



(51) International Patent Classification:

B60K 6/387 (2007.10) *F16H 41/24* (2006.01)
B60K 6/405 (2007.10) *F16H 45/02* (2006.01)

(21) International Application Number:

PCT/US2024/054515

(22) International Filing Date:

05 November 2024 (05.11.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

18/388,644 10 November 2023 (10.11.2023) US

(71) Applicant: **SCHAEFFLER TECHNOLOGIES AG & CO. KG** [DE/DE]; Industriestraße 1-3, 91074 Herzogenaurach (DE).

(71) Applicant (for PH only): **SCHAEFFLER GROUP USA, INC.** [US/US]; 308 Springhill Farm Road, Fort Mill, South Carolina 29715 (US).

(72) Inventors: **HARTZLER, Baylor**; 3401 Old Airport Rd, Wooster, Ohio 44691 (US). **RIGGENBACH, Noah**; 4425 Egypt Rd, Smithville, Ohio 44677 (US).

(74) Agent: **SUGGS, LeKeisha**; 1750 E. Big Beaver Road, Troy, Michigan 48083 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

(54) Title: HYBRID MODULE THRUST BUSHING

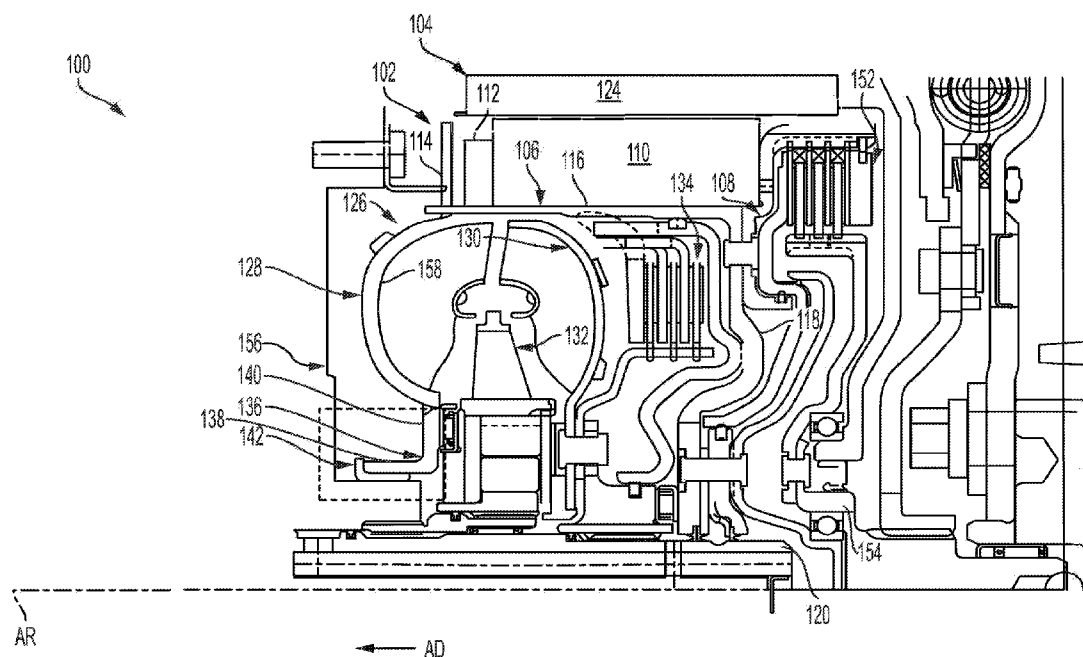


FIG. 1

(57) Abstract: A hybrid module includes a rotor carrier, a torque converter, and a thrust bushing. The rotor carrier includes an axially extending portion and a radially extending portion extending radially inward from the axially extending portion. The torque converter includes an impeller having an impeller shell fixed to the rotor carrier and an impeller hub fixed to the impeller shell. The impeller hub extends in an axial direction away from the radially extending portion of the rotor carrier to a distal end. The thrust bushing is connected to the impeller hub. The thrust bushing includes an axial portion in contact with the impeller hub and a radial portion extending radially outward from the axial portion. The radial portion is in contact with the distal end.



TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, 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).

Published:

— *with international search report (Art. 21(3))*

HYBRID MODULE THRUST BUSHING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Patent Application No. 18/388644, filed November 10, 2023, the disclosure of which is incorporated in its entirety by reference herein.

TECHNICAL FIELD

[0002] The present disclosure relates generally to a hybrid module and, more specifically, to a thrust bushing for a torque converter of a hybrid module.

BACKGROUND

[0003] Hybrid modules are generally known. In some arrangements, the hybrid modules may include a torque converter and multiple components, e.g., a drive plate bolted to a housing, a bearing and spring arranged between the torque converter and the housing, etc., configured to axially position the torque converter when the torque converter is not operating. Often, it is a challenge to package and/or fit all the desired components, e.g., an e-motor, crank damper, torque converter, torque converter clutch, K0 clutch, and resolver within the hybrid module architecture due to axial and radial constraints. Due to limited spacing within a hybrid module envelope, it is desirable to have alternative designs and configurations to fit all the necessary components within the hybrid module while still meeting durability and performance requirements.

SUMMARY

[0004] Embodiments of the present disclosure provide a hybrid module including a rotor carrier, a torque converter, and a thrust bushing. The rotor carrier includes an axially extending portion and a radially extending portion extending radially inward from the axially extending portion. The torque converter includes an impeller having an impeller shell fixed to the rotor

carrier and an impeller hub fixed to the impeller shell. The impeller hub extends in an axial direction away from the radially extending portion of the rotor carrier to a distal end. The thrust bushing is connected to the impeller hub. The thrust bushing includes an axial portion in contact with the impeller hub and a radial portion extending radially outward from the axial portion. The radial portion is in contact with the distal end.

[0005] In embodiments, the thrust bushing may be L-shaped. In embodiments, the rotor carrier and the impeller may define a housing of the torque converter. The radial portion may be disposed external to the housing. The hybrid module may further include a lock-up clutch disposed within the housing and arranged axially between the radial portion and the radially extending portion.

[0006] In embodiments, the axial portion of the thrust bushing may be configured to receive an axially extending portion of a transmission housing. The axial portion of the thrust bushing may be configured to be in contact with the axially extending portion of the transmission housing. The thrust bushing may be non-rotatably connected to the impeller hub and may be configured to be rotatably connected to the axially extending portion of the transmission housing.

[0007] In embodiments, the radial portion may be configured to axially constrain the torque converter in the axial direction. In embodiments, the thrust bushing may be non-rotatably connected to the impeller hub. In embodiments, the torque converter may further include a turbine arranged axially between the impeller and the radial portion of the rotor carrier. The distal end being disposed axially between the radial portion of the thrust bushing and the turbine.

[0008] Embodiments of the present disclosure further provide a torque converter for a hybrid module. The torque converter includes a turbine, an impeller in fluid communication with the turbine, and a thrust bushing. The impeller includes an impeller shell and an impeller hub fixed to the impeller shell. The impeller hub extends in an axial direction away from the turbine to a distal end. The thrust bushing is connected to the impeller hub. The thrust bushing includes an axial portion in contact with the impeller hub and a radial portion extending radially outward from the axial portion. The radial portion is in contact with the distal end.

[0009] In embodiments, the thrust bushing may be L-shaped. In embodiments, the distal end may be disposed axially between the radial portion and the turbine. In embodiments, the radial portion may be configured to axially constrain the torque converter in the axial direction. In embodiments, the thrust bushing may be non-rotatably connected to the impeller hub.

[0010] In embodiments, the axial portion of the thrust bushing may be configured to receive an axially extending portion of a transmission housing. The axial portion of the thrust bushing may be configured to be in contact with the axially extending portion of the transmission housing. The thrust bushing may be non-rotatably connected to the impeller hub and may be configured to be rotatably connected to the axially extending portion of the transmission housing.

[0011] In embodiments, the impeller may define, at least partially, a housing of the torque converter. The turbine may be disposed within the housing, and the radial portion may be disposed external to the housing. The torque converter may further include a lock-up clutch disposed within the housing. The turbine may be disposed axially between the radial portion and the lock-up clutch.

