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Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

(54) Title: VEHICLE DRIVELINE COMPONENT HAVING HEAT SINK FOR INCREASED HEAT REJECTION CAPABILITIES

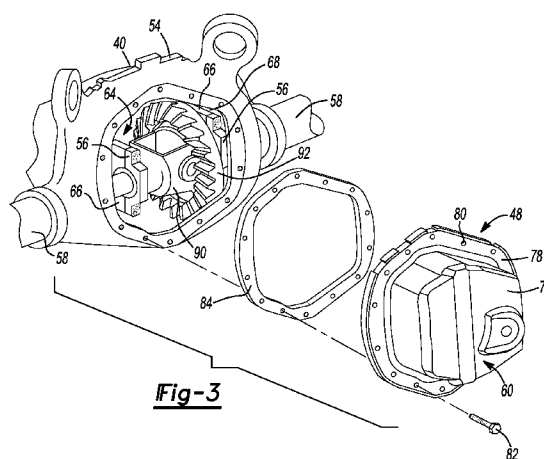


Fig-3

(57) Abstract: An axle assembly that includes an axle housing assembly, a differential disposed in the axle housing assembly, an input pinion, a pair of axle shafts and a heat sink. The input pinion is coupled to the axle housing assembly and is configured to transmit a rotary input to the differential. The axle shafts are coupled to the differential and housed in the axle housing assembly. The heat sink is coupled to the axle housing assembly and is formed of a material having a thermal conductivity that is greater than that of the axle housing assembly. The heat sink does not consist entirely of a chrome plating, a zinc plating or a cadmium plating. A cover for an axle assembly is also provided.

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earlier application (Rule 4.17(iii))*

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VEHICLE DRIVELINE COMPONENT HAVING HEAT SINK FOR INCREASED HEAT REJECTION CAPABILITIES

FIELD OF THE INVENTION

5 **[0001]** The present invention generally relates to vehicle driveline components and more particularly to a vehicle driveline component, such as an axle assembly, having a heat sink that is configured to improve the rejection of heat from the vehicle driveline component.

10 **[0002]** Modernly, vehicle consumers have expressed a desire for vehicles having larger payloads and greater towing capacities. Given these parameters, it is desirable that such axle assemblies be capable of rejecting a sufficient quantity of heat to protect the lubricants within the axle assembly, as well as the seals and the power transmitting components of the axle assembly. It will be appreciated that the life of such lubricants, seals and components can be
15 significantly shortened by exposure to elevated temperatures.

15 **[0003]** Accordingly, there remains a need in the art for an axle assembly having improved heat rejection capabilities.

SUMMARY OF THE INVENTION

20 **[0004]** In one form, the teachings of the present disclosure provide an axle assembly that includes an axle housing assembly, a differential disposed in the axle housing assembly, an input pinion, a pair of axle shafts and a heat sink. The input pinion is coupled to the axle housing assembly and is configured to transmit a rotary input to the differential. The axle shafts are coupled to the differential and
25 housed in the axle housing assembly. The heat sink is coupled to the axle housing assembly and is formed of a material having a thermal conductivity of at least about 1.00 W/cm²K. The heat sink does not consist entirely of a chrome plating, a zinc plating or a cadmium plating.

30 **[0005]** In another form, the teachings of the present disclosure provide axle assembly that includes an axle housing, a differential, an input pinion, a pair of axle shafts and a cover. The axle housing defines an aperture into which the differential is received. The input pinion is coupled to the axle housing and is configured to transmit a rotary input to the differential. The axle shafts are coupled

to the differential. The differential transmits rotary power from the input pinion to the axle shafts. The cover closes the aperture in the axle housing and has a first layer, which is formed of a ferrous material, and a second layer that is formed of another material having a thermal conductivity that is greater than about 1.30
5 W/cm²K. The first and second layers are in thermal communication to transmit heat therebetween.

[0006] In yet another form, the teachings of the present disclosure provide an axle cover for an axle assembly. The axle cover includes a first member and a second member. The first member has a body portion and a flange portion that is
10 disposed about a perimeter of the body portion. The body portion has a three-dimensionally contoured surface. The flange portion is configured to be coupled to an axle housing. The first member is formed of a first material having a first thermal conductivity. The second member is formed of a second material having a second thermal conductivity that is greater than the first thermal conductivity. The
15 second member being coupled to the body of the first member. The second member does not consist entirely of a chrome plating, a zinc plating or a cadmium plating.

