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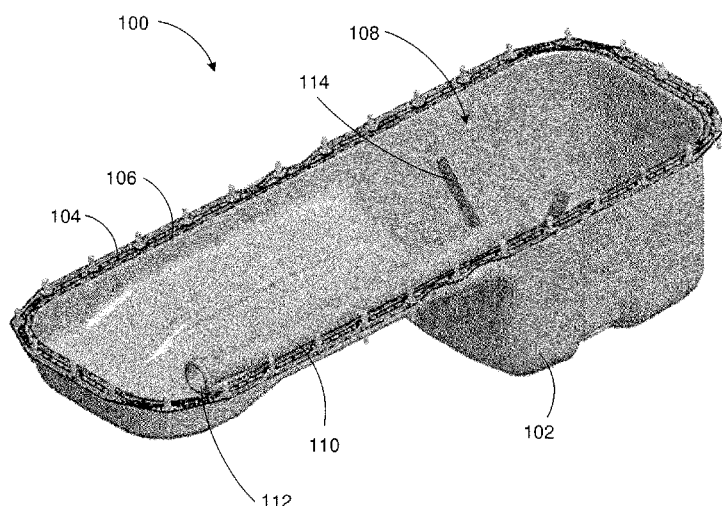


Fig. 1

(57) Abstract: An oil pan assembly includes an interior cavity defining a sump and an elevated portion. The elevated portion is defined in part by a first floor portion. The sump is defined in part by a second floor portion and by an intermediate wall extending between the first and second floor portions. The oil pan assembly also includes a suction tube integral to the oil pan and shaped so as to define stiffening ribs. The suction tube extends from an inlet positioned in the sump to an outlet external to the interior cavity. The suction tube includes first, second, and third sections. The first section is formed in the first floor portion and defines the outlet. The second section is formed in the second floor portion and defines the inlet. The third section is formed in the intermediate wall and fluidly couples the first and second sections.



OIL PAN WITH INTEGRAL LUBE SUCTION AND STIFFENING PASSAGE

TECHNICAL FIELD

[0001] The present disclosure relates generally to oil pan assemblies for use with internal combustion engines.

BACKGROUND

[0002] Oil is used to lubricate the moving parts of an internal combustion engine. In many implementations, oil is provided and collected in a reservoir at the bottom of a crankcase of an engine, which is often referred to as an oil pan. An oil pump draws oil from the oil pan through a suction tube. The oil pump pressurizes and pumps the oil through an oil filter to remove contaminants. The oil is then provided to the crankshaft, connecting rod bearings, and other engine components, and is also applied onto the cylinder walls. Eventually, the oil drips off of the engine components and collects into the oil pan, from which it may be recirculated through the engine.

SUMMARY

[0003] One embodiment relates to an oil pan assembly having an interior cavity defining a sump and an elevated portion. The elevated portion is defined in part by a first floor portion. The sump is defined in part by a second floor portion and by an intermediate wall extending between the first and second floor portions. The first floor portion is elevated along a vertical axis relative to the second floor portion. The oil pan assembly also includes a suction tube integral to the oil pan and shaped so as to define stiffening ribs of the oil pan. The suction tube extends from an inlet positioned in the sump to an outlet external to the interior cavity of the oil pan. The suction tube includes first, second, and third sections. The first section is formed in the first floor portion and defines the outlet. The second section is formed in the second floor portion and defines the

inlet. The third section is formed in the intermediate wall and fluidly couples the first and second sections.

[0004] Another embodiment relates to an oil pan assembly, including an oil pan and a plurality of suction tubes formed integrally with the oil pan. Each of the plurality of suction tubes has an inlet positioned in a sump of the oil pan and an outlet providing fluid communication between the oil pan and an oil pump. The oil pan assembly also includes a plug fluidly blocking the outlet of one of the suction tubes.

[0005] Another embodiment relates to a system including an internal combustion engine and an oil pan coupled to the internal combustion engine. The oil pan includes a plurality of suction tubes formed integrally therein. Each of the plurality of suction tubes has an inlet positioned in a sump of the oil pan and an outlet providing fluid communication between the oil pan and an oil pump. The suction tubes are shaped so as to define stiffening ribs of the oil pan.

[0006] These and other features, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Fig. 1 is a perspective view of a conventional oil pan assembly.

[0008] Fig. 2 is a perspective view of an oil pan assembly, according to an embodiment.

[0009] Fig. 3 is perspective view of the oil pan assembly of Fig. 2 with the oil pan shown in phantom view.

[0010] Figs. 4A and 4B are perspective views of the oil pan assembly of Figs. 2-3.

[0011] Fig. 5A is a cross-sectional view of the oil pan assembly of Figs. 2-4B, taken along line 5-5 of Fig. 2.

[0012] Fig. 5B is a bottom view of the oil pan assembly of Figs. 2-5A.

DETAILED DESCRIPTION

[0013] Fig. 1 is a perspective view of a conventional oil pan assembly 100. The oil pan assembly 100 includes an oil pan 102 having a flange 104 by which the oil pan assembly 100 is mounted to a crankcase of an engine (not shown). A gasket 106 is positioned between the flange 104 and the crankcase to fluidly seal the oil pan assembly 100 to the engine. The oil pan 102 is shaped so as to define a recessed cavity, commonly referred to as a sump 108. In operation, oil collects in the sump 108 after lubricating the engine.

[0014] The oil pan assembly 100 also includes a suction tube 110 fixedly coupled to the oil pan 102. The suction tube 110 is defined by an inlet (not shown) disposed within the sump 108, and an outlet 112 opposite the inlet. The outlet 112 is operably coupled to an oil pump (not shown) to draw oil from within the sump 108 and convey the oil to various parts of the engine. As illustrated in Fig. 1, the suction tube 110 is fixedly coupled to the oil pan 102 via mounting brackets 114. In other example implementations, the suction tube 110 may be coupled to the oil pan 102 in other ways, such as via welding, or otherwise coupling the suction tube 110 to the oil pan 102 using any of various types of fasteners and/or adhesives. In addition, conventional suction tubes, such as the suction tube 110, are typically designed for a single orientation of the oil pan assembly 100. Therefore, different suction tubes must be utilized if the orientation of the oil pan assembly 100 is changed (e.g., across different vehicle models or design configurations).