[0012] Embodiments of the present disclosure provide the advantageous benefit of axially constraining a torque converter, for example, by providing a thrust bushing for axially constraining an impeller hub of the torque converter. Further embodiments disclosed herein offer design advantages by axially constraining the torque converter with a single component, which can reduce costs and complexity of the torque converter while satisfying packaging constraints in hybrid modules and still meeting durability and performance requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Figure 1 shows a partial cross-sectional view of a hybrid module according to an exemplary embodiment of the present disclosure.

[0014] Figure 2 illustrates an enlarged view of an area of the hybrid module shown in Figure 1.

DETAILED DESCRIPTION

[0015] Embodiments of the present disclosure are described herein. It should be appreciated that like drawing numbers appearing in different drawing views identify identical, or functionally similar, structural elements. Also, it is to be understood that the disclosed embodiments are merely examples and other embodiments can take various and alternative forms. The figures are not necessarily to scale; some features could be exaggerated or minimized

to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the embodiments. As those of ordinary skill in the art will understand, various features illustrated and described with reference to any one of the figures can be combined with features illustrated in one or more other figures to produce embodiments that are not explicitly illustrated or described. The combinations of features illustrated provide representative embodiments for typical applications. Various combinations and modifications of the features consistent with the teachings of this disclosure, however, could be desired for particular applications or implementations.

[0016] The terminology used herein is for the purpose of describing particular aspects only and is not intended to limit the scope of the present disclosure. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. Although any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the disclosure, the following example methods, devices, and materials are now described.

[0017] Referring to Figures 1-2 a portion of a hybrid module 100 is illustrated according to an exemplary embodiment of the present disclosure. At least some portions of the hybrid module 100 are rotatable about an axis of rotation AR. While only a portion of the hybrid module 100 above the axis of rotation AR is shown in Figure 1, it should be understood that the hybrid module 100 can appear substantially similar below the axis of rotation AR with many components extending about the axis of rotation AR. Words such as “axial,” “radial,” “circumferential,” “outward,” etc. as used herein are intended to be with respect to the axis of rotation AR.

[0018] The hybrid module 100 includes a rotor assembly 102 and a stator assembly 104 forming an e-motor assembly. The rotor assembly 102 includes a rotor carrier 106, a rotor flange 108, a rotor segment 110, a spring end plate 112, and an end ring 114. The rotor carrier 106 includes an axially extending portion 116 and a radially extending portion 118 extending radially inward from the axially extending portion 116 toward the axis of rotation AR, wherein the radially extending portion 118 is configured to connect with a transmission input shaft 120. The rotor flange 108 is fixed to the radially extending portion 118 of the rotor carrier 106. The rotor

flange 108 may include a carrier portion (not numbered) arranged radially outward of the axially extending portion 116 of the rotor carrier and extending away from the rotor assembly 102.

[0019] The rotor segment 110 is installed and arranged on a radially outer surface of the axially extending portion 116 of the rotor carrier 106. Additionally, the rotor segment 110 may contact an axial surface of the rotor flange 108. In one embodiment, the rotor segment 110 may be comprised of a stack of segments. The spring end plate 112 is assembled on an axial side of the rotor segment 110 opposite the rotor flange 108. In another embodiment, the hybrid module 100 may include a second spring end plate assembled axially between the rotor segment 110 and the axial surface of the rotor flange 108. The end ring 114 is fixed to the radially outer surface of the axially extending portion 116 of the rotor carrier 106 adjacent to the spring end plate 112. In this way, the spring end plate 112 is disposed axially between the end ring 114 and the rotor segment 110. The end ring 114 is configured to compress the spring end plate 112 to clamp and/or secure the rotor segment 110 to the rotor carrier 106 and the rotor flange 108 for frictional torque transmission therebetween. Once the desired compression force is achieved, the end ring 114 is fixed to the rotor carrier 106, e.g., by welding.