[0007] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be
20 understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

25 **[0008]** Additional advantages and features of the present invention will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, wherein:

[0009] Figure 1 is a schematic illustration of a vehicle having a rear axle constructed in accordance with the teachings of the present disclosure;

30 **[0010]** Figure 2 is a partially broken-away perspective view of a portion of the vehicle of Figure 1 illustrating the rear axle in more detail;

[0011] Figure 3 is an exploded perspective view of the rear of the rear

axle of Figure 1;

[0012] Figure 4 is a cross-sectional view taken through a portion of the rear axle, illustrating the cover and the heat sink in more detail;

[0013] Figure 5 is an enlarged portion of the sectional view of Figure 4;

5 **[0014]** Figure 6 is a portion of a cross-sectional view similar to that of Figure 5 but illustrating the heat sink as coupled to the cover via an adhesive;

[0015] Figure 7 is a portion of a cross-sectional view similar to that of Figure 5 but illustrating the heat sink as coupled to the cover via threaded fasteners;

10 **[0016]** Figure 8 is a portion of a cross-sectional view similar to that of Figure 5 but illustrating the heat sink as coupled to the cover via rivets;

[0017] Figure 9 is a portion of a cross-sectional view similar to that of Figure 5 but illustrating the heat sink as coupled to the cover via a brazing compound;

15 **[0018]** Figure 10 is a sectional view of a portion of another axle constructed in accordance with the teachings of the present disclosure, the axle having a heat sink having fingers that extend into the internal cavity of the carrier housing;

[0019] Figure 11 is a front view of a portion of the axle of Figure 10 illustrating the fingers of the heat sink in more detail;

20 **[0020]** Figure 12 is a cross-sectional view similar to that of Figure 5 but illustrating the heat sink as coupled to the exterior of the cover; and

[0021] Figure 13 is a cross-sectional view similar to that of Figure 5, but illustrating the heat sink as coupled to the interior and the exterior of the cover.

25

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] With reference to Figure 1 of the drawings, a vehicle having a differential assembly that is constructed in accordance with the teachings of the present disclosure is generally indicated by reference numeral 10. The vehicle
30 10 can include a driveline 12 that is drivable via a connection to a power train 14. The power train 14 can include an engine 16 and a transmission 18. The driveline 12 can include a propshaft 20, a rear axle 22 and a plurality of wheels

24. The engine 16 can be mounted in an in-line or longitudinal orientation along the axis of the vehicle 10 and its output can be selectively coupled via a conventional clutch to the input of the transmission 18 to transmit rotary power (i.e., drive torque) therebetween. The input of the transmission 18 can be
5 commonly aligned with the output of the engine 16 for rotation about a rotary axis. The transmission 18 can also include an output and a gear reduction unit. The gear reduction unit can be operable for coupling the transmission input to the transmission output at a predetermined gear speed ratio. The propshaft 20 can be coupled for rotation with the output of the transmission 18. Drive torque
10 can be transmitted through the propshaft 20 to the rear axle 22 where it can be selectively apportion in a predetermined manner to the left and right rear wheels 24a and 24b, respectively.

[0023] With reference to Figures 2 through 4, the rear axle 22 can include an axle housing assembly 40, a differential 42, an input pinion assembly 44, a
15 pair of axle shafts 46, and a heat sink 48.

[0024] In the particular example provided, the axle housing assembly 40 includes a carrier housing 54, a pair of bearing caps 56, a pair of axle tubes 58 and a cover 60. The carrier housing 54 can define an internal cavity 64, a pair of bearing journals 66, a differential aperture 68, which can intersect the internal
20 cavity 64 from a first side of the carrier housing 54, a pinion aperture 70, which can intersect the internal cavity from a second side of the carrier housing 54 opposite the differential aperture 68, and a pair of axle tube apertures 72 that can intersect the opposite lateral sides of the internal cavity 64. The bearing caps 56 can be removably coupled to the bearing journals 66. The axle tubes 58
25 can be received in the axle tube apertures 72 and can be fixedly coupled to the carrier housing 54. The cover 60 can include a body portion 76 and a flange portion 78 that can be coupled to the carrier housing 54. The body portion 76 can be three-dimensionally contoured (e.g., bulged outwardly) to effectively increase the volume within the differential axle housing assembly 40. The flange
30 portion 78 can extend about the body portion 76 and in the particular example provided, includes a plurality of through holes 80 that permit the cover 60 to be removably coupled to the carrier housing 54 (via a plurality of threaded fasteners

82). It will be appreciated that a gasket 84 or a sealant (not shown), such as PERMATEX®, can be employed to seal the interface between the cover 60 and the carrier housing 54.

