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- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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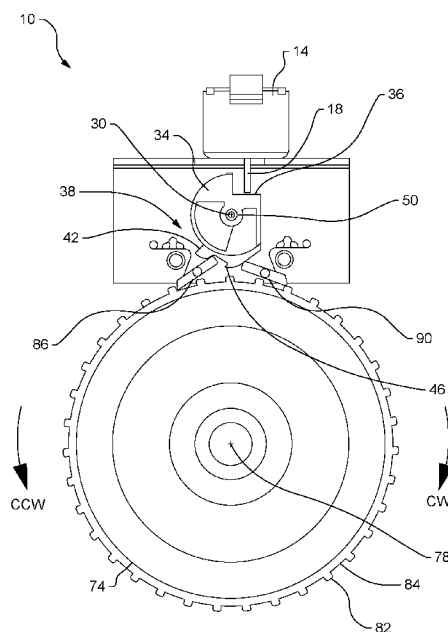
(54) **Title:** MULTI-MODE CLUTCH ASSEMBLY WITH SINGLE CAM

FIG. 1

(57) **Abstract:** A clutch assembly (10) includes locked, one-way, or unlocked operating modes with respect to an inner race (74). As such, the clutch assembly (10) interacts with the inner race (74) to selectively provide multiple modes of clutch operation. The clutch assembly (10) includes an actuator (14), and a single cam (34) operatively rotated by movement of the actuator (14). The cam (34) includes a circumferential boundary (38) having a plurality of selectively operable cam profiles (42, 46). A pair of pawls (86, 90) is configured to interact with the cam profiles (42, 46) for allowing selective engagement and disengagement between the pawls (86, 90) and the inner race (74). As disclosed, the cam profiles (42, 46) are arranged along the circumferential boundary (38) of the cam (34). A cam contact face (36), also on the cam boundary (38) is spaced circumferentially from the cam profiles (42, 46). The actuator (14) includes a linearly movable armature pin (18) configured to engage the cam contact face (36), and the various actuator positions represent different clutch modes of operation.

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

MULTI-MODE CLUTCH ASSEMBLY WITH SINGLE CAM

Cross-Reference to Related Application

[0001] This is a non-provisional patent application claiming priority under 35 USC §119 (e) to US Provisional Patent Application Serial No. 62/148,032 filed on April 15, 2015.

Technical Field

[0002] This disclosure generally relates to clutches and, more particularly, relates to a multi-mode clutch assembly.

Background of Disclosure

[0003] An automotive vehicle typically includes an internal combustion engine containing a rotary crankshaft configured to transfer motive power from the engine through a driveshaft to turn the wheels. A transmission is interposed between engine and driveshaft components to selectively control torque and speed ratios between the crankshaft and driveshaft. In a manually operated transmission, a corresponding manually operated clutch may be interposed between the engine and transmission to selectively engage and disengage the crankshaft from the driveshaft to facilitate manual shifting among available transmission gear ratios.

[0004] On the other hand, if the transmission is automatic, the transmission will normally include an internal plurality of automatically actuated clutches adapted to dynamically shift among variously available gear ratios without requiring driver intervention. Pluralities of clutches, also called clutch modules and/or assemblies, are incorporated within such transmissions to facilitate the automatic gear ratio changes.

[0005] In an automatic transmission for an automobile, anywhere from three to ten forward gear ratios may be available, not including a reverse gear. The various gears may be structurally comprised of inner gears, intermediate gears such as planet or pinion gears supported by carriers, and outer ring gears. Specific transmission

clutches may be associated with specific sets of the selectable gears within the transmission to facilitate the desired ratio changes.

[0006] By way of an example, one of the clutch assemblies of an automatic transmission associated with first (low) and reverse gear ratios may be normally situated at the front of the transmission and closely adjacent the engine crankshaft. The clutch may have an inner race and an outer race disposed circumferentially about the inner race. One of the races, for example the inner race, may be drivingly rotatable in only one direction. The inner race may be selectively locked to the outer race via an engagement mechanism such as, but not limited to, a roller, a sprag, or a pawl, as examples. In the one direction, the inner race may be effective to directly transfer rotational motion from the engine to the driveline.

[0007] Within the latter system, the outer race may be fixed to an internal case or housing of an associated planetary member of the automatic transmission. Under such circumstances, in a first configuration the inner race may need to be adapted to drive in one rotational direction, but freewheel in the opposite direction, in a condition referred to as overrunning. Those skilled in the art will appreciate that overrunning may be particularly desirable under certain operating states, as for example when a vehicle is traveling downhill. Under such circumstance, a driveline may occasionally have a tendency to rotate faster than its associated engine crankshaft. Providing for the inner race to overrun the outer race may avoid damage to the engine and/or transmission components.

[0008] In a second configuration, such as when a vehicle may be in reverse gear, the engagement mechanisms may be adapted for actively engaging in both rotational directions of the inner race, thus not allowing for the overrunning condition in the non-driving direction.

[0009] Because automatic transmissions include pluralities of gear sets to accommodate multiple gear ratios, achieving simplicity of parts and their functions are constant issues. For example, reliability can be improved as physical numbers of mechanical interactions are decreased in any given system. Thus, much effort has been directed to finding ways to simplify components and their functions within automatic transmission components and systems.