[0015] In operation, vibration can cause component failures or otherwise undesirable performance (e.g., leaking, decreased fluid flow, noise, etc.) of the oil pan assembly 100. Such failures may result in high warranty costs and decreased customer satisfaction. The oil pan assembly 100 is susceptible to vibration from various sources, such as from the engine, from vehicle operation (e.g., inertial loading), from fluid flow within the oil pan assembly 100, etc.

Such vibrations may cause failure of the suction tube 110 and/or the oil pan 102. For example, the suction tube 110 may crack, the couplings (e.g., mounting hardware, welds, etc.) may break or loosen, the mounting brackets 114 may break, or gaskets (not shown) coupled to the suction tube 110 may degrade or otherwise fail. In addition to failures of the suction tube 110, the oil pan 102 itself may crack, the mounting hardware (e.g., fasteners that couple the oil pan assembly 100 to the engine) may break or loosen, or the gasket 106 may degrade or otherwise fail. In some conventional systems, mounting brackets (e.g., the mounting brackets 114) are utilized to increase the stiffness of the suction tube 110. However, the mounting brackets 114 add component cost, weight, and manufacturing complexity to the oil pan assembly 100. Moreover, the mounting brackets 114 alone may not sufficiently cure all vibration-related issues.

[0016] The present disclosure is directed to an oil pan assembly having an oil pan with an integrally formed suction tube. Integrally forming the suction tube with the oil pan results in a one-piece oil pan assembly, thereby eliminating separate components and manufacturing processes corresponding with a separate suction tube. The suction tube may define stiffening ribs in the oil pan. The stiffening ribs increase the stiffness and structural strength of the oil pan assembly (e.g., to shift the resonant frequency above the operating frequency of the engine), thereby reducing or eliminating vibration-induced component failures. According to various embodiments, the suction tube may include a plurality of suction tube passages. The plurality of suction tube passages allows the oil pan assembly to be configurable for various applications (e.g., across several different vehicle platforms). According to various embodiments, the suction tube may be cast-in-place using sand casting or investment casting techniques, or may be formed using other manufacturing techniques, such as insert molding or multi-part stamping, for example.

[0017] Fig. 2 is a perspective view of an oil pan assembly 200, according to an embodiment. The oil pan assembly 200 includes an oil pan 202 having a flange 204 defining mounting holes 206 sized to receive fasteners (e.g., bolts) to mount the oil pan assembly 200 to a crankcase of an engine (not shown). The oil pan 202 is shaped so as to define an interior cavity 208 including a sump 212 and an elevated portion 210 (relative to the sump). The elevated portion 210 is defined

in part by a first floor portion 214. The sump 212 is defined in part by a second floor portion 216 and by an intermediate wall 218 that connects the first and second floor portions 214, 216.

[0018] As discussed in further detail below, the oil pan assembly 200 includes one or more suction tubes 220 which are integral to the oil pan 202. Each of the suction tubes 220 extends from an inlet in fluid communication with a strainer bowl 222 defined by the second floor portion 216 to an outlet external to the interior cavity 208 of the oil pan 202. According to various embodiments, the oil pan 202 may include one or more suction tubes 220. The suction tubes 220 define stiffening ribs which increase the stiffness and structural strength of the oil pan assembly 200, thereby increasing the resonant frequency of the modes of vibration of the oil pan assembly 200 (e.g., to shift the resonant frequency above the operating frequency of the engine). Further, by integrally forming the suction tubes with the oil pan 202, separate suction tube components and associated mounting features are eliminated.

[0019] Fig. 3 is perspective view of the oil pan assembly 200 of Fig. 2 with the oil pan 202 shown in phantom view to illustrate the suction tubes 220 formed integrally with the oil pan 202. As illustrated in Fig. 3, the oil pan 202 includes a front end 224 and a rear end 226 opposite the front end 224. The elevated portion 210 is proximate the front end 224 and the sump 212 is proximate the rear end 226. The oil pan 202 also includes a length 228 extending between the front and rear ends 224, 226, and a height 230 extending between the second floor portion 216 and the flange 204.

[0020] As illustrated in Fig. 3, the oil pan assembly 200 includes several suction tubes 220. Each of the suction tubes 220 extends from an inlet (e.g., a first inlet 232) in fluid communication with the strainer bowl 222 to an outlet external to the interior cavity 208 of the oil pan 202. The strainer bowl 222 is defined by the second floor portion 216 and includes a recessed cavity 234. A strainer 236 (Fig. 2) is disposed over the recessed cavity 234 of the strainer bowl 222. In an embodiment, the strainer 236 is a dome-shaped perforated plate that allows fluid communication between the interior cavity 208 of the oil pan 202 and the strainer bowl 222, while preventing debris from entering the strainer bowl 222. The dome shape of the

strainer 236 operates to minimize debris from collecting on top of the strainer 236 and clogging the strainer 236. In effect, the strainer 236 operates as an initial (e.g., coarse) oil filter.

[0021] The suction tubes 220 include longitudinal suction tubes 238 that extend generally along the length 228 of the oil pan 202. The longitudinal suction tubes 238 include a first section 240 formed in the first floor portion 214 and defining a first outlet 242 external to the interior cavity 208 at the front end 224 of the oil pan assembly 200. The longitudinal suction tubes 238 also include a second section 244 formed in the second floor portion 216 and defining the first inlet 232. The first inlet 232 is in fluid communication with the strainer bowl 222 defined by the second floor portion 216. The longitudinal suction tubes 238 further include a third section 246 formed in the intermediate wall 218 and extending between the first and second sections 240, 244 to fluidly couple the first and second sections 240, 244. According to various embodiments, the oil pan assembly 200 may include several longitudinal suction tubes 238. For example, as illustrated in Fig. 3, the longitudinal suction tubes 238 include three longitudinal suction tubes 238, which are parallel to and offset from each other. Other embodiments may include more or fewer longitudinal suction tubes 238 than included in the embodiment illustrated in Fig. 3.