[0025] The differential 42 can be any appropriate vehicle differential and can conventionally include a case 90, a ring gear 92, which can be coupled to the case 90, and a gearset 94 that can be housed in the case 90. The differential 42 can be received into the internal cavity 64 through the differential aperture 68. The bearing journals 66 and the bearing caps 56 can cooperate to support the differential 42 for rotation in the internal cavity 64 about a first rotational axis 96.

[0026] The input pinion assembly 44 can conventionally include an input shaft 100 and an input pinion 102 that can be coupled for rotation with the input shaft 100. The input pinion assembly 44 can be received into the carrier housing 54 through the pinion aperture 70 such that the input pinion 102 is meshingly engaged to the ring gear 92. A pair of bearings 104 can be coupled to the carrier housing 54 and the input shaft 100 and can support the input pinion assembly 44 for rotation about a second rotational axis 106 that can be generally perpendicular to the first rotational axis 96. An end of the input shaft 100 opposite the input pinion 102 can be adapted to be coupled to a driveline component, such as the propshaft 20 (Fig. 1), to receive rotary power therefrom.

[0027] Each of the axle shafts 46 can be received through an associated one of the axle tubes 58 and can be coupled for rotation with an associated side gear 108 in the gearset 94 of the differential 42. Accordingly, it will be appreciated that rotary power input to the axle 22 via the input pinion assembly 44 is transmitted through the ring gear 92, to the case 90 and the gearset 94 and output to the axle shafts 46 to provide propulsive power to the left and right rear wheels 24a and 24b (Fig. 1).

[0028] With reference to Figures 3 through 5, the heat sink 48 can be coupled to a member of the axle housing assembly 40, such as the cover 60, and can be employed to aid in the rejection of heat from the axle housing assembly 40. The heat sink 48 can be formed onto the cover 60 in any appropriate manner, such as plating or dipping, or can be a discrete and

separately formed structure that can be secured to the cover 60 through any appropriate means, such as thermally conductive adhesives 110a (Fig. 6), threaded fasteners 110b (Fig. 7), rivets 110c (Fig. 8), solder or brazing compound 110d (Fig. 9) and combinations thereof.

- 5 **[0029]** Generally, the cover 60 (or other portion of the axle housing assembly 40 to which the heat sink 48 is coupled) can be formed of a first material and the heat sink 48 can be formed of a second material having a thermal conductivity that is greater than a thermal conductivity of the first material. However, the heat sink 48 does not consist entirely of a chrome plating,
10 a zinc plating or a cadmium plating. Non-limiting examples of suitable first and second materials are shown in the following table.

First Material	Thermal Conductivity	Second Material	Thermal Conductivity
Steel	0.45 - 0.65 W/cm °K	Aluminum	2.37 W/cm °K
		Copper	4.01 W/cm °K
		Magnesium	1.56 W/cm °K
Cast Iron	0.76 W/cm °K	Aluminum	2.37 W/cm °K
		Copper	4.01 W/cm °K
		Magnesium	1.56 W/cm °K
Aluminum	2.37 W/cm °K	Copper	4.01 W/cm °K

- 15 Preferably, the second material has a thermal conductivity that is greater than about 1.30 W/cm °K if the first material is a ferrous material.

- [0030]** In the example provided, the heat sink 48 co-extends with a portion of the cover 60 (e.g., the body portion 76). It will be appreciated, however, that a portion of the heat sink 48 could diverge from the portion of the axle housing assembly 40 to which the heat sink 48 is coupled. For example, the heat sink
20 48a could include an outwardly flared portion 120 as illustrated in Figures 10 and 11. In this example, the outwardly flared portion 120 includes a plurality of fingers 122 that are received into the internal cavity 64 in the carrier housing 54 where they are submerged in a lubricating oil (not shown). The fingers 122 can facilitate the rejection of heat from the sump in which the lubricating oil is
25 disposed.

- [0031]** It will be appreciated that while the heat sink 48 has been

illustrated and described thus far as being located within the axle housing assembly 40, the disclosure, in its broadest aspects, may be constructed somewhat differently. For example, the heat sink 48b can be coupled to the exterior of the axle housing assembly 40 as illustrated in Figure 12, or the heat
5 sink 48c could be coupled to both the interior and exterior of the axle housing assembly 40 as illustrated in Figure 13. To the extent that the heat sink is disposed on the exterior of the axle housing assembly 40, the heat sink can include portions, such as fingers, that can be exposed to air currents when a vehicle (not shown) that employs the rear axle 22 is operated. Such portions of
10 the heat sink could be formed to minimize drag, or could be formed to deflect air against the axle housing assembly 40 to increase the convection cooling of the rear axle 22.