[0020] The stator assembly 104 is disposed radially outside of the rotor assembly 102 and is fixed relative to the rotor assembly 102. The stator assembly 104 includes a stator carrier (not shown) and a stator segment 124. In one embodiment, the stator segment 124 may be a stack of stator segments. The stator segment 124 is installed and arranged on an inner surface of the stator carrier. In one embodiment, the stator segment 124 may be installed on the stator carrier via a shrink fit arrangement. That is, the stator carrier is heated to expand the inner surface, the stator segment 124 is installed on the stator carrier, and the inner surface shrink fits to the stator segment 124 after the stator carrier cools.

[0021] The hybrid module 100 further includes a torque converter assembly 126 fully disposed radially inside the rotor assembly 102. The torque converter assembly 126 includes: an impeller 128 having an impeller shell 158 with at least one blade attached thereto, a turbine 130 having a turbine shell with at least one blade attached thereto; a stator 132 having at least one blade attached thereto; and a lock-up clutch 134. The impeller shell 158 may be fixed to the rotor carrier 106, e.g., via a welded connection.

[0022] The impeller 128 further includes an impeller hub 136 connected to an inner end of the impeller shell 158, e.g., via welding. The impeller hub 136 includes a first portion 138

extending in an axial direction AD away from the turbine 130 to a distal end 150. The first portion 138 may extend substantially parallel to the axis of rotation AR. By “substantially parallel,” we mean that a longitudinal axis of the first portion 138 and the axis of rotation AR extend in a common axial direction with the understanding that they may deviate from being parallel with each other due to manufacturing tolerances and capabilities. The impeller hub 136 may include a second portion 140 extending radially inward from the impeller shell 158 to the first portion 138.

[0023] The impeller 128 and the rotor carrier 106 together form a housing for the torque converter assembly 126. The lock-up clutch 134, the turbine 130, and the stator 132 are disposed within the housing formed by the impeller 128 and the rotor carrier 106.

[0024] The lock-up clutch 134 may be disposed between the turbine 130 and the radially extending portion 118 of the rotor carrier 106. The lock-up clutch 134 may include: a piston (not numbered); a reaction plate (not numbered) fixed to the axially extending portion 116 of rotor carrier 106 and disposed axially between the piston and the turbine 130; a plurality of clutch plates (not numbered) disposed axially between the piston and the reaction plate; and an inner disk carrier (not numbered) disposed axially between the piston and the turbine 130. The plurality of clutch plates may be connected to the inner disk carrier. The piston may be sealed to the rotor carrier 106 at a radially outer end and may be sealed to an output hub (not numbered) at a radially inner end. The inner disk carrier may be connected to the turbine shell and the output hub at a radially inner end, for example, via a riveted connection. The output hub is connected to the transmission input shaft 120 for torque transmission therebetween.

[0025] The torque converter assembly 126 further includes a thrust bushing 142. The thrust bushing 142 includes an axial portion 144 extending along the axis of rotation AR and a radial portion 146 extending radially outward, i.e., away from the axis of rotation AR, from an end of the axial portion 144. That is, the thrust bushing 142 has an L-shape in cross-section along the axis of rotation AR. The axial portion 144 may, for example, be non-rotatably connected to the impeller hub 136, e.g., via a press-fit connection. That is, the first portion 138 of the impeller hub 136 may be configured to receive the axial portion 144 of the thrust bushing 142. The axial portion 144 is configured to receive an axially extending portion 148 of a transmission housing 156. That is, the axial portion 144 is arranged radially between the first portion 138 of the impeller hub 136 and the axially extending portion 148 of the transmission housing 156. The

axial portion 144 is configured to center, i.e., pilot, the impeller hub 136 relative to the axially extending portion 148. Specifically, the axial portion 144 is in contact with the first portion 138 and the axially extending portion 148. The thrust bushing 142 may, for example, be rotatably connected to the axially extending portion 148 of the transmission housing 156, e.g., via a slip-fit connection.