Summary of Disclosure

[0010] In accordance with one aspect of the disclosure, a multi-mode clutch assembly is disclosed. The clutch assembly is configured to interact with an inner race to selectively provide multiple modes of clutch operation with respect to the inner race. In the disclosed embodiment, the clutch assembly includes an actuator, and a cam operatively rotated about an axis of rotation of the cam, upon movement of the actuator. The cam includes a plurality of selectively operable cam profiles. A pair of pawls is configured to interact with the cam profiles to provide for selective engagement and disengagement between the pawls and the inner race. The various actuator positions represent different clutch modes of operation.

[0011] In accordance with another aspect of the disclosure, the cam has a circumferential boundary, and the cam profiles are arranged along the circumferential boundary of the cam.

[0012] In accordance with another aspect of the disclosure, the cam includes a contact face, and the actuator includes a linearly movable armature pin configured to engage the cam contact face.

[0013] In accordance with another aspect of the disclosure, the cam contact face is spaced circumferentially from the cam profiles.

[0014] In accordance with yet another aspect, the cam contact face is spaced circumferentially from the cam profiles.

[0015] In accordance with a still further aspect, the linearly movable armature pin is selectively extensible and retractable.

[0016] In accordance with yet another aspect, the armature pin extends along an axis orthogonal to the axis of rotation of the cam.

[0017] These and other aspects and features of the present disclosure may be better appreciated by reference to the following detailed description and accompanying drawings.

Brief Description of the Drawings

[0018] For further understanding of the disclosed concepts and embodiments, reference will be made to the following detailed description, read in connection with the drawings, wherein like elements are numbered alike, and in which:

[0019] FIG. 1 is a side view of a clutch assembly, which may be constructed in accordance with the present disclosure;

[0020] FIG. 2 is another side view of the clutch assembly of FIG. 1, which may be constructed in accordance with the present disclosure;

[0021] FIG. 3 is a side view of the clutch assembly of FIG. 1 in a different mode than that of FIG. 1, which may be constructed in accordance with the present disclosure;

[0022] FIG. 4 is a side view of the clutch assembly of FIG. 1 in a different mode than that of FIGS. 1 or 3, which may be constructed in accordance with the present disclosure;

[0023] FIG. 5 is a perspective view of the clutch assembly of FIG. 1, shown with cam removed to better reveal an alternative pawl shape, which may be constructed in accordance with the present disclosure;

[0024] FIG. 6 is a perspective view of an embodiment of the clutch assembly of FIG. 1, shown with cam removed to reveal a different alternative pawl shape, which may be constructed in accordance with the present disclosure;

[0025] FIG. 7 is another perspective view of the embodiment of FIG. 6 of the clutch assembly of FIG. 1, which may be constructed in accordance with the present disclosure;

[0026] It should be noted that the appended drawings illustrate only typical embodiments, and are thus not to be considered limiting with respect to scope of disclosure or claims. Rather, the concepts of the present disclosure may apply equally effectively within other embodiments and/or environments. Moreover, the drawings are not necessarily to scale, as emphasis is intended to be placed upon only principles of operation for each of the various embodiments.

Detailed Description

[0027] Turning now to the drawings, and with specific reference to FIG. 1, a clutch assembly 10 may be constructed in accordance with the present disclosure. The clutch assembly 10 is shown to include an actuator 14 including an armature pin 18. The actuator 14 may be a solenoid, magnetic device, hydraulic device, or other type of actuator 14. The armature pin 18 is configured to be translated upon motion of the actuator 14. In the described embodiment, the armature pin 18 is moved linearly (vertically, as shown) relative to the actuator 14. As such, the armature pin 18 is linearly extensible from the actuator 14, and also reciprocally retractable into the actuator 14.

[0028] A bracket 26 may be attached to the actuator 14. The bracket 26 may include a pivot axis 30 about which a cam 34 rotates. The cam 34 may be rotated through actuation, or impingement, by the armature pin 18 on a cam face 36. Extension or retraction of the armature pin 18 along an axis 20 (FIG. 2), as induced by the actuator 14, rotates the cam 34 about the pivot axis 30. The cam 34 has a circumferential boundary 38 that includes a first cam profile 42 and a second cam profile 46, although additional or fewer cam profiles are possible. Further, a cam return spring 50 may bias the cam 34, and thus the cam face 36 to rotate against the direction of actuation on the cam 34 from the actuator 14 and armature pin 18. Thus, as disclosed, the armature pin 18 is urged against the cam face 36, rotating the cam 34 clockwise against the force of a cam return spring 50, for example.

[0029] The clutch assembly 10 may be configured to interact with an inner race 74 rotatable about a rotation axis 78. The inner race 74 may include a series of cogs 82 and notches 84, the notches being defined by spaces between the circumferentially disposed cogs 82. Referring to FIG. 2, a first pawl 86 and a second pawl 90 may be attached to the bracket 26, and may rotate about first and second pawl pivot axes 94, 98 respectively. The pawls 86, 90 may rotate between open and locked positions. An open position will allow inner race 74 to rotate in either a clockwise or a counterclockwise direction, as reflected by the arrows CW and CCW, respectively. Alternatively, the same open position may allow rotation of the inner race 74 in both directions, while a locked position may not allow rotation of the inner race 74 in a particular direction due to interference between one of the pawls 86, 90 and the cogs 82. Additionally, a first pawl spring 102 is configured to be fixed to the bracket 26 in

order to bias the first pawl 86 into a locked position, and a similarly fixed second pawl spring 106 to bias the second pawl 90 into a locked position.