[0032] While the rear axle 22 has been illustrated and described as being a Salisbury-type axle, it will be appreciated that the disclosure, in its broadest
15 aspects, need not be limited to any particular type of axle. For example, the rear axle 22 could be a banjo-type axle and the heat sink 48 could be coupled to a rear cover (not shown) that is fixedly and non-removably coupled to a remainder of the axle housing (not shown) via welding. Moreover, it will be appreciated that the teachings of the present disclosure need not be limited to rear axles but
20 could be utilized in any type of axle or driveline component, including differentials, viscous couplings, and transfer cases.

[0033] While the invention has been described in the specification and illustrated in the drawings with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and
25 equivalents may be substituted for elements thereof without departing from the scope of the invention as defined in the claims. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment illustrated by
30 the drawings and described in the specification as the best mode presently contemplated for carrying out this invention, but that the invention will include any embodiments falling within the foregoing description and the appended claims.

CLAIMS

What is claimed is:

1. An axle assembly comprising:
 - an axle housing that defines an aperture;
 - 5 a differential received in the aperture in the axle housing;
 - an input pinion coupled to the axle housing and adapted to transmit a rotary input to the differential;
 - a pair of axle shafts coupled to the differential, the differential transmitting rotary power from the input pinion to the axle shafts; and
 - 10 a cover closing the aperture in the axle housing, the cover having a first layer that is formed of a ferrous material and a second layer that is formed of another material having a thermal conductivity that is greater than about 1.30 W/cm²K, the first and second layers being in thermal communication to transmit heat therebetween.
- 15 2. The axle assembly of Claim 1, wherein the cover is removably coupled to the axle housing.
3. The axle assembly of Claim 1, wherein the another material is
20 selected from a group consisting of aluminum, copper, magnesium and combinations thereof.
4. The axle assembly of Claim 1, wherein the second layer is a discrete member that is secured to the first layer.
- 25 5. The axle assembly of Claim 4, wherein the second layer is coupled to the first layer with a thermally conductive adhesive.
6. The axle assembly of Claim 4, wherein a layer of braze compound or
30 solder compound secures the second layer to the first layer.
7. The axle assembly of Claim 4, wherein a plurality of threaded

fasteners secure the second layer to the first layer.

8. The axle assembly of Claim 4, wherein a portion of the second layer extends outwardly from the first layer so as to be separated therefrom by a space.

5

9. An axle assembly comprising:
an axle housing assembly;
a differential disposed in the axle housing assembly;
an input pinion coupled to the axle housing assembly, the input pinion being
10 adapted to transmit a rotary input to the differential;
a pair of axle shafts coupled to the differential and housed in the axle housing assembly; and
a heat sink coupled to the axle housing assembly, the heat sink being formed of a material having a thermal conductivity that is greater than a thermal
15 conductivity the axle housing assembly;
wherein the heat sink does not consist entirely of a chrome plating, a zinc plating or a cadmium plating.

10. The axle assembly of Claim 6, wherein the axle housing assembly
20 includes a housing structure and a cover and wherein the heat sink is coupled to the cover.

11. The axle assembly of Claim 10, wherein the cover is removably coupled to the housing structure.

25

12. The axle assembly of Claim 9, wherein the heat sink is formed of a material selected from a group consisting of aluminum, copper, magnesium and combinations thereof.

13. The axle assembly of Claim 9, wherein the heat sink is a discrete member that is secured to the axle housing assembly.

30

14. The axle assembly of Claim 13, wherein at least one of a thermally conductive adhesive, a threaded fastener, a solder material and a brazing compound secures the heat sink to the axle housing assembly.

- 5 15. An axle cover for an axle assembly, the axle cover comprising:
a first member having a body portion and a flange portion that is disposed about a perimeter of the body portion, the body portion having a three-dimensionally contoured surface, the flange portion being adapted to be coupled to an axle housing, the first member being formed of a first material having a first
10 thermal conductivity; and
a second member formed of a second material having a second thermal conductivity that is greater than the first thermal conductivity, the second member being coupled to the body of the first member;
wherein the second member does not consist entirely of a chrome plating, a
15 zinc plating or a cadmium plating.

16. The axle cover of Claim 15, wherein the first material is steel and the second material is selected from a group consisting of aluminum, copper, magnesium, zinc and combinations thereof.

20

17. The axle cover of Claim 15, wherein the first material is cast iron and the second material is selected from a group consisting of aluminum, copper, magnesium, zinc and combinations thereof.

25 18. The axle cover of Claim 15, wherein the first material is aluminum and the second material is copper.