[0022] As illustrated in Fig. 3, the oil pan assembly 200 may include other suction tubes 220 in addition to the longitudinal suction tubes 238. For example, as illustrated in Fig. 3, front transverse suction tubes 248 extend transverse to the length 228 of the oil pan 202 (e.g., transverse to the longitudinal suction tubes 238) proximate the front end 224. The front transverse suction tubes 248 are fluidly coupled to the longitudinal suction tubes 238. Rear transverse suction tubes 250 extend transverse to the length 228 of the oil pan 202 proximate the rear end 226. The rear transverse suction tubes 250 are fluidly coupled to the strainer bowl 222. Side vertical suction tubes 252 are fluidly coupled to the rear transverse suction tubes 250, and extend from the second floor portion 216 towards the flange 204. A rear segment 251 is fluidly coupled to the strainer bowl 222 and extends therefrom towards the rear end 226. Rear vertical suction tubes 253 extend from the second floor portion 216 towards the flange 204.

[0023] In general, each of the suction tubes 220 define passages that are formed in the oil pan 202 to allow fluid (e.g., oil) to flow from the sump 212 to the first outlet 242 and/or to other outlets. The passages may be any shape. In some implementations, as illustrated in Fig. 3, the passages have square (e.g., with rounded edges) and circular cross-sections. However, in other implementations, the passages may have different shapes and need not have a constant cross-sectional area.

[0024] Each of the suction tubes 220 include outlets extending through the oil pan 202 to an opening external to the interior cavity 208 of the oil pan 202. The outlets provide fluid communication between the interior cavity 208 of the oil pan 202 and an oil supply line (not shown) through which the oil is transferred by an oil pump (not shown) to lubricate the engine. For example, the longitudinal suction tubes 238 include the first outlet 242 and the front transverse suction tubes 248 include a second outlet 254. Because the oil pan assembly 200 includes multiple outlets, the oil pan assembly 200 is highly configurable for different applications. One or more of the outlets corresponding to any of the suction tubes 220 may be plugged, for example, with a threaded plug. Therefore, the oil pan assembly 200 provides substantial flexibility in choosing which of the outlets to plug and which to utilize. Accordingly, the oil pan assembly 200 may utilize a single design for several different applications. For example, instead of requiring different oil pan designs and/or different suction tube designs for different applications (e.g., front-mount and rear-mount applications), a single oil pan assembly 200 may be utilized with different outlets being plugged depending on the requirements for each application. Furthermore, the oil pan assembly 200 provides additional flexibility by allowing multiple outlets to be utilized. In some implementations, the pattern of the mounting holes 206 (Fig. 2) on the flange 204 may be changed depending on the orientation. However, this process is relatively simple and may be performed by simply drilling a different hole pattern on the same oil pan assembly 200 component.

[0025] Figs. 4A and 4B are perspective views of the oil pan assembly 200 of Figs. 2-3, illustrating the ribs defined by the suction tubes 220. As illustrated in Fig. 4A, the oil pan 202 includes an exterior surface 256. The suction tubes 220 define an outer rib 258 projecting

outward (e.g., in a direction opposite the interior cavity) from the exterior surface 256. Similarly, as illustrated in Fig. 4B, the oil pan assembly includes an interior surface 260. The suction tubes 220 define an inner rib 262 extending inward (e.g., into the interior cavity 208) from the interior surface 260. The outer and inner ribs 258, 260 may project from the respective exterior and interior surfaces 256, 260 by the same lengths or by different lengths. In other words, each of the outer and inner ribs 258, 260 may vary in size. In the embodiment illustrated in Fig. 4B, the oil pan 202 includes a shelf 264 that extends from the front transverse suction tubes 248 towards the front 232 of the oil pan 202 to prevent oil from collecting in a pocket adjacent the front transverse suction tubes 248.

[0026] The oil pan assembly 200 may be manufactured using several manufacturing methods. In one embodiment, the oil pan assembly 200 is formed using a sand-casting or investment casting process. In other embodiments, the oil pan assembly 200 is formed using a lost-wax or lost-foam casting process. Each of the suction tubes 220 may be formed using a removable core molded of any of several types of suitable materials such as sand, wax, salt, etc. The core is formed and positioned in an outer mold. The core may be formed as a unitary structure or the core may be formed in multiple segments which may be joined together before positioning the core in the outer mold. The oil pan assembly 200 is formed by casting a metal (e.g., aluminum or steel) in the outer mold and around the core. After casting the oil pan assembly 200, the core is removed by breaking up the sand and removing the sand through each of the outlets. One or more of the outlets may subsequently be plugged (e.g., using a threaded fitting. By utilizing several suction tubes 220, the core may be securely supported during the casting process.

[0027] In other embodiments, the oil pan assembly 200 may be formed of an injection-molded thermosetting polymer, such as polyamide (e.g., nylon), poly(methyl methacrylate), polypropylene, polypropylene, polyethylene (e.g., high or low-density polyethylene) which may be reinforced with fibers (e.g., glass, carbon, etc.). In such embodiments, the suction tubes 220 may be formed in a first process (e.g., from metal tubing) and insert molded into the oil pan assembly 200. In further embodiments, the oil pan assembly 200 may be formed using a two-part or multi-part stamping, which may be bonded using various techniques such as welding (e.g.,

arc, TIG (tungsten, inert gas), MIG (metal, inert gas), resistance, friction, etc.) to form the oil pan assembly 200.

[0028] Fig. 5A is a cross-sectional view of the oil pan assembly 200 of Figs. 2-4B, taken along line 5-5 of Fig. 2. As shown in Fig. 2, line 5-5 extends through the center longitudinal suction tube 238. Fig. 5B is a bottom view of the oil pan assembly 200 of Figs. 2-5A. As illustrated in Fig. 5A, the oil pan assembly 200 may be mounted to an engine 266. An oil passage 268 is fluidly coupled to an outlet (e.g., the first outlet 242) of the oil pan assembly 200. An oil pump 270 is operably coupled to the oil passage 268. In operation, the oil pump 270 draws oil from the interior cavity 208 of the oil pan 202 through the suction tubes 220, and through the oil passage 268. The oil is pressurized by the oil pump 270 and is conveyed to the engine 266, where it operates to lubricate various components within the engine 266. In some embodiments, multiple oil passages 268 may be coupled to multiple outlets of the oil pan assembly 200.