[0030] For this purpose, the first pawl 86 may include a first heel 110 and a first toe 114, and the second pawl 90 may include a second heel 118 and a second toe 122. Each heel 110, 118 may be actuated by respective cam profiles 42, 46 during operation, and each toe 114, 122 may be biased towards the locked position by each respective pawl spring 102, 106. Further, each toe 114, 122 may engage the cogs 82 to lock respective pawls 86, 90 into their locked positions, thus preventing rotation of the inner race 74 in either direction.

[0031] In operation, the actuator 14 may move the armature pin 18 into various positions, as now described. A given actuator 14 and armature pin 18 movement may cause the cam 34 to rotate to a particular position such that one or more cam profiles 42, 46 moves to cause one or more pawls 86, 90 to rotate. For example, the first cam profile 42 may induce rotation of the first pawl 86, while the second cam profile 46 may induce rotation of the second pawl 90. In one described embodiment, three actuator 14 positions reflect distinct modes of the clutch assembly 10, although more or fewer positions are within the scope of this disclosure. Further, the clutch assembly 10 may be arranged in such a way that different positions of the actuator 14 produce different positions of the pawls 86, 90. As such, in the embodiment shown, three specific actuator 14 positions provide for three different positions of the pawls 86, 90, each position of the actuator 14 corresponding to a different clutch mode, based upon a specific engagement or disengagement of the pawls 86, 90 with respect to the inner race 74.

[0032] In a first position, shown in FIGS. 1 and 2, the clutch assembly 10 is depicted in a first mode of operation, wherein the first pawl 86 is in an open position, and the second pawl 90 is in a locked position. In this mode, rotation of the inner race 74 is possible in the counterclockwise (CCW) direction, but not in the clockwise (CW) direction.

[0033] In FIG. 3, another position is shown in which the clutch assembly is in a second mode of operation. In this position, both first and second pawls 86, 90 are in locked positions. In this mode, rotation of the inner race 74 is prevented not possible in both clockwise (CW) and counterclockwise (CCW) directions.

[0034] In FIG. 4, the clutch assembly is shown in a third mode of operation, wherein both pawls 86, 90 are in open positions. In this mode, rotation of the inner race 74 rotation is permitted in either direction.

[0035] A variety of approaches may be used to enable the clutch assembly 10 to achieve multiple operating modes corresponding to different armature pin 18 settings. For example, multiple operating modes may be achieved by varying the shapes and/or locations of the cam 34, pivot axis 30 or cam profiles 42, 46. Further, locations of the first and second pawls and/or their pivot axes 94, 98 may be configured to achieve multi-mode capability. Additionally, shapes, orientations or sizes of the pawls 86, 90 may be configured to facilitate and enable multi-mode operation.

[0036] FIG. 5 provides a perspective view of pawls 86, 90 to reflect a wide range of variability of their shapes and sizes. The pawls 86, 90 may be substantially rectangular in shape. In an additional embodiment, as best shown in FIGS. 6 and 7, the pawls 86, 90 may further include first and second pawl indentations 126, 130, respectively. Each pawl indentation 126, 130 may be sized and shaped such that the first and second cam profiles 42, 46 can rotate respective pawls 86, 90 while avoiding interference from the cam 34 or the other cam profile 42, 46 during cam 34 rotation.

[0037] It is to be understood that the foregoing is merely a description of one or more embodiments of the invention, and that the invention is not intended to be limited to any particular embodiment(s) as herein disclosed. Indeed, various other embodiments and changes or modifications to any disclosed embodiment(s) may likely become apparent to those skilled in the art. Among other aspects, even though the inner race 74 may be shown herein as a driving, rather than driven, component, the clutch assembly 10 could be configured such that an outer race could be the driving component, for example. Furthermore, and even more generally, any statements contained in the description of any particularly described embodiment are not to be construed as limiting the appended claims, either in scope of the invention or in definitions of terms used.

CLAIMS

What is claimed is:

1. A clutch assembly (10) is configured to interact with an inner race (74) to selectively provide multiple modes of clutch operation with respect to the inner race (74), the clutch assembly (10) comprising:
 - an actuator (14);
 - a single cam (34) operatively rotated about an axis of rotation (30) of the cam (34) upon movement of the actuator (14), the cam (34) including a plurality of selectively operable cam profiles (42, 46);
 - a pair of pawls (86, 90) configured to interact with the cam profiles (42, 46) for providing selective engagement and disengagement between the pawls (86, 90) and the inner race (74);
 - wherein various actuator positions represent different clutch modes of operation.
2. The clutch assembly (10) of claim 1, wherein the cam (34) has a circumferential boundary (38), and wherein the cam profiles (42, 46) are arranged along the circumferential boundary (38) of the cam (34).
3. The clutch assembly (10) of claim 1, wherein the cam (34) includes a contact face (36), and wherein the actuator (14) includes a linearly movable armature pin (18) configured to engage the cam contact face (36).
4. The clutch assembly (10) of claim 3, wherein the cam contact face (36) is spaced along the circumferential boundary (38) from the cam profiles (42, 46).
5. The clutch assembly (10) of claim 3, wherein the linearly movable armature pin (18) is selectively extensible and retractable.
6. The clutch assembly (10) of claim 3, wherein the armature pin (18) extends along an axis (20) orthogonal to the axis of rotation (30) of the cam (34).
7. The clutch assembly (10) of claim 1, wherein the inner race (74) has an axis of rotation (78), and wherein the axis of rotation (30) of the cam (34) is parallel to the axis of rotation (78) of the inner race (74).

