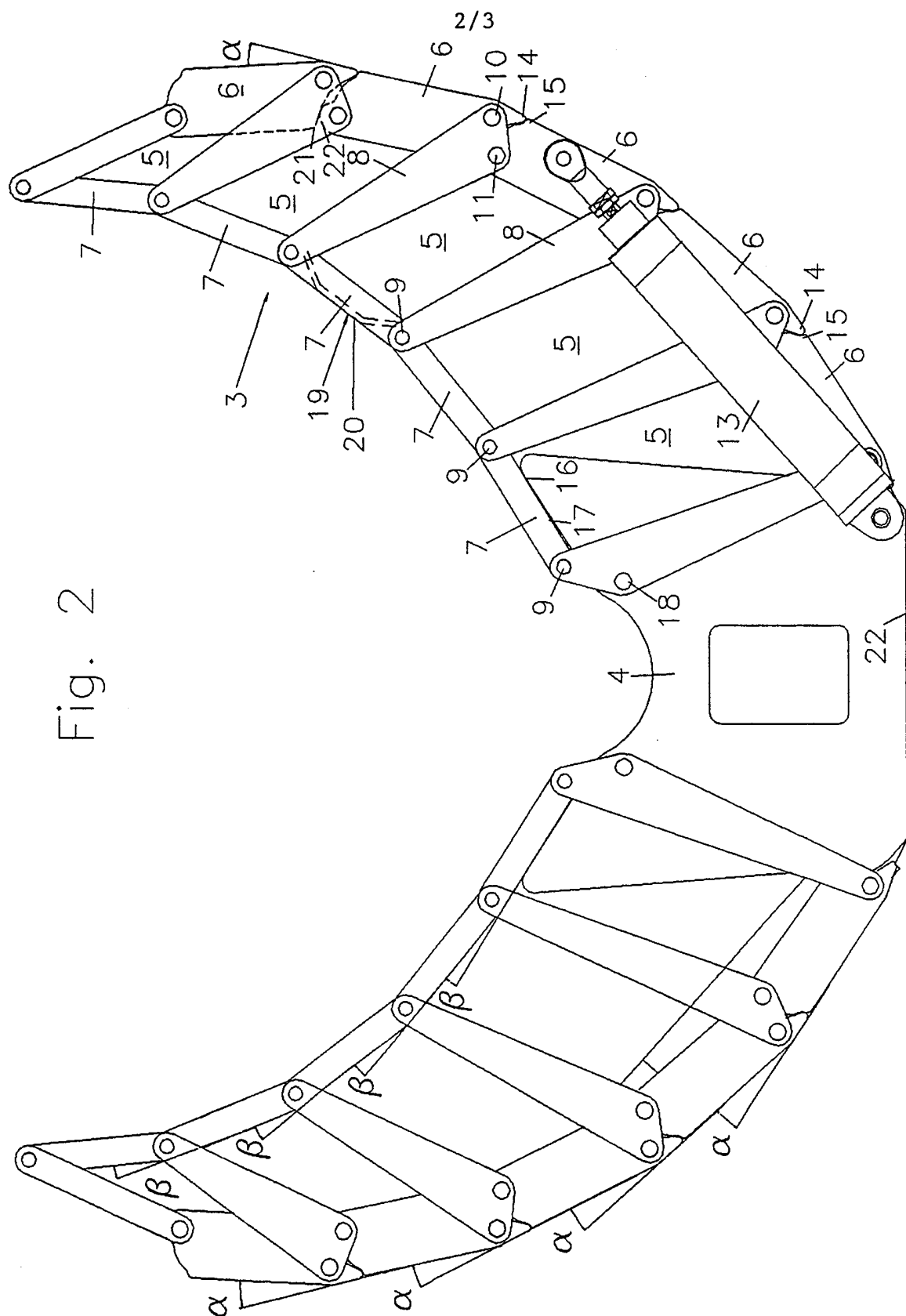


Fig. 2

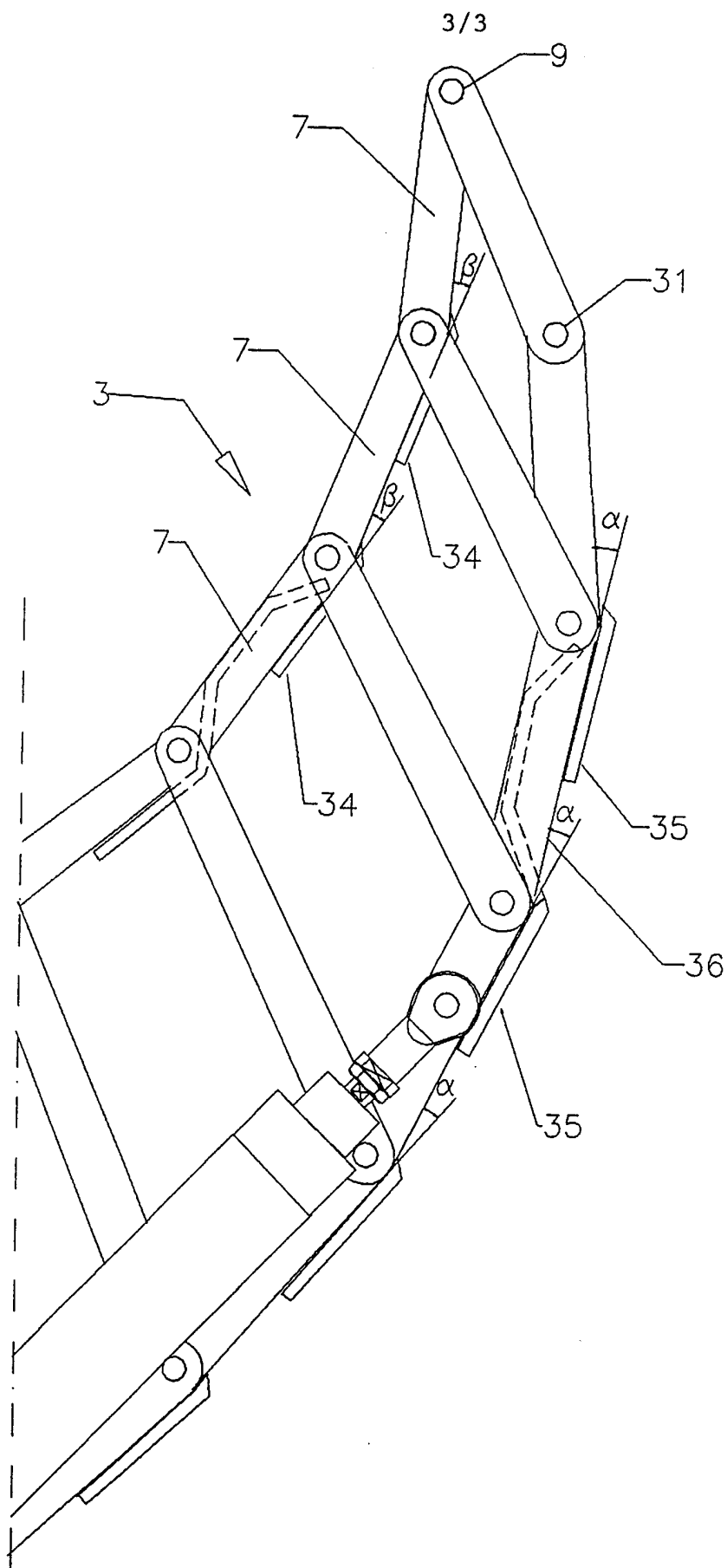


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 99/00418

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: B25J 15/00, B66C 1/42 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)		
IPC6: B25J, B66C, B23Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent's abstract, No G5003 D/28, week 8128, ABSTRACT OF SU, 772846 (IRKUTPOLY), 25 October 1980 (25.10.80) --	1-16
A	JP 5969288 A (DAIKIN IND LTD), 19 April 1984 (19.04.84), figures 1-13 --	1,11-16
A	US 4367891 A (WAUER ET AL), 11 January 1983 (11.01.83), figures 5,6 --	1-2,4-16
A	Derwent's abstract, No 87-191001/27, week 8727, ABSTRACT OF SU, 1271745 (VEDENEV VT), 23 November 1986 (23.11.86) --	1-16
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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PCT/SE 99/00418

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2875913 A (R.W. GOHRKE ET AL), 3 March 1959 (03.03.59), figures 1-6 -- -----	1-2,13,16

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/06/99

International application No.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 4367891 A	11/01/83	DE 2823584 A,C JP 1296097 C JP 54157967 A JP 60010877 B SE 437128 B,C SE 7904502 A	06/12/79 26/12/85 13/12/79 20/03/85 11/02/85 01/12/79
US 2875913 A	03/03/59	NONE	