[0029] Figs. 5A and 5B further illustrate the multiple outlets that are available with the oil pan assembly 200. As illustrated in Fig. 5A, the longitudinal suction tubes 238 define the first outlet 242 proximate the front end 224 of the oil pan assembly 200. As shown in Fig. 5B, the oil pan assembly 200 includes first outlets 242 defined by each of the longitudinal suction tubes 238. The oil pan assembly 200 also includes second outlets 254 defined by each of the front transverse suction tubes 248. The oil pan assembly 200 further includes third outlets 272 extending downwards (i.e., away from the flange 204) and defined by the third section 246 of the longitudinal suction tubes 238. Still further, the oil pan assembly 200 includes fourth outlets 274 extending downwards and defined by at least one of the rear transverse suction tubes 250 and the side vertical suction tubes 252. Further yet, the oil pan assembly 200 includes fifth outlets 276 extending outwardly (i.e., transverse to the length 228 of the oil pan assembly 200) proximate the second floor portion 216 and defined by at least one of the rear transverse suction tubes 250 and the side vertical suction tubes 252. In addition, the oil pan assembly 200 includes sixth outlets 278 extending outwardly proximate the flange 204 and defined by the side vertical suction tubes 252. The sixth outlets 278 are elevated along a vertical axis relative to the rear transverse suction tubes 250. Further yet, the oil pan assembly includes seventh outlets 280 extending outwardly

proximate the second floor portion 216 and defined by at least one of the rear section 251 and the rear vertical suction tubes 253. Still further, the oil pan assembly 280 includes eighth outlets 282 extending outwardly proximate the rear end 226 defined by the rear vertical suction tubes 253. As mentioned above, one or more of the first, second, third, fourth, fifth, sixth, seventh, and eighth outlets 242, 254, 272, 274, 276, 278, 280, 282 may be plugged (e.g., using a threaded insert), and the unplugged outlets may provide fluid communication to an oil pump (not shown). In addition, each of the first, second, third, fourth, fifth, sixth, seventh, and eighth outlets 242, 254, 272, 274, 276, 278, 280, 282 may be positioned at a distal end of the respective suction tubes 220, or they may be positioned anywhere along the length of the respective suction tubes 220.

[0030] It should be noted that any use of the term “exemplary” herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

[0031] The terms “coupled,” “connected,” and the like as used herein mean the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another. It should be also be understood that, where the terms “approximately” and “about” are used, the identified dimensions and/or ranges are intended to cover slight variations that may result due to standard manufacturing and/or assembly tolerances as understood in the art.

[0032] References herein to the positions of elements (e.g., “top,” “bottom,” “front,” “rear,” etc.) are merely used to describe the orientation of various elements in the figures. It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

[0033] It is important to note that the construction and arrangement of the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described herein. For example, the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the present invention.

[0034] While various embodiments of the disclosure have been shown and described, it is understood that these embodiments are not limited thereto. The embodiments may be changed, modified and further applied by those skilled in the art. Therefore, these embodiments are not limited to the detail shown and described previously, but also include all such changes and modifications.

WHAT IS CLAIMED IS:

1. An oil pan assembly, comprising:
an oil pan having an interior cavity defining a sump and an elevated portion, the elevated portion defined in part by a first floor portion and the sump defined in part by a second floor portion and by an intermediate wall extending between the first and second floor portions, the first floor portion elevated along a vertical axis relative to the second floor portion; and
a suction tube integral to the oil pan and shaped so as to define stiffening ribs of the oil pan, the suction tube extending from an inlet positioned in the sump to an outlet external to the interior cavity of the oil pan, the suction tube including:
a first section formed in the first floor portion and defining the outlet,
a second section formed in the second floor portion and defining the inlet,
and
a third section formed in the intermediate wall and fluidly coupling the first and second sections.
2. The oil pan assembly of claim 1, wherein the stiffening ribs defined by the suction tube include an inner rib projecting from an interior surface of the oil pan into the interior cavity and an outer rib projecting from an exterior surface of the oil pan in a direction opposite the interior cavity.
3. The oil pan assembly of claim 2, wherein the inner rib projects from the interior surface to a first projection length and the outer rib projects from the exterior surface to a second projection length, one of the first and second projection lengths being longer than the other of the first and second projection lengths.
4. The oil pan assembly of claim 1, wherein the suction tube is a first suction tube, and further comprising a second suction tube parallel to and offset from the first suction tube.
5. The oil pan assembly of claim 4, further comprising a third suction tube parallel to and offset from each of the first and second suction tubes.

6. The oil pan assembly of claim 1, wherein the suction tube is a longitudinal suction tube, and further comprising a front transverse suction tube fluidly coupled to the longitudinal suction tube and extending transverse to the longitudinal suction tube to second outlets external to the interior cavity of the oil pan.

7. The oil pan assembly of claim 1, further comprising a strainer bowl integral to the second floor portion, the strainer bowl having a top opening in fluid communication with the sump.

8. The oil pan assembly of claim 7, wherein the inlet of the suction tube is fluidly coupled to the strainer bowl.

9. The oil pan assembly of claim 7, further comprising a strainer disposed over the top opening of the strainer bowl, the strainer comprising a dome-shaped perforated plate.

10. The oil pan assembly of claim 9, wherein the suction tube is a longitudinal suction tube, and further comprising rear transverse suction tubes fluidly coupled to the strainer bowl, the rear transverse suction tubes extending transverse to the longitudinal suction tubes, and defining third outlets external to the interior cavity of the oil pan.

11. The oil pan assembly of claim 10, further comprising side vertical suction tubes fluidly coupled to and extending vertically from the rear transverse suction tubes, the side vertical suction tubes defining fourth outlets external to the interior cavity of the oil pan, the fourth outlets being elevated along a vertical axis relative to the third passages.

12. The oil pan assembly of claim 11, further comprising at least one plug to fluidly block at least one of the third and fourth outlets.

13. The oil pan assembly of claim 1, wherein the oil pan assembly is formed of at least one of cast steel or cast aluminum.

14. The oil pan assembly of claim 13, wherein the outlet defines a path for removing a sand core utilized during a casting process.

15. An oil pan assembly, comprising:
an oil pan, the oil pan including a plurality of suction tubes formed integrally therein, each of the plurality of suction tubes having an inlet positioned in a sump of the oil pan and an outlet providing fluid communication between the oil pan and an oil pump; and
a plug fluidly blocking the outlet of one of the suction tubes.

16. The oil pan assembly of claim 15, wherein the plug is a first plug, and further comprising a second plug fluidly blocking the outlet of a second one of the suction tubes.