19. The axle cover of Claim 15, wherein the second member is a discrete structure that is coupled to the first member.

30

20. The axle cover of Claim 15, wherein a plurality of through-holes are formed through the flange.

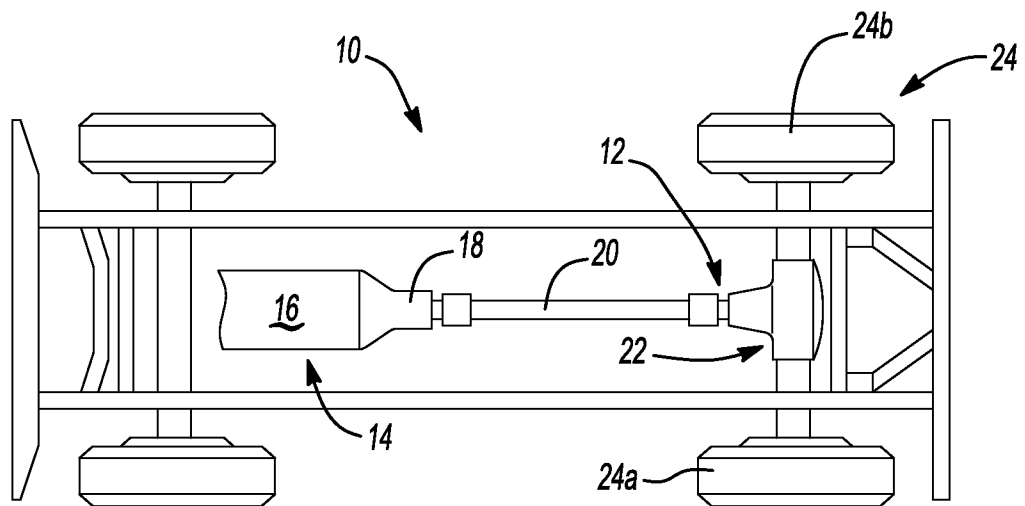


Fig-1

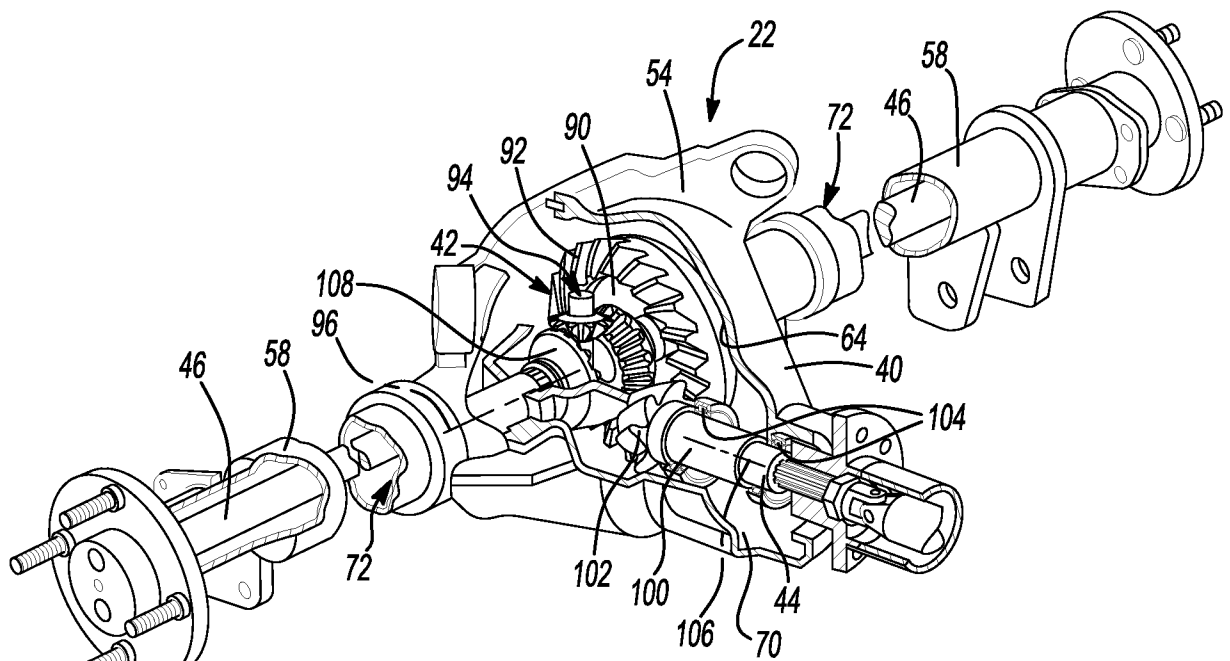


Fig-2

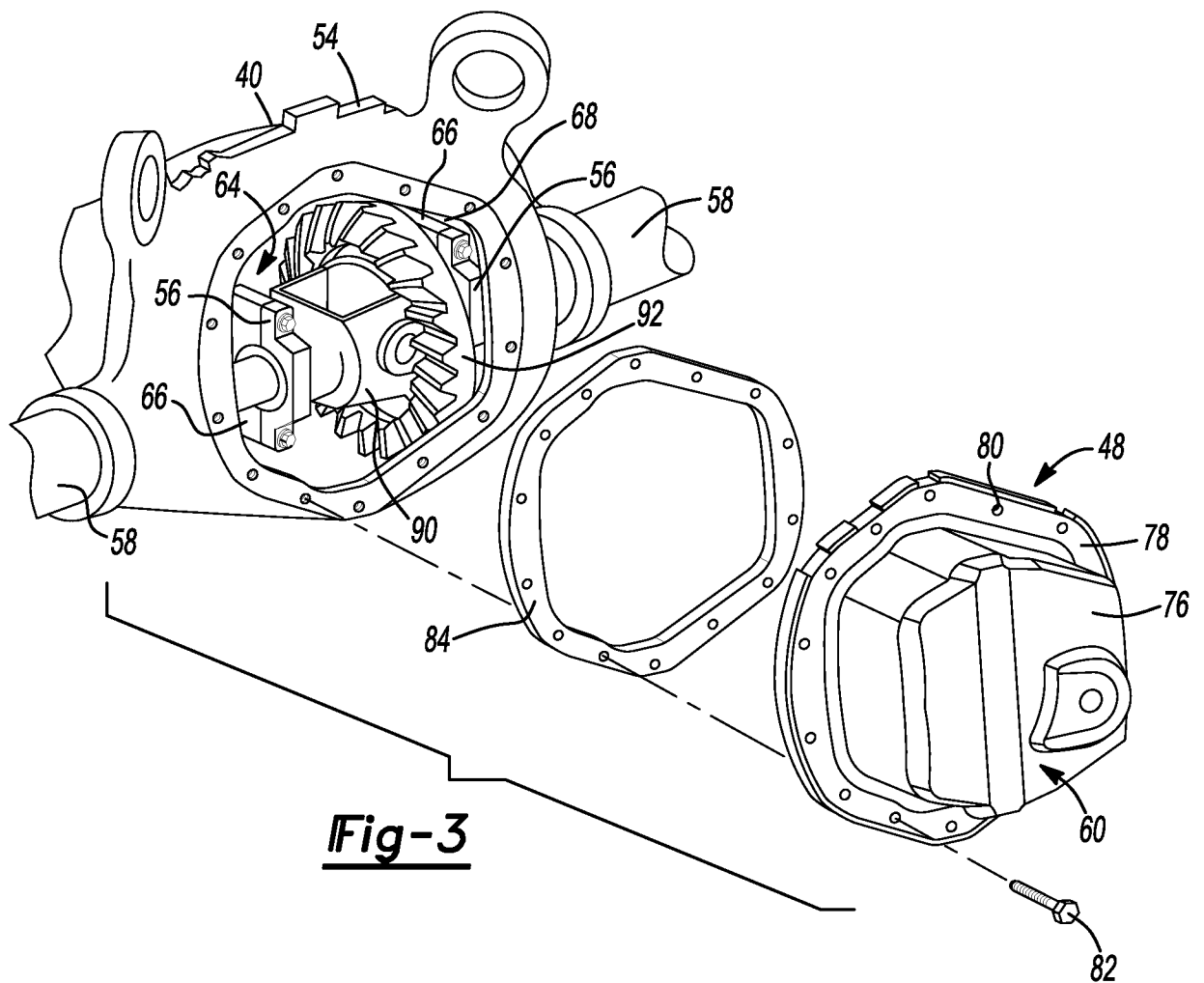


Fig-3

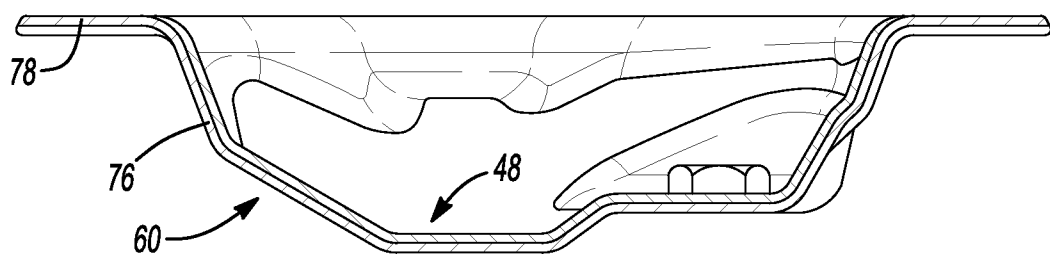


Fig-4

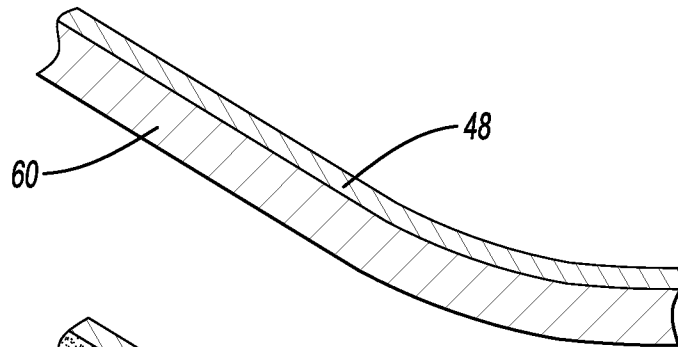


Fig-5

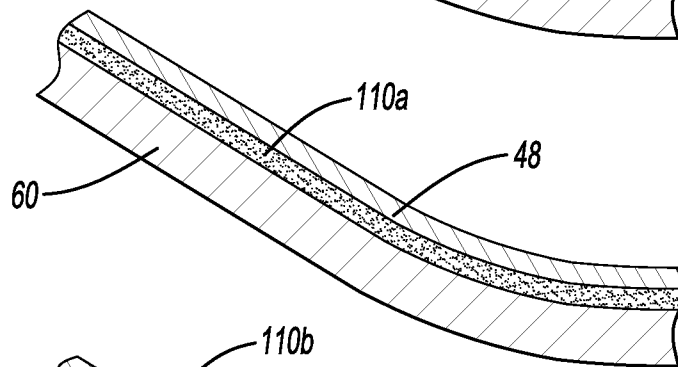


Fig-6