8. A cam (34) configured to interact with an inner race (74) to selectively provide multiple modes of operation of a clutch assembly (10) with respect to the inner race (74), the cam (34) comprising:
- an actuator (14) selectively engageable with the cam (34);
 - the cam (34) operatively rotated about an axis of rotation (30) upon movement of the actuator (14), the cam (34) including a plurality of selectively operable cam profiles (42, 46);
 - a pair of pawls (86, 90) configured to interact with the cam profiles (42, 46) for providing selective engagement and disengagement between the pawls (86, 90) and the inner race (74);
 - wherein various actuator positions represent different clutch modes of operation.
9. The cam (34) of claim 8, further comprising a circumferential boundary (38), and wherein the cam profiles (42, 46) are arranged along the circumferential boundary (38) of the cam (34).
10. The cam (34) of claim 8, further comprising a contact face (36), and wherein the actuator (14) includes a linearly movable armature pin (18) configured to engage the cam contact face (36).
11. The cam (34) of claim 10, wherein the cam contact face (36) is spaced along the circumferential boundary (38) from the cam profiles (42, 46).
12. The cam (34) of claim 10, wherein the linearly movable armature pin (18) is selectively extensible and retractable.
13. The cam (34) of claim 10, wherein the armature pin (18) extends along an axis (20) orthogonal to the axis of rotation (30) of the cam (34).
14. The cam (34) of claim 8, wherein the inner race (74) has an axis of rotation (78), and wherein the axis of rotation (30) of the cam (34) is parallel to the axis of rotation (78) of the inner race (74).
15. A method of making a cam (34) configured to interact with an inner race (74), to selectively provide multiple modes of operation of a clutch assembly (10) with respect to the inner race (74), the method comprising:
- forming a single cam (34);
 - forming an actuator (14) to be selectively engageable with the cam (34);

positioning the cam (34) to be operatively rotated about an axis of rotation (30) upon movement of the actuator (14);

forming a plurality of selectively operable cam profiles (42, 46) on the cam (34);

placing a pair of pawls (86, 90) to interact with the cam profiles (42, 46) for providing selective engagement and disengagement between the pawls (86, 90) and the inner race (74);

wherein various actuator positions represent different clutch modes of operation.