17. The oil pan assembly of claim 15, wherein the plug is removably coupled to the one of the suction tubes, and wherein the oil pan assembly is configurable between a first configuration in which the plug is coupled to a first one of the suction tubes, and a second configuration in which the plug is coupled to a second one of the suction tubes.

18. The oil pan assembly of claim 15, wherein each of the plurality of suction tubes is shaped so as to define stiffening ribs in the oil pan.

19. The oil pan assembly of claim 18, wherein the stiffening ribs include an inner rib projecting from an interior surface of the oil pan into an interior cavity of the oil pan and an outer rib projecting from an exterior surface of the oil pan in a direction opposite the interior cavity.

20. The oil pan assembly of claim 15, wherein the inlet is positioned proximate a rear end of the oil pan, the oil pan having a front end opposite the rear end, and wherein the plurality of suction tubes includes longitudinal suction tubes having a first outlet proximate the front end of the oil pan.

21. The oil pan assembly of claim 20, further comprising at least one transverse suction tube extending transverse to the longitudinal suction tubes.

22. A system, comprising:
an internal combustion engine; and
an oil pan coupled to the internal combustion engine, the oil pan including a plurality of suction tubes formed integrally therein, each of the plurality of suction tubes having an inlet positioned in a sump of the oil pan and an outlet providing fluid communication between the oil pan and an oil pump, the suction tubes being shaped so as to define stiffening ribs of the oil pan.

23. The system of claim 22, wherein the stiffening ribs defined by the suction tubes include an inner rib projecting from an interior surface of the oil pan into an interior cavity of the oil pan and an outer rib projecting from an exterior surface of the oil pan in a direction opposite the interior cavity.

24. The system of claim 22, further comprising a plug fluidly blocking the outlet of one of the suction tubes.

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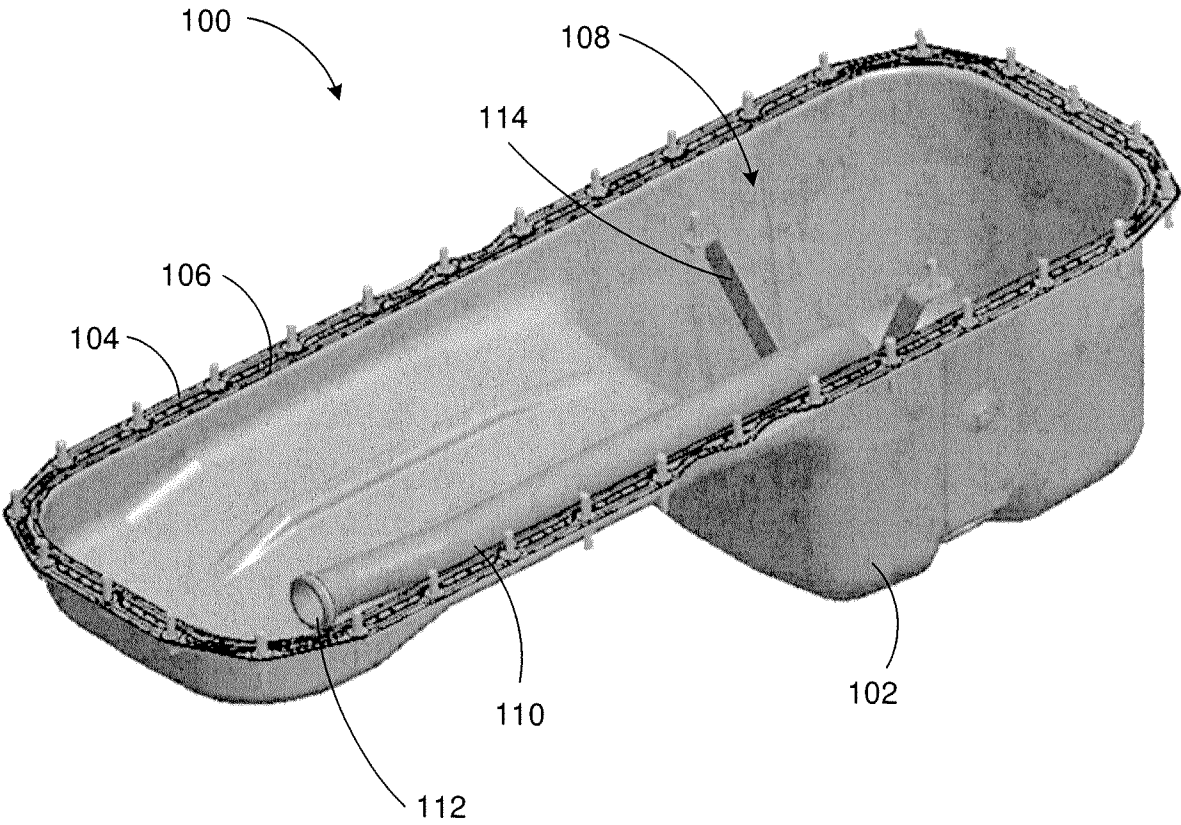


