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(54) **Title:** PISTON COOLING ARRANGEMENT

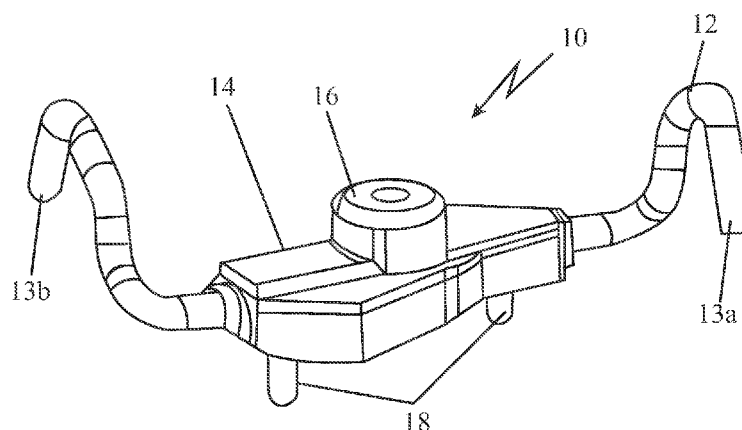


FIGURE 1

(57) **Abstract:** The piston cooling arrangement (10) of the present disclosure enables delivery of cooling fluid for cooling a piston of an internal combustion engine. The piston cooling arrangement (10) includes body portion (14) having a hollow hub (16) and at least one bolting hole. At least one inlet pipe (12) having an opening is insert molded within the body portion (14) for feeding the cooling fluid within the hollow hub (16) to cooling the piston which is guided therewithin.

PISTON COOLING ARRANGEMENT

FIELD OF THE DISCLOSURE

The present disclosure relates to the field of piston cooling nozzles for an engine.

BACKGROUND

During operation of an internal combustion engine, a small percentage of the heat in combustion fuel is absorbed by pistons/plungers. Although the percentage of the heat absorbed by the pistons/plungers is minimal, however, continuous absorption of heat results in a substantial rise in temperature of the pistons/plungers. Certain percentage of the heat is dissipated away from the pistons/plungers via conduction heat transfer from the piston rings and skirt portions of the piston to the water jacket and crankcase oil. However, the dissipation of the absorbed heat by conduction heat transfer is not sufficient to maintain the temperature of the pistons/plungers within a target operating temperature range and results in carbon deposits on the crown, the top land and the top groove of the pistons/plungers. Hence, an additional cooling system is required to be incorporated in the engine for cooling of the piston/plunger in order to ensure satisfactory operation of the piston/plunger.

Conventional piston cooling arrangement used for cooling of the pistons/plungers requires a piston cooling nozzle (PCN) in combination with a specific construction of the pistons/plungers. Conventional piston cooling arrangement using the PCN has an inlet which receives cooling oil/fluid at a rifle pressure from an oil rifle located in an engine block. An outlet is provided to direct the cooling oil/fluid toward the piston,

resulting in a divergent and non-targeted plume of cooling oil to be sprayed onto the piston. This results in spraying of the cooling oil/fluid against the piston/plunger surfaces which are not critical and preferred surface for most effective cooling and heat transfer from the pistons/plungers. Thus, conventional piston cooling arrangement causes insufficient cooling of the surface of the piston/plunger due to incorrectly directed and non-uniform application of cooling oil/fluid on the piston/plunger surface. This results in cracking of the pistons due to temperature differentials arising out of localized “hot spots” on the piston surface resulting from insufficient cooling of the surface of the piston/plunger.

SUMMARY

In accordance with one aspect of the present disclosure there is provided a piston cooling arrangement for delivering cooling fluid to a piston of an internal combustion engine, the arrangement comprising:

- a hub defining a hollow;
- at least one inlet pipe feeding cooling fluid within the hollow of the hub, the inlet pipe provided with at least one opening for feeding the cooling fluid;
- a body portion defining the hub, the body portion cast and configured to be mounted on the internal combustion engine; and
- at least one bolting hole provided on the body portion.

The hub may be integrally formed during casting of the body portion.

Typically, a single inlet pipe may be insert molded within the body portion. The body portion may be machined to define the hollow of the hub.

Typically, a portion of the inlet pipe within the hollow may be deformed to form the at least one opening during the machining process.

Alternatively, the hub may be formed by precisely positioning an insert and molding the insert during casting of the body portion.

Alternatively, two inlet pipes may be insert molded within the body portion.

