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(54) **Title:** FLEXURE APPARATUSES, LINEAR ROTARY CONVERTERS, AND SYSTEMS

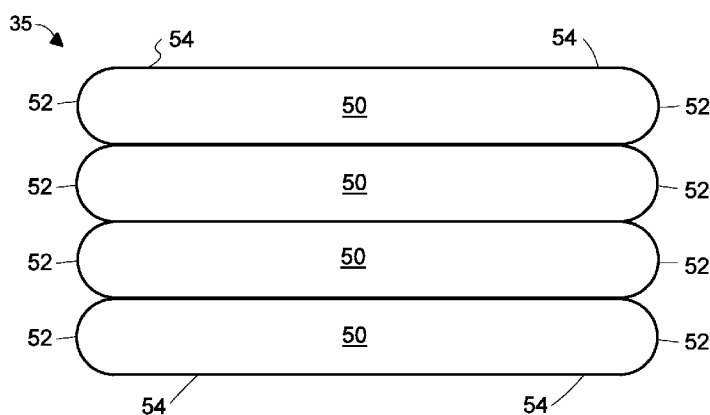


FIG. 1

(57) **Abstract:** The following description pertains to flexure structures, apparatuses comprising flexure structures, systems compris-
ing flexure structures, methods of using flexure structures, methods of using apparatuses comprising flexure structures, and methods of
using systems comprising flexure structures. The following description also pertains to methods, systems, and apparatuses for lin-
ear to rotary motion converters.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/37839

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F04B 43/08, 45/02; F15B 15/10; F16J 3/04, 3/06 (2015.01)

CPC - F16J 3/04, 3/041

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(8) - F04B 43/08, 45/02; F15B 15/10; F16J 3/04, 3/06 (2015.01)

CPC - F16J 3/04, 3/041

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - F16J 3/06; F04B 43/08, 43/088, 43/0054, 43/0063, 43/0072, 45/02; B29L 2031/703; F15B 15/10

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

Patbase; Google Patents; Google Scholar; Google Web; Espacenet; Search Terms: aperture*, axial*, band*, bellow*, circular*, combust*, controller*, convert*, cool*, diaphragm*, disc*, disk*, dispense*, expan*, fluid*, edge*, elipt*, heat*, hole*, hollow*, inflat*, linear*, meter*, multi*, nuta*, opening*, periph*, plastic*, plural*, polymer*, pressur

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 3,442,005 A (Langlet et al.) 06 May 1969 (06.05.1969), Figs. 3, 4c, col. 3, ln. 69-70, col. 4, ln. 3-74	1-6, 9-15 and 47 --- 7-8, 16-18, 19/(1-17), 20/(1-17), 21/(1-17), 22/(1-17), 23/(1-17), 24/(1-17), 25/(1-17), 26/(1-17), 27/(1-17), 28/(1-17), 48 --- 29-46 and 56 7-8, 16-18, 19/(7-8, 16-17), 20/(7-8, 16-17), 21/(7-8, 16-17), 22/(7-8, 16-17), 23/(7-8, 16-17), 24/(7-8, 16-17), 25/(7-8, 16-17), 26/(7-8, 16-17), 27/(7-8, 16-17), 28/(7-8, 16-17) --- 29-46 and 56 19/(1-17), 48
Y ----- A	US 6,076,557 A (Carney) 20 June 2000 (20.06.2000), Fig. 3c(1), col. 3, ln. 8-26, col. 5, ln. 51-52	
Y	GB 2166496 A (Stoll) 08 May 1986 (08.05.1986), Fig. 9, pg. 5, ln. 110-113	

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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22 October 2015 (22.10.2015)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/37839

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 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 No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
--- See supplemental box ---

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 additional fees, this Authority did not invite payment of additional fees.
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.:
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.:
1-48 and 56

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/37839

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,061,156 A (Kuehne et al.) 29 October 1991 (29.10.1991), col. 1, ln. 6-10	20/(1-17), 21/(1-17)
Y	US 2004/0011411 A1 (Thordarson et al.) 22 January 2004 (22.01.2004), para [0147], [0163]	22/(1-17)
Y	US 2003/0136358 A1 (Galvin) 24 July 2003 (24.07.2003), Figs. 5-6, para [0043]	23/(1-17)
Y	GB 480850 A (Frederick), 01 March 1938 (01.03.1938), Figs. 1-2, pg. 2, ln. 25-40	24/(1-17)
Y	US 6,263,671 B1 (Bliesner) 24 July 2001 (24.07.2001), col. 5, ln. 10-11, col. 8, ln. 34-40	25/(1-17), 26/(1-17), 27/(1-17)
Y	US 2008/0199335 A1 (Melatti) 21 August 2008 (21.08.2008), Fig. 4, para [0021]	28/(1-17)
A	US 1,736,974 A (King) 26 November 1929 (26.11.1929), Fig. 2, pg. 3, ln. 83-101	29-46
A	US 3,861,277 A (Wagner et al.) 21 January 1975 (21.01.1975), Figs. 1-8, col. 2, ln. 19-67	1-48 and 56
A	US 2,323,985 A (Fausek et al.) 13 July 1943 (13.07.1943), Figs. 6-7, pg. 2, col. 2, ln. 3-28	1-48 and 56

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/37839

Continuation of Box No. III - Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-48 and 56, directed to a flexure structure including a plurality of hollow disk-like convolutions and method of using such a structure, and method of obtaining such a flexure structure design.

Group II: Claims 49-55, directed to a method of providing fluid to a flexure structure at a differential pressure exceeding 200 kPa (2 Bar) between the interior and exterior.

Group III: Claims 57-58, directed to a bellows in combination with a port plate and nutation rig.

The inventions listed as Groups I-III do not relate to a single inventive concept under PCT Rule 13.1 because under PCT Rule 13.2 they lack the same or corresponding technical features for the following reasons:

Special Technical Features

Group I includes the special technical features of a plurality of hollow disk-like convolutions, the periphery of the hollow disk-like convolutions being curved, the sides of the hollow disk-like convolutions being substantially flat, the sides of the hollow disk-like convolutions having a hole, the adjacent hollow disk-like convolutions being joined that are not required by Groups II-III.

Group II includes the special technical features of creating a differential pressure exceeding 200 kPa (2 Bar) between an interior and exterior of a flexure structure that are not required by Groups I and III.

Group III includes the special technical features of a first port plate, the first port plate being substantially rigid, the base having an opening; a nutation rig, the nutation rig having a substantially planar surface, the nutation rig being substantially rigid; a nutation coupling connected with the nutation rig through the opening; and an at least one bellows being coupled between the base and the nutation rig that are not required by Groups I-II.

Common Technical Features

Groups I-III share the common technical feature of a flexure structure / bellows. However, this shared technical feature does not represent a contribution over the prior art as being anticipated by US 4,464,980 A (Yoshida) which discloses a flexure structure / bellows (Fig. 16).

Therefore, Groups I-III lack unity under PCT Rule 13 because they do not share a same or corresponding technical feature.