Fig. 1

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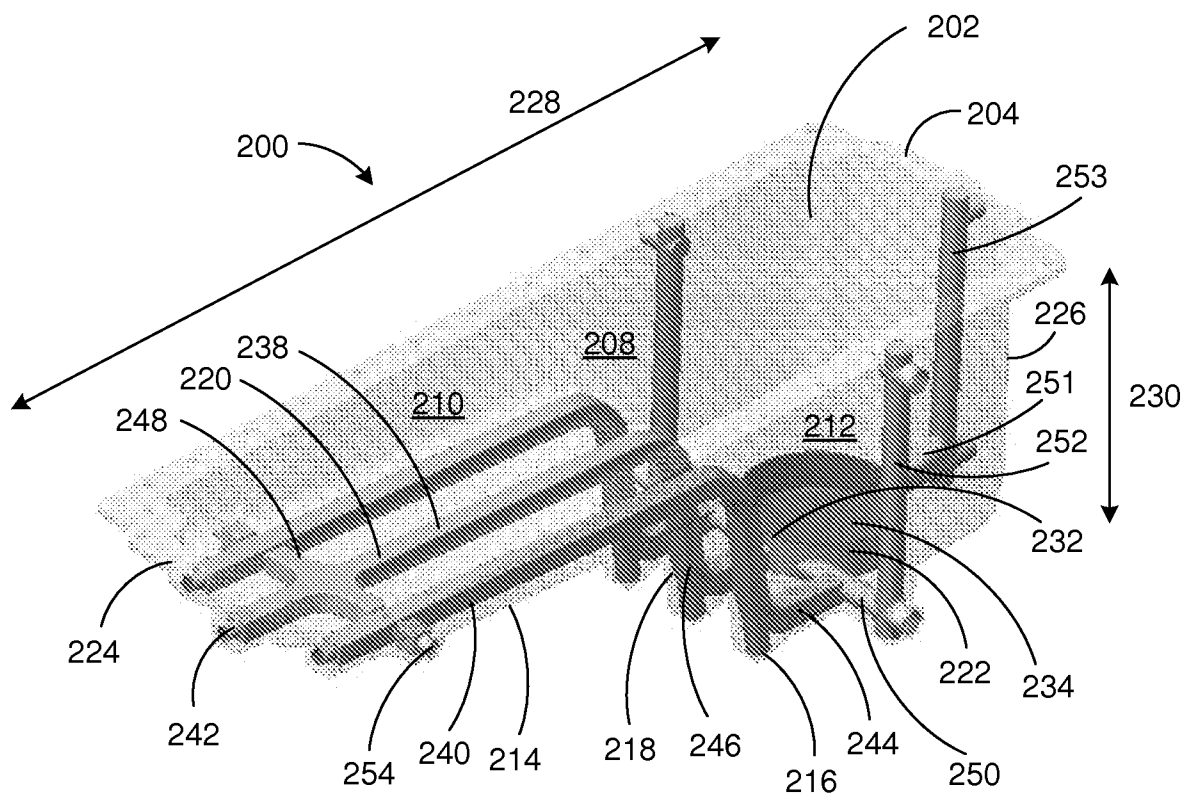
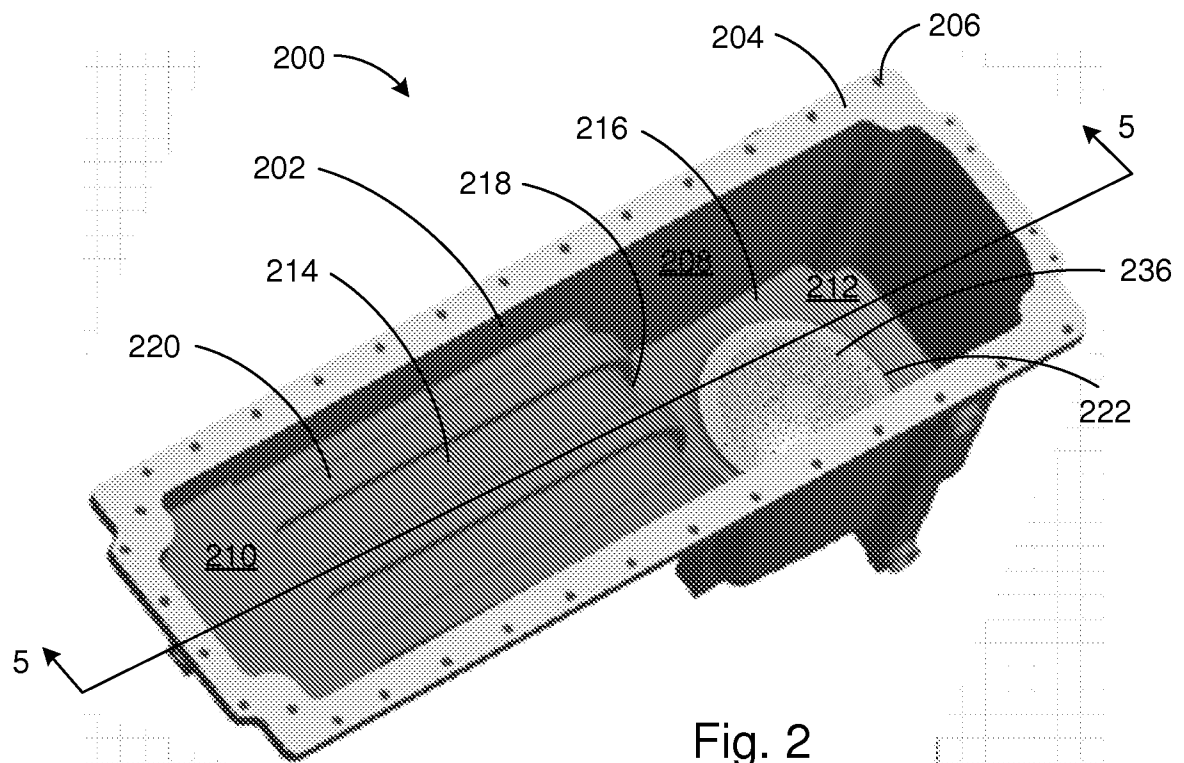


Fig. 3

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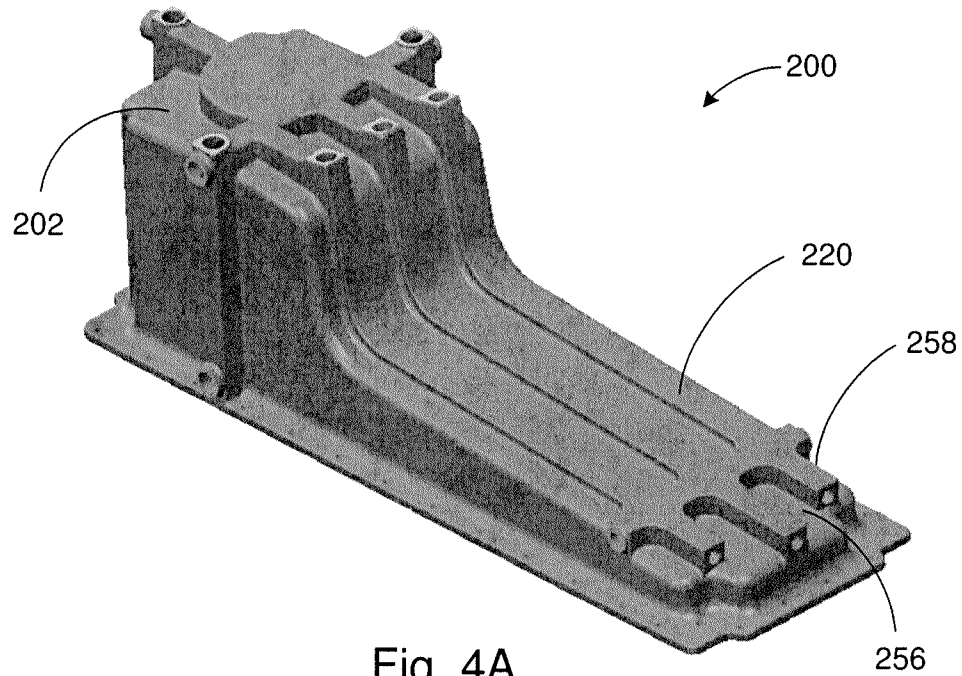