1/7

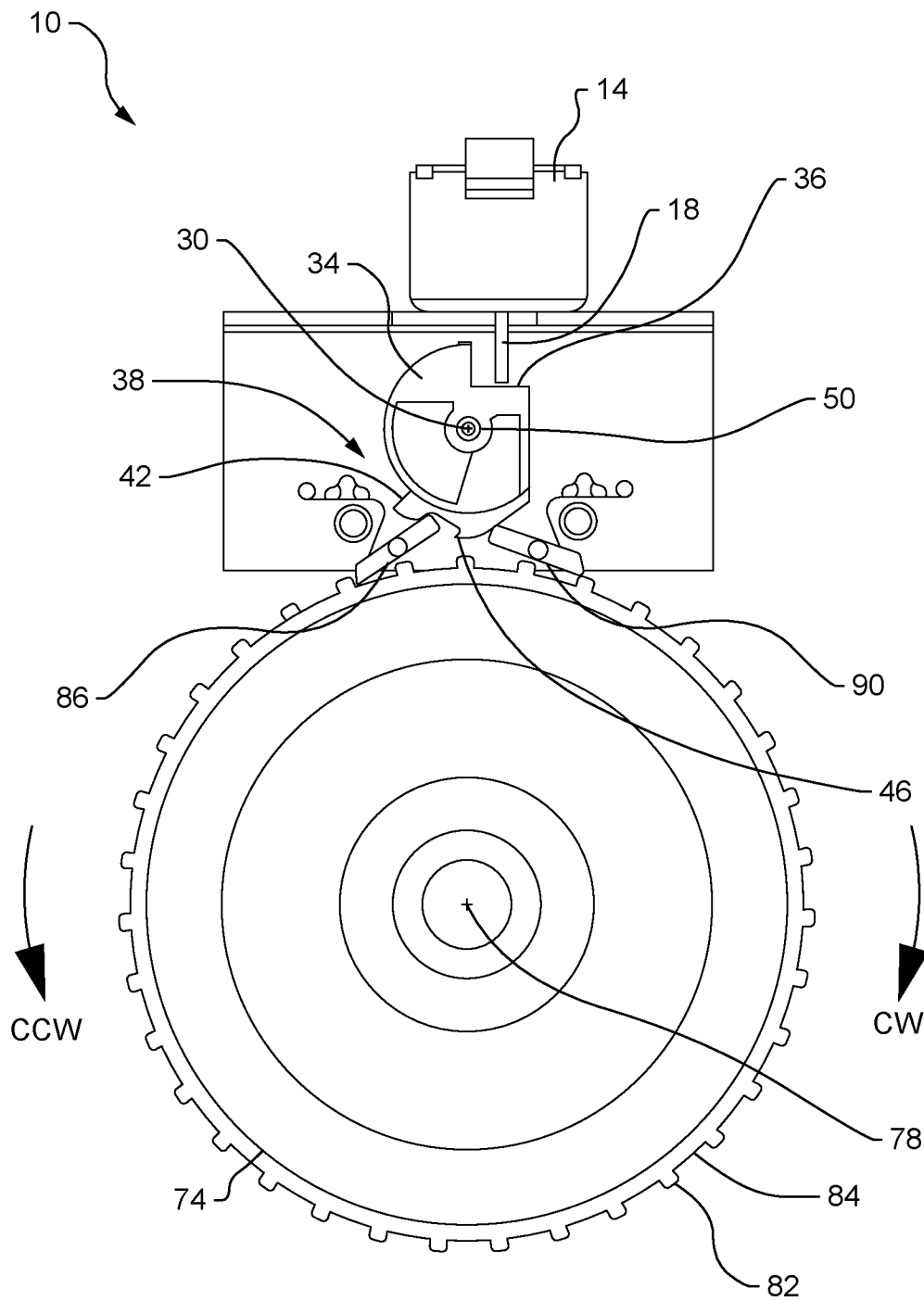


FIG. 1

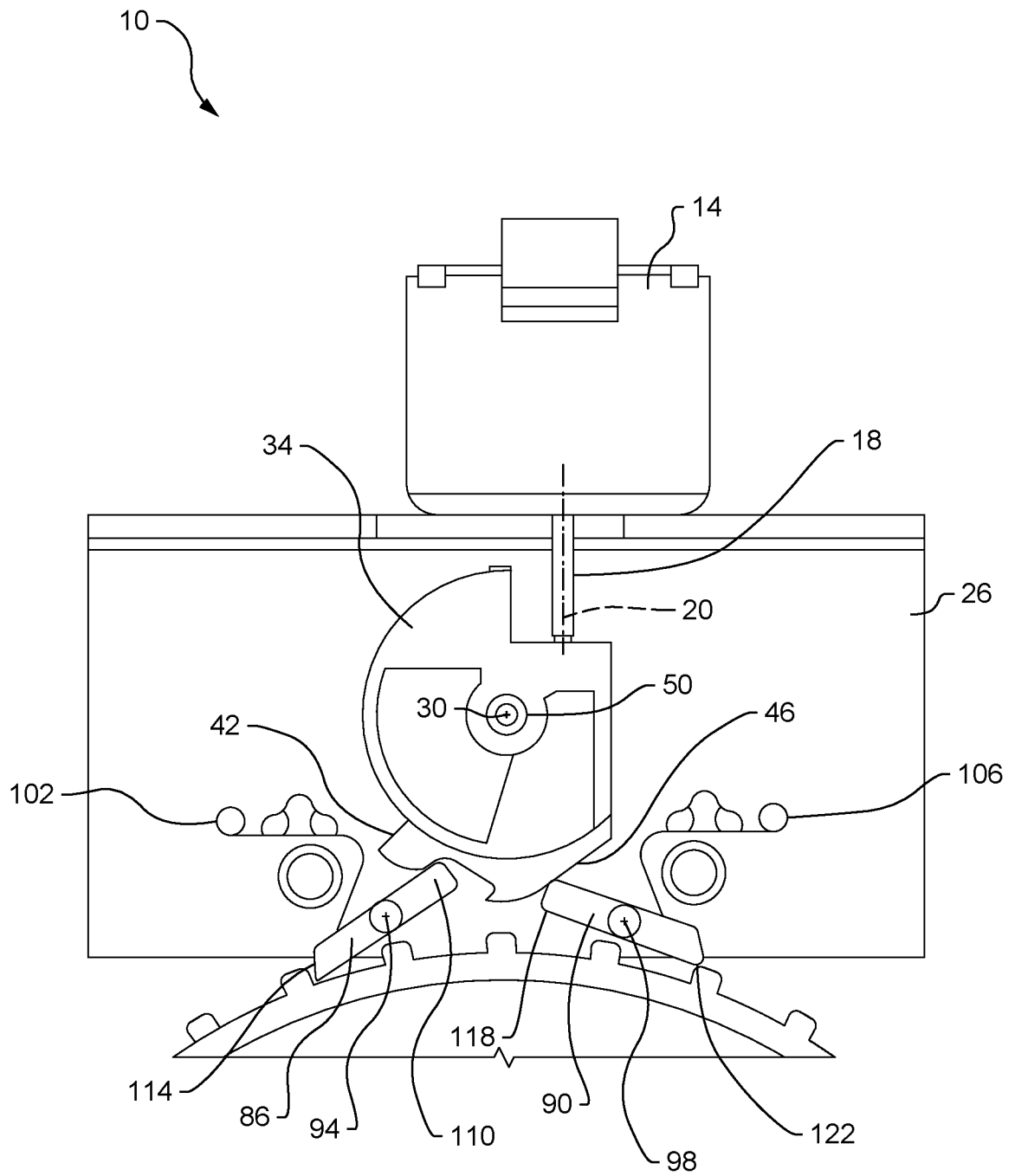


FIG. 2

3/7

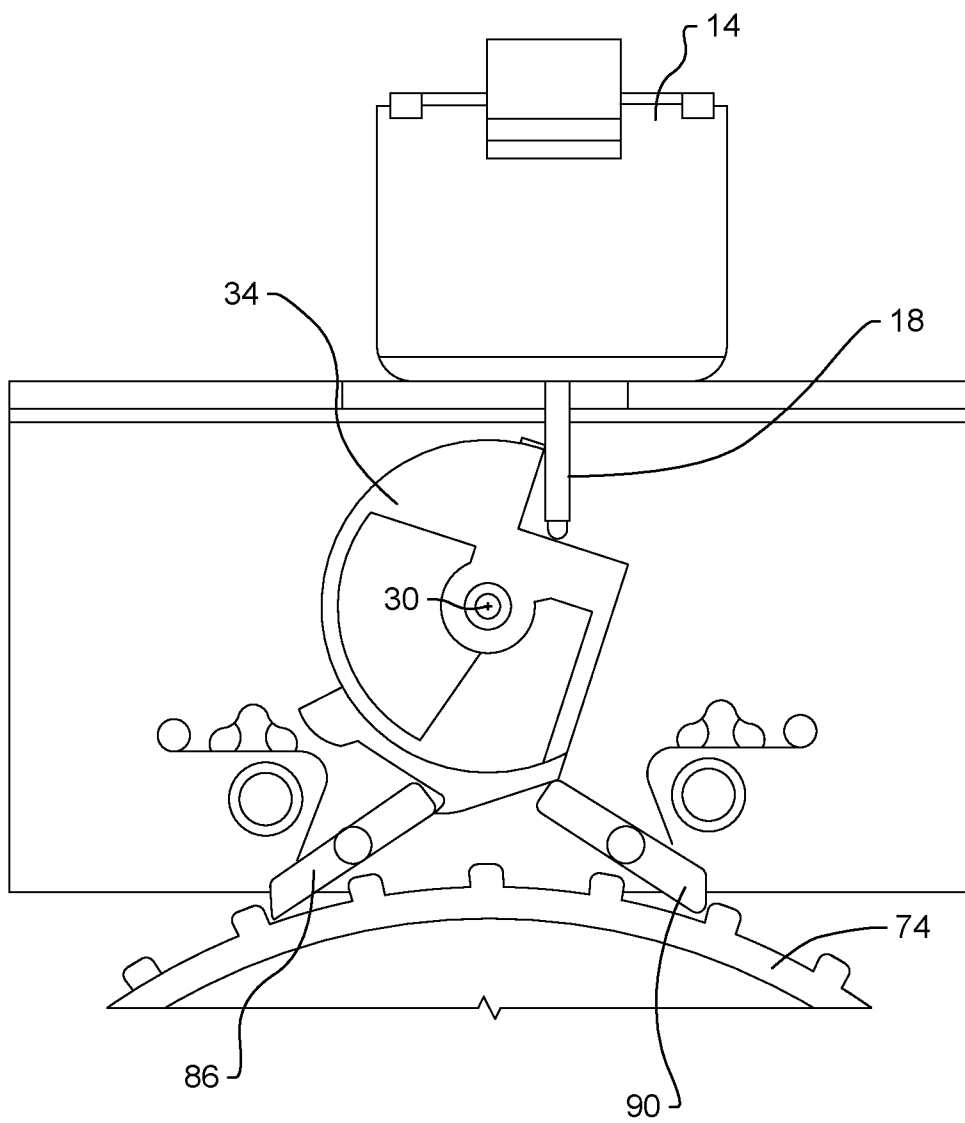


FIG. 3

4/7

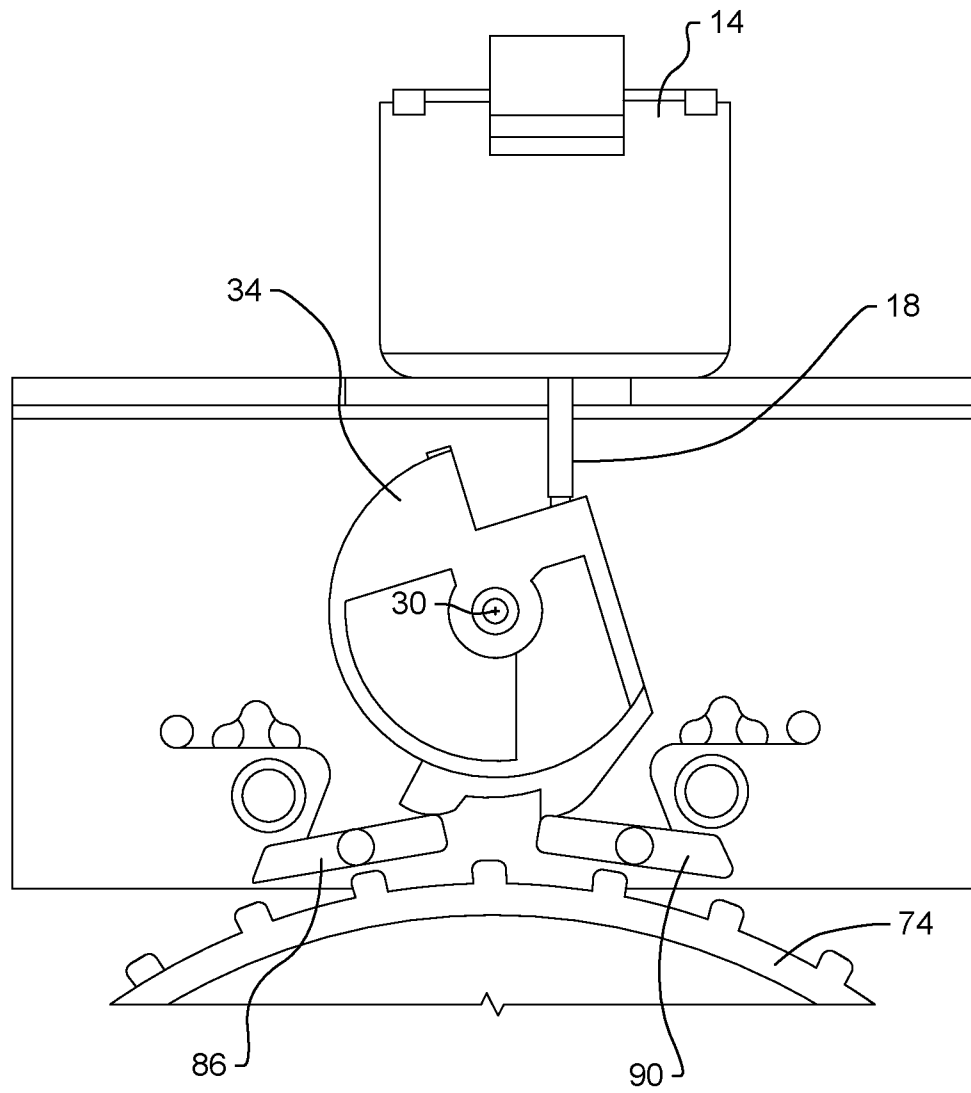


FIG. 4

5/7

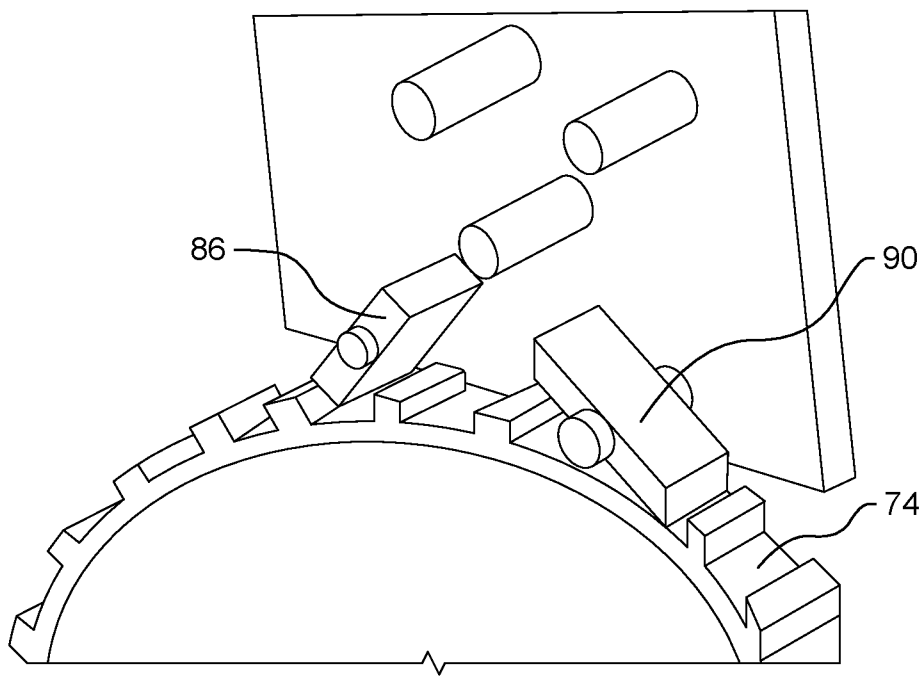


FIG. 5

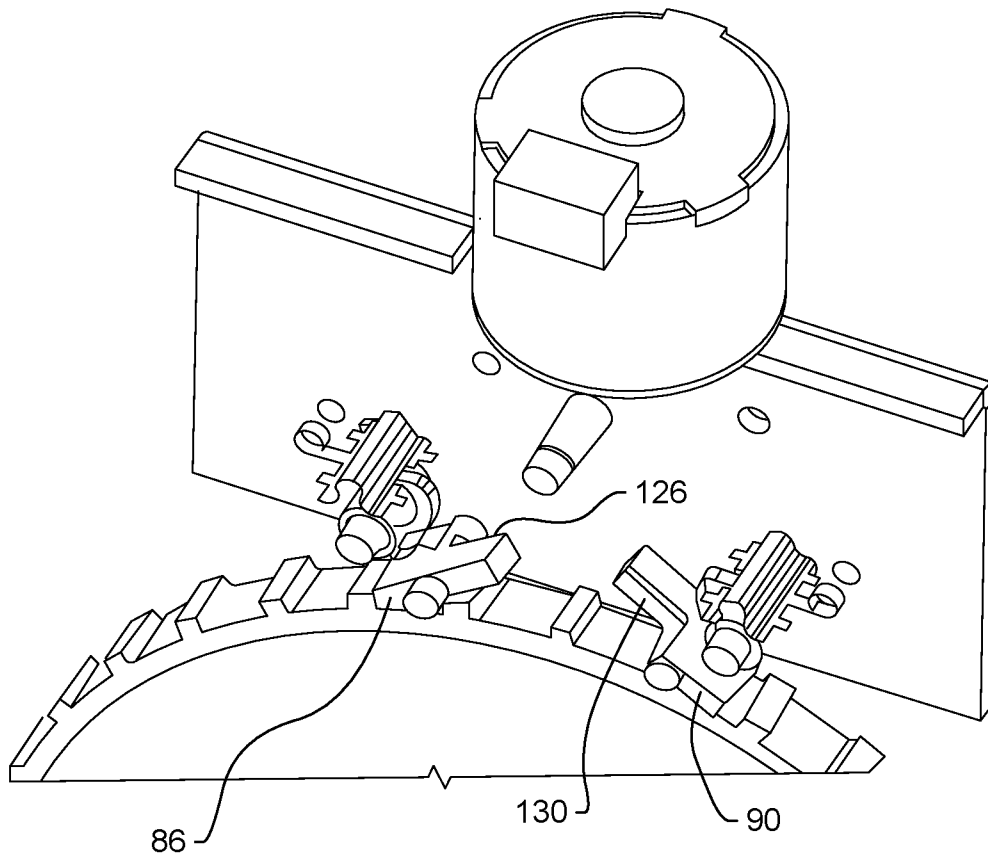


FIG. 6

7/7

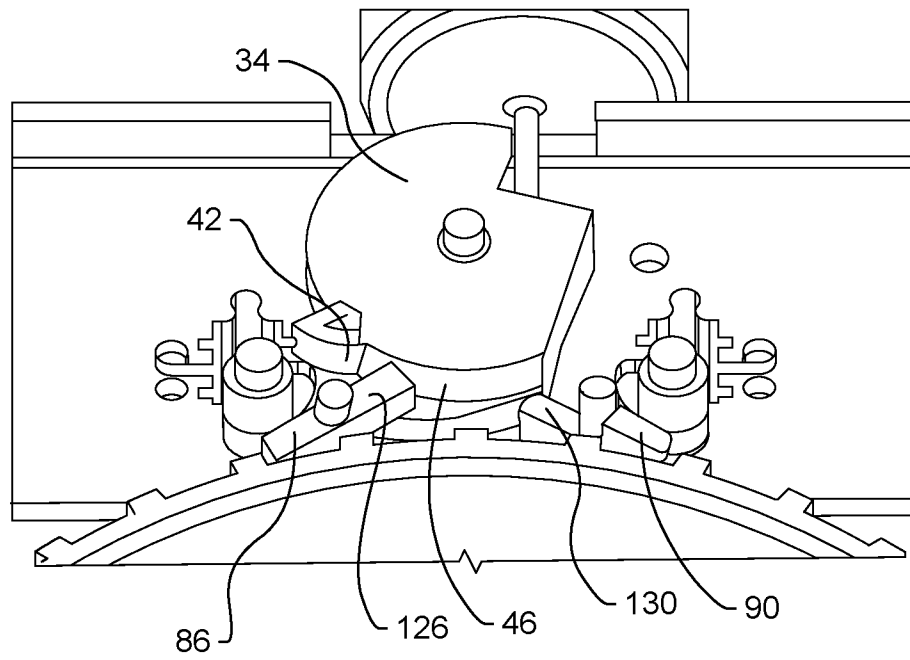


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/026867**A. CLASSIFICATION OF SUBJECT