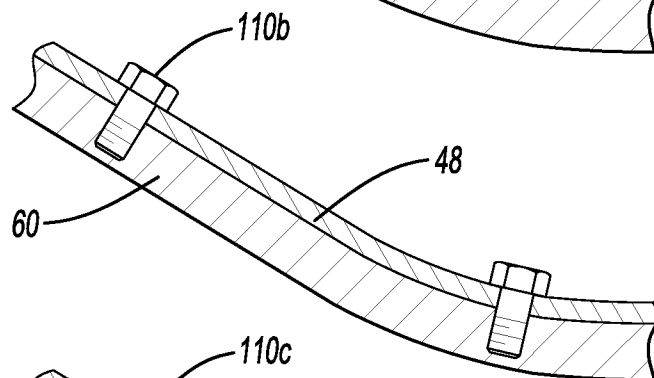


Fig-7

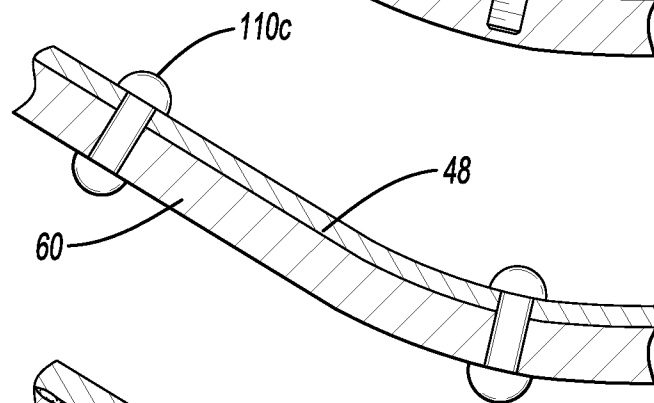


Fig-8

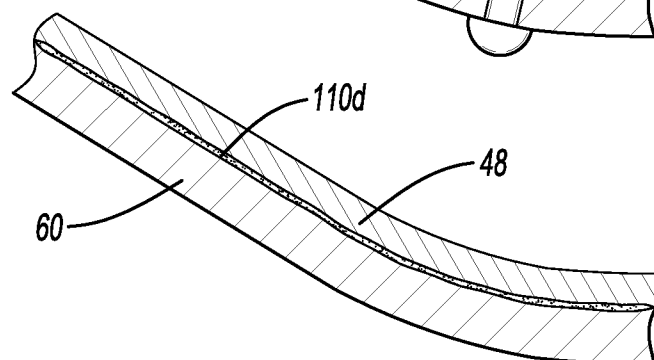


Fig-9

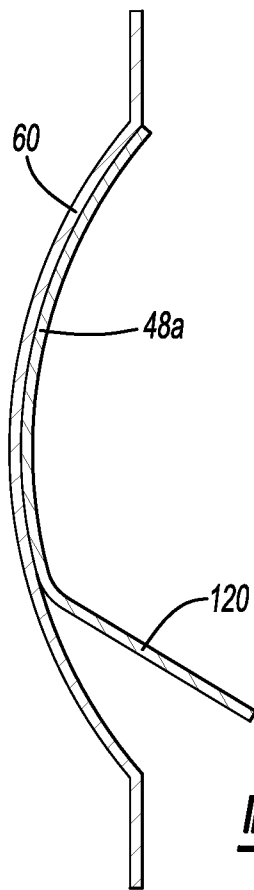


Fig-10

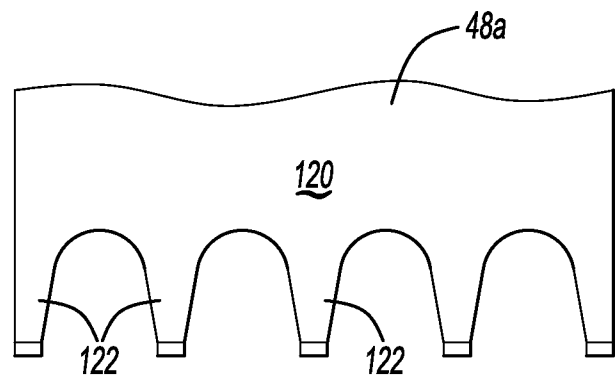


Fig-11

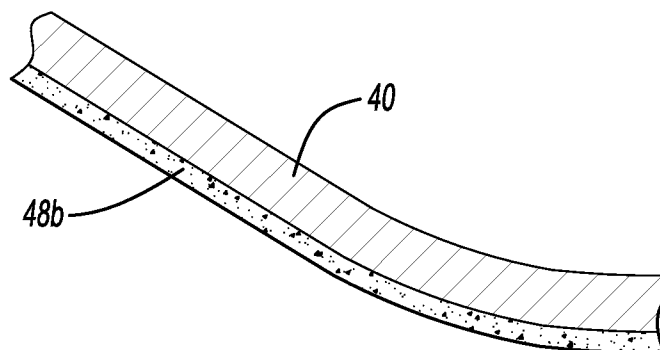


Fig-12

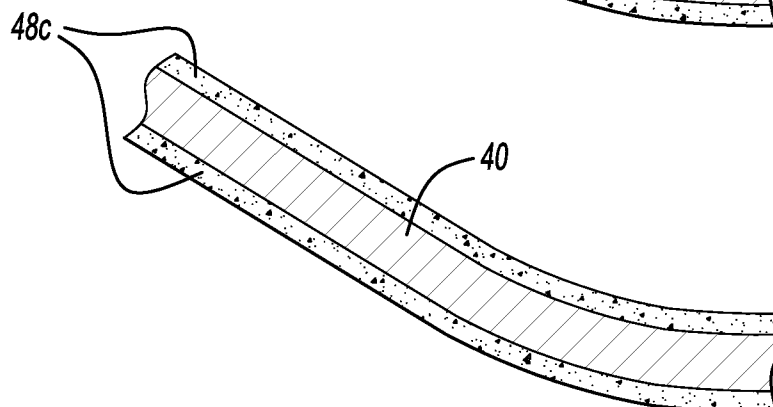


Fig-13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/064219**A. CLASSIFICATION OF SUBJECT MATTER****B60K 17/16(2006.01)i, F16H 57/04(2006.01)i, F16H 48/00(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)

IPC 8 B60K17/00 F16H57/04

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 since 1975

Japanese Utility models and applications for Utility models since 1975

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

eKIPASS (KIPO internal)

Keywords : "differential", "power train", "heat sink"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2007-0046268 A (HUYNDAI MOTOR CO. LTD.) 03 MAY 2007	9, 12-14
A	See Figures 2 and related descriptions	1-8,10-11,15-20
A	JP 2001-119810 A (AISIN AW CO.) 27 APRIL 2001	1-20
	See Figures 5 and related descriptions	
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	See Figures 1 and related descriptions	
A	US 5,839,327 A (GARRETT W. GAGE ET AL) 24 NOVEMBER 1998	1-20
	See Figures 1 and related descriptions	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

30 SEPTEMBER 2008 (30.09.2008)

Date of mailing of the international search report

30 SEPTEMBER 2008 (30.09.2008)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2008/064219

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