[0026] The radial portion 146 is arranged external to the housing of the torque converter assembly 126. That is, the distal end 150 of the first portion 138 is disposed axially between the radial portion 146 and the turbine 130. The radial portion 146 is in contact with the distal end 150 of the first portion 138. The radial portion 146 is configured to axially constrain the torque converter assembly 126. That is, the radial portion 146 provides axial thrust support for the impeller hub 136. Specifically, the radial portion 146 exerts a force on the distal end 150 of the first portion 138 to assist in positioning the torque converter assembly 126 when the torque converter assembly 126 is not operating. For example, when the torque converter assembly 126 is not operating, the radial portion 146 can axially constrain the torque converter assembly 126, i.e., limit axial movement of the torque converter assembly 126 in the axial direction AD.

[0027] The hybrid module 100 may further include a K0 clutch 152. The K0 clutch 152 may be disposed on an axial side of the radially extending portion 118 opposite the lock-up clutch 134. That is, the radially extending portion 118 may be disposed axially between the lock-up clutch 134 and the K0 clutch 152. Said differently, the K0 clutch may be disposed external to the housing of the torque converter assembly 126. The K0 clutch 152 is arranged to drivingly connect the rotor assembly 102 to a K0 shaft 154. In other words, the K0 clutch 152 selectively connects and disconnects the rotor assembly 102 and the K0 shaft 154. The K0 shaft 154 is arranged for driving connection with a crankshaft (not numbered) of an internal combustion engine (not shown). In other words, the K0 shaft 154 is arranged to receive torque from the engine and/or transmit torque to the engine when installed and operated in a vehicle powered at least in part by the engine.

[0028] Providing the thrust bushing 142 allows for axially supporting the impeller hub 136, which can axially constrain the torque converter assembly 126 when the torque converter assembly 126 is not operating. Further, embodiments disclosed herein allows for positioning the torque converter assembly 126 when the torque converter assembly 126 is not operating without

requiring multiple components, which can reduce costs and complexity of the hybrid module and can assist in packaging the hybrid module 100 in smaller envelopes.

[0029] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms encompassed by the claims. The words used in the specification are words of description rather than limitation, and it is understood that various changes can be made without departing from the spirit and scope of the disclosure. As previously described, the features of various embodiments can be combined to form further embodiments of the disclosure that may not be explicitly described or illustrated. While various embodiments could have been described as providing advantages or being preferred over other embodiments or prior art implementations with respect to one or more desired characteristics, those of ordinary skill in the art recognize that one or more features or characteristics can be compromised to achieve desired overall system attributes, which depend on the specific application and implementation. These attributes can include, but are not limited to cost, strength, durability, life cycle cost, marketability, appearance, packaging, size, serviceability, weight, manufacturability, ease of assembly, etc. As such, to the extent any embodiments are described as less desirable than other embodiments or prior art implementations with respect to one or more characteristics, these embodiments are not outside the scope of the disclosure and can be desirable for particular applications.

List of Reference Numbers

[0030]	100	hybrid module
[0031]	102	rotor assembly
[0032]	104	stator assembly
[0033]	106	rotor carrier
[0034]	108	rotor flange
[0035]	110	rotor segment
[0036]	112	spring end plate
[0037]	114	end ring
[0038]	116	axially extending portion
[0039]	118	radially extending portion
[0040]	120	transmission input shaft
[0041]	124	stator segment
[0042]	126	torque converter assembly
[0043]	128	impeller
[0044]	130	turbine
[0045]	132	stator
[0046]	134	lock - up clutch
[0047]	136	impeller hub
[0048]	138	first portion
[0049]	140	second portion
[0050]	142	thrust bushing
[0051]	144	axial portion
[0052]	146	radial portion
[0053]	148	axially extending portion
[0054]	150	distal end
[0055]	152	K0 clutch
[0056]	154	K0 shaft
[0057]	156	transmission housing
[0058]	158	impeller shell
[0059]	AR	axis of rotation

[0060] AD axial direction

WHAT IS CLAIMED IS:

1. A hybrid module, comprising:
 - a rotor carrier including an axially extending portion and a radially extending portion extending radially inward from the axially extending portion;
 - a torque converter including an impeller having an impeller shell fixed to the rotor carrier and an impeller hub fixed to the impeller shell, the impeller hub extending in an axial direction away from the radially extending portion of the rotor carrier to a distal end; and
 - a thrust bushing connected to the impeller hub, the thrust bushing including an axial portion in contact with the impeller hub and a radial portion extending radially outward from the axial portion, wherein the radial portion is in contact with the distal end.
2. The hybrid module according to claim 1, wherein the thrust bushing is L-shaped.
3. The hybrid module according to claim 1, wherein the rotor carrier and the impeller define a housing of the torque converter, the radial portion being disposed external to the housing.
4. The hybrid module according to claim 3, further comprising a lock-up clutch disposed within the housing and arranged axially between the radial portion and the radially extending portion.
5. The hybrid module according to claim 1, wherein the axial portion of the thrust bushing is configured to receive an axially extending portion of a transmission housing.
6. The hybrid module according to claim 5, wherein the axial portion of the thrust bushing is configured to be in contact with the axially extending portion of the transmission housing.

7. The hybrid module according to claim 5, wherein the thrust bushing is non-rotatably connected to the impeller hub and is configured to be rotatably connected to the axially extending portion of the transmission housing.

8. The hybrid module according to claim 1, wherein the radial portion is configured to axially constrain the torque converter in the axial direction.

9. The hybrid module according to claim 1, wherein the thrust bushing is non-rotatably connected to the impeller hub.

10. The hybrid module according to claim 1, wherein the torque converter further includes a turbine arranged axially between the impeller and the radial portion of the rotor carrier, the distal end being disposed axially between the radial portion of the thrust bushing and the turbine.

11. A torque converter for a hybrid module, comprising:
a turbine;
an impeller in fluid communication with the turbine, the impeller including:
an impeller shell; and
an impeller hub fixed to the impeller shell, the impeller hub extending in an axial direction away from the turbine to a distal end; and
a thrust bushing connected to the impeller hub, the thrust bushing including an axial portion in contact with the impeller hub and a radial portion extending radially outward from the axial portion, wherein the radial portion is in contact with the distal end.

12. The torque converter according to claim 11, wherein the thrust bushing is L-shaped.

13. The torque converter according to claim 11, wherein the distal end is disposed axially between the radial portion and the turbine.

14. The torque converter according to claim 11, wherein the axial portion of the thrust bushing is configured to receive an axially extending portion of a transmission housing.

15. The torque converter according to claim 14, wherein the axial portion of the thrust bushing is configured to be in contact with the axially extending portion of the transmission housing.