Fig. 4A

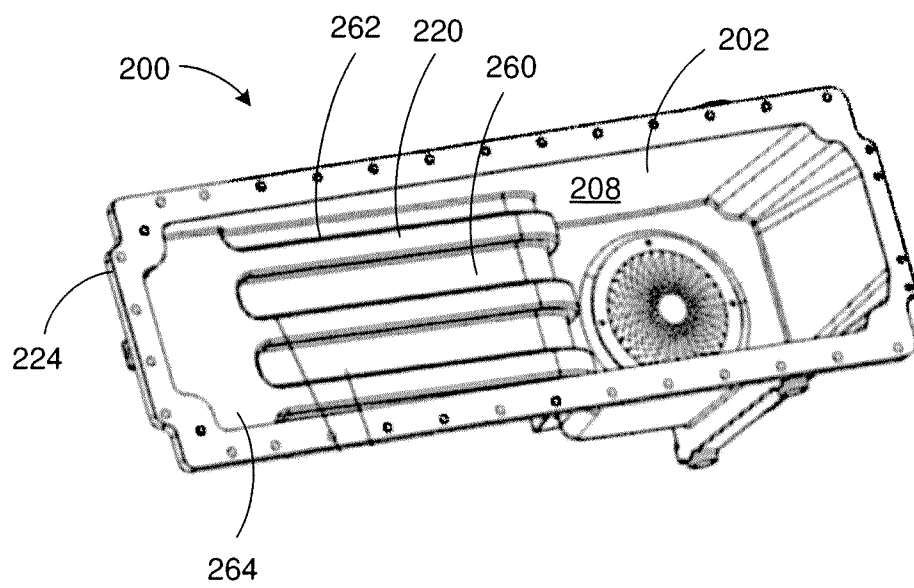


Fig. 4B

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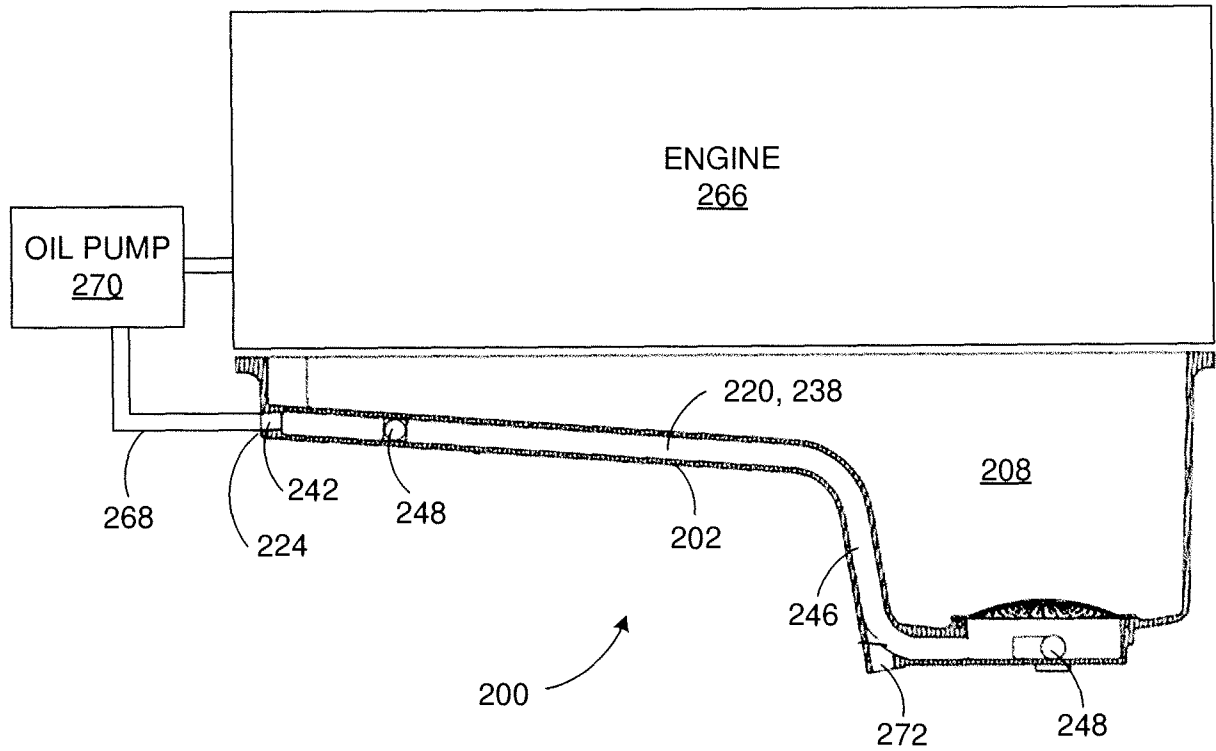