MATTER****F16D 41/08(2006.01)i, F16D 41/06(2006.01)i, F16D 23/00(2006.01)i**

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)

F16D 41/08; F16D 41/30; B27N 3/16; F16D 41/02; F16D 27/09; F16D 41/14; F16D 41/00; F16D 41/12; F16D 41/06; F16D 23/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: clutch, single cam, multi-mode, multi-stage, pawl, crank, pivot, actuator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-249115 A (KAYSEVEN CO., LTD.) 15 September 2005 See paragraphs [0014]-[0032] and figures 1-8.	1-15
Y	US 2013-0140124 A1 (MITCHELL, VINCE) 06 June 2013 See paragraphs [0039]-[0049] and figures 4-8.	1-15
A	CN 2881199 Y (LIU, JIE) 21 March 2007 See page 4, line 11 - page 5, line 13 and figures 1, 2.	1-15
A	US 2014-0305761 A1 (MEANS INDUSTRIES, INC.) 16 October 2014 See paragraphs [0056]-[0075] and figures 1-3.	1-15
A	CN 1666849 A(SHANGHAI WOOD-BASED PANEL MACHINERY CO., LTD.)14 September 2005 See abstract and figures 1-5.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"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

Date of the actual completion of the international search

08 August 2016 (08.08.2016)

Date of mailing of the international search report

08 August 2016 (08.08.2016)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/026867

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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