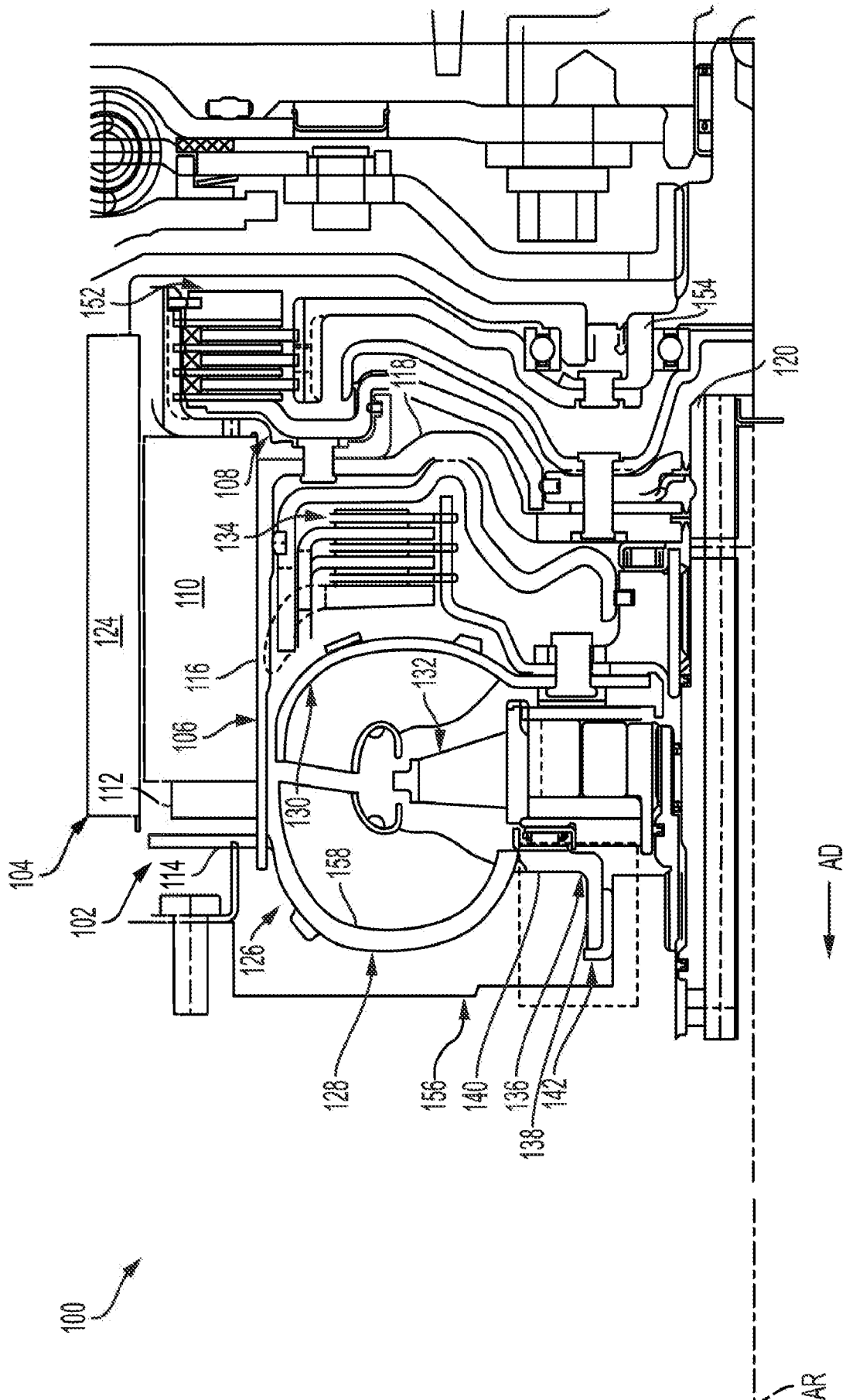
16. The torque converter according to claim 14, wherein the thrust bushing is non-rotatably connected to the impeller hub and is configured to be rotatably connected to the axially extending portion of the transmission housing.

17. The torque converter according to claim 11, wherein the radial portion is configured to axially constrain the torque converter in the axial direction.

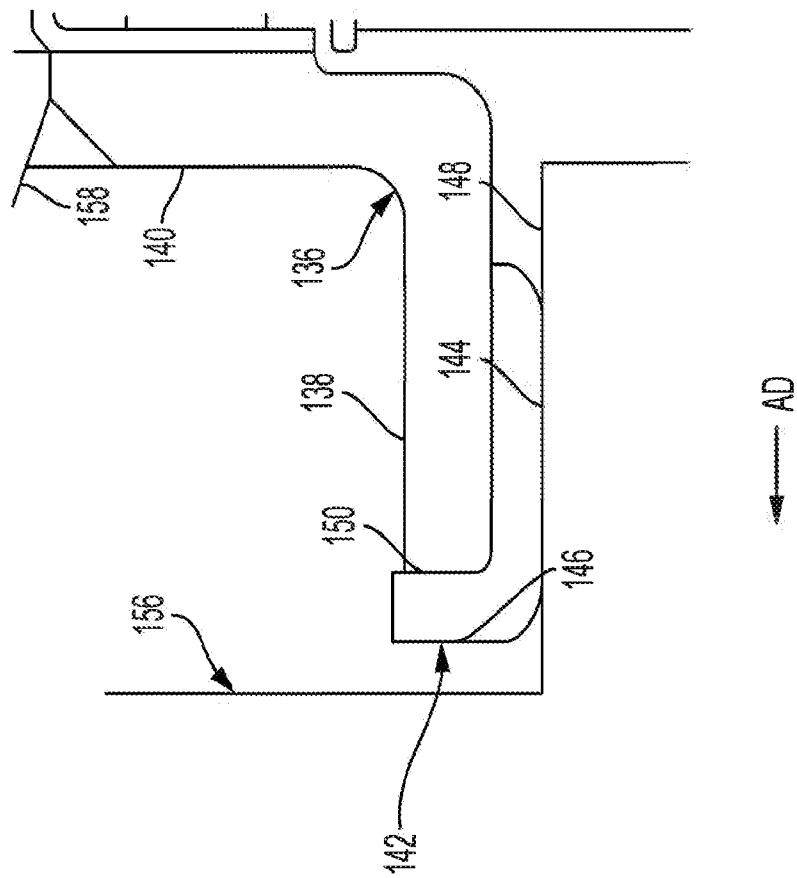
18. The torque converter according to claim 11, wherein the thrust bushing is non-rotatably connected to the impeller hub.