Fig. 5A

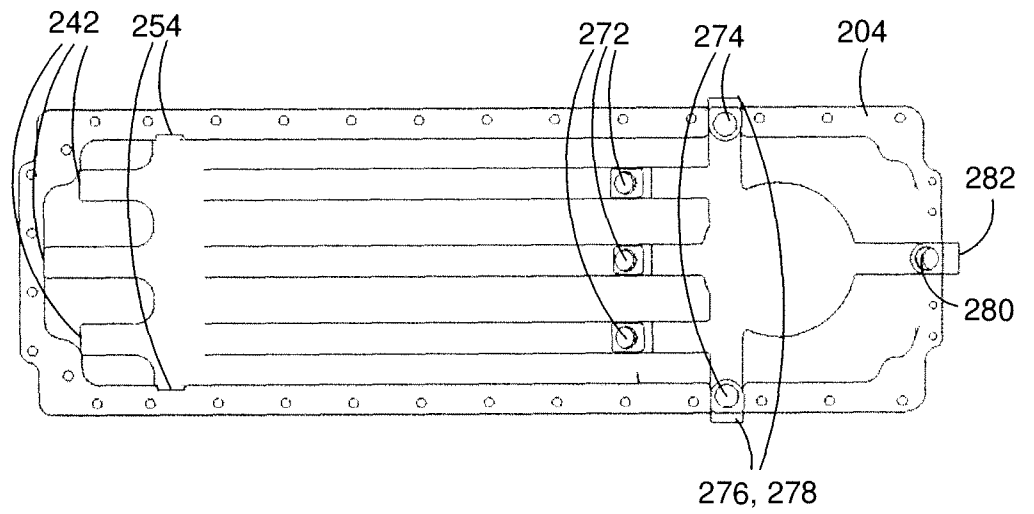


Fig. 5B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 15/18901

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F01M 11/00, F01M 11/02, F01M 11/03, F16N 31/00 (2015.01)

CPC - F01M11/00, F01M11/0004, F01M11/02, F01M11/03, F16N31/00

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) F01M 11/00, F01M 11/02, F01M 11/03, F16N 31/00 (2015.01)

CPC: F01M11/00, F01M11/0004, F01M11/02, F01M11/03, F16N31/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC (8) F01M 11/00, F01M 11/02, F01M 11/03, F01M 11/06, F02F 7/00, F02B 77/00, B22C 9/10, F16N 31/00 (2015.01) CPC:
F01M11/00, F01M11/0004, F01M11/02, F01M11/03, F01M2011/007, F01M2011/0091, F01M2011/0029 (keyword limited; terms below)

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; Search terms used: Oil pan tray container sump reservoir well elevated raised higher top portion level area suction tube pipe line member stiffening support member rib strainer filter sieve plug stopper blocker cap cock outlet tube sand cast casting cast steel aluminum first second multiple suct

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,796,283 B1 (Fleury et al.) 28 September 2004 (28.09.2004), entire document, especially Fig. 1, 4; col 2, ln 48-50; col 2, ln 61-62; col 2, ln 66-67; col 3, ln 13-14; col 3, ln 2-3; col 3, ln 7-8;	1-3, 7, 8
Y		4, 5, 9, 13
A		6, 10-12, 14
Y	US 2010/0230212 A1 (Jensen et al.) 16 September 2010 (16.09.2010), entire document, especially Fig. 1A, 1B, 3; para[0013]; para[0014];	4, 5
Y	DE 8,911,897 U1 (Mussetto) 21 December 1989 (21.12.1989), entire document, especially Fig. 1; pg 3, ln 7;	9
A		6, 10-12
Y	US 2005/0257766 A1 (Rau et al.) 24 November 2005 (24.11.2005), entire document, especially Fig. 2; para[0025]; para[0004];	13
A		14
A	US 2010/0224450 A1 (Dods et al.) 09 September 2010 (09.09.2010), entire document, especially Fig. 1, 3, 4; para[0016]; para[0021];	1-14
A	US 4,446,906 A (Ackerman et al.) 08 May 1984 (08.05.1984), entire document, especially Fig. 3; col 2, ln 47-52; col 1, ln 30-34;	1-14
A	US 2010/0147253 A1 (Burke et al.) 17 June 2010 (17.06.2010), entire document	1-14

☐ 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

Date of the actual completion of the international search

01 July 2015 (01.07.2015)

Date of mailing of the international search report

24 JUL 2015

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/18901

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:

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 1-14 directed to an oil pan assembly.

Group II: Claim 15-24 directed to a system comprising an internal combustion engine and an oil pan.

— Continued in 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.:
1-14

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 15/18901

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

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

SPECIAL TECHNICAL FEATURES

The invention of Group I includes the special technical features of an oil pan assembly, comprising: an oil pan having an elevated portion, the elevated portion defined in part by a first floor portion and the sump defined in part by a second floor portion and by an intermediate wall extending between the first and second floor portions, the first floor portion elevated along a vertical axis relative to the second floor portion; and a suction tube extending to an outlet external to the interior cavity of the oil pan, the suction tube including: a first section formed in the first floor portion and defining the outlet, a second section formed in the second floor portion and defining the inlet, and a third section formed in the intermediate wall and fluidly coupling the first and second sections, not required by the claims of Group II.

The invention of Group II includes the special technical features of a system comprising: an internal combustion engine; and an oil pan coupled to the internal combustion engine, the oil pan including a plurality of suction tubes formed integrally therein, each of the plurality of suction tubes having an outlet providing fluid communication between the oil pan and an oil pump; and a plug fluidly blocking the outlet of one of the suction tubes, not required by the claims of Group I.

COMMON TECHNICAL FEATURES

Groups I-II share the common technical features of an oil pan assembly comprising: an oil pan defining a sump; and a suction tube integral to the oil pan and shaped so as to define stiffening ribs of the oil pan, the suction tube extending from the an inlet positioned in the sump to an outlet.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by US 2010/0224450 (Dods et al.), which discloses an oil pan assembly (10, Fig. 1; para[0016], 'an oil pan assembly 10') comprising: an oil pan (12, Fig. 1; para[0017], 'oil pan assembly 10 includes an oil pan 12') defining a sump (18, Fig. 1; para[0018], 'a reservoir or sump 18 of the pan 12'); and a suction tube (14, Fig. 1; para[0016], 'a suction tube 14') integral to the oil pan and shaped so as to define stiffening ribs of the oil pan (Fig. 1; para[0023], 'the suction tube 14 can be made integral to the pan assembly 10, such that it and the pan 12 are considered a single part'), the suction tube extending from the an inlet positioned in the sump (20, Fig. 1, 2; para[0020], 'an oil inlet 20 of the suction tube 14') to an outlet (24, 26, Fig. 2, 3; para[0021], 'the suction tube 14 also includes two outlets 24 and 26').

As the common technical features were known in the art at the time of the invention, these cannot be considered special technical feature that would otherwise unify the groups.

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