19. The torque converter according to claim 11, wherein the impeller defines, at least partially, a housing of the torque converter, the turbine being disposed within the housing, and the radial portion being disposed external to the housing.

20. The torque converter according to claim 19, further comprising a lock-up clutch disposed within the housing, the turbine being disposed axially between the radial portion and the lock-up clutch.



٢٤

2. GLE

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/054515

A. CLASSIFICATION OF SUBJECT MATTER**B60K 6/387**(2007.10)i; **B60K 6/405**(2007.10)i; **F16H 41/24**(2006.01)i; **F16H 45/02**(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)

B60K 6/387(2007.10); B60K 6/40(2007.10); F16C 17/12(2006.01); F16H 41/24(2006.01); F16H 41/28(2006.01); F16H 45/02(2006.01); H02K 1/28(2006.01); H02K 3/46(2006.01)

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: hybrid, torque converter, rotor, carrier, impeller, shell, hub, bushing, clutch, transmission housing, turbine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2020-0185996 A1 (SCHAEFFLER TECHNOLOGIES AG. & CO. KG.) 11 June 2020 (2020-06-11) paragraphs [0018]-[0019] and figure 1	1-4,8-13,17-20
A		5-7,14-16
Y	US 2016-0258520 A1 (SCHAEFFLER TECHNOLOGIES AG. & CO. KG.) 08 September 2016 (2016-09-08) paragraphs [0011]-[0015] and figures 1a-1b	1-4,8-13,17-20
A	WO 2018-164555 A1 (VALEO KAPEC CO., LTD.) 13 September 2018 (2018-09-13) paragraphs [0046]-[0059] and figure 1	1-20
A	JP 2007-107689 A (DAIHATSU MOTOR CO., LTD.) 26 April 2007 (2007-04-26) paragraphs [0020]-[0021] and figures 1-2	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

“D” document cited by the applicant in the international application

“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

Date of the actual completion of the international search

17 February 2025

Date of mailing of the international search report

17 February 2025

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon
35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

PARK, Tae Wook

Telephone No. +82-42-481-3405

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/054515

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2022-0176799 A1 (DAIMLER AG.) 09 June 2022 (2022-06-09) paragraphs [0018]-[0038] and figure	1-20

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/054515

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2020-0185996	A1	11 June 2020	CN	111293808	A	16 June 2020
				CN	111293808	B	16 August 2024
				DE	102019133628	A1	10 June 2020
				US	10784739	B2	22 September 2020
US	2016-0258520	A1	08 September 2016	DE	102016202297	A1	08 September 2016
WO	2018-164555	A1	13 September 2018	CN	110691926	A	14 January 2020
				CN	110691926	B	27 December 2022
				EP	3586038	A1	01 January 2020
				EP	3586038	B1	18 January 2023
				JP	2020-510801	A	09 April 2020
				JP	7138650	B2	16 September 2022
				KR	10-2019-0119068	A	21 October 2019
				KR	10-2570739	B1	24 August 2023
				US	11143280	B2	12 October 2021
				US	2021-0140524	A1	13 May 2021
JP	2007-107689	A	26 April 2007	JP	4698379	B2	08 June 2011
US	2022-0176799	A1	09 June 2022	CN	113597384	A	02 November 2021
				CN	113597384	B	28 June 2024
				DE	102019001959	A1	24 September 2020
				DE	102019001959	B4	08 April 2021
				US	11926219	B2	12 March 2024
				WO	2020-187605	A1	24 September 2020