The two inlet pipes may be positioned diametrically opposite each other to direct the cooling fluid within the hollow.

At least one dowel may be integrally formed on the body portion during casting.

The at least one bolting hole may be defined on the body portion by machining.

The at least one bolting hole may be formed by insert molding at least one bolting hole insert during casting of the body portion.

The at least one inlet pipe may extend from either ends of the body portion.

The size of the at least one inlet pipe may be variable corresponding to the quantity of cooling fluid to be supplied to the hollow.

In accordance with another aspect of the present disclosure there is provided a method for manufacturing a piston cooling arrangement for delivering cooling fluid to a piston, the method comprising the steps of:

- configuring at least one inlet pipe to a predetermined shape;

- precisely positioning the at least one inlet pipe within a mould;
- pouring casting material into the mould for casting a body portion;
- defining at least one bolting hole and a hollow hub on the body portion; and
- providing at least one opening on the inlet pipe for feeding cooling fluid within the hollow hub.

Typically, the step of configuring may be followed by a step of knurling the tubes.

The step of pouring casting material includes integrally forming at least one dowel on the body portion.

The step of defining the at least one bolting hole is carried out by machining the body portion.

The step of defining the hollow hub is carried out by machining the body portion.

The step of providing the at least one opening includes the step of deforming a portion of the at least one inlet pipe to form the at least one opening.

Alternatively, the step of pouring may be preceded by the step of precisely positioning at least one bolting hole insert and a hub insert for respectively defining the at least one bolting hole and the hollow hub on the body portion.

Alternatively, the step of providing includes insert molding two inlet pipes positioned diametrically opposite each other to direct the cooling fluid within the hollow hub.

BRIEF DESCRIPTION OF ACCOMPANYING DRAWINGS

The piston cooling arrangement of the present disclosure will now be described with the help of accompanying drawings, in which:

Figure 1 illustrates a perspective top view of the piston cooling arrangement in accordance with the present disclosure;

Figure 2 illustrates a bottom view of the of the piston cooling arrangement shown in **Figure 1**;

Figure 3 illustrates a perspective bottom view of the piston cooling arrangement shown in **Figure 1**;

Figure 4 illustrates an imaginary cutting circle for forming an opening in a tube for supplying cooling oil/fluid;

Figure 5 illustrates the opening in the tube for supplying cooling oil/fluid to a piston/plunger; and

Figure 6 illustrates an alternate embodiment of the piston cooling arrangement with metal inserts molded into a body portion;

Figure 7 illustrates the metal inserts to be molded into the body portion shown in **Figure 6**; and

Figure 8 illustrates the path of cooling oil/fluid in the piston cooling arrangement illustrated in **Figure 6**.

DETAILED DESCRIPTION

Conventional piston cooling arrangement includes a Piston Cooling Nozzle (PCN) having an inlet for receiving cooling oil/fluid and an outlet for spraying the cooling oil/fluid received from the inlet onto the surface of a piston/plunger. However, conventional piston cooling arrangement results in divergent and non-targeted plume of cooling oil sprayed against the surface of the piston/plunger. This results in an inaccurate application

of cooling oil/fluid leading to creation of “hot spots” on the piston/plunger surface. The “hot spots” on the piston surface results in temperature differentials which causes cracking of the pistons/plungers.

Several attempts have been made to manufacture piston cooling arrangement for heat transfer from the piston/plunger.

Accordingly, United States Patent Number **US4979473** discloses a nozzle used to cool the underside of a piston mounted in an engine. The nozzle includes a two piece assembly which includes a structural body attached to the engine and a formed tube having one end forming an orifice and the other end attached to the body. The body includes a passage and a bore intersecting the passage. The end of the tube attached to the body is positioned in the bore. One major disadvantage of **US4979473** is that the flow area between the two pieces of the assembly fails to provide a smooth and efficient flow of cooling fluid.

Again, United States Patent Application **US20100095910** discloses a piston cooling nozzle comprising a nylon body having a hub, a pair of integral legs extending from the hub and a tube for delivering coolant to a piston. The pair of integral legs is formed relative to the hub and the tube to ensure that when the body is mounted to an engine block, the legs are engaged to a cylinder liner in order to position the tube between a skirt of the piston and a connecting rod coupled to the piston. One disadvantage of **US20100095910** is that the piston cooling nozzle is difficult to manufacture as the tube is required to be mounted at a precise location and at a precise angle.

The applicant has recognized that prior art piston cooling arrangement does not provide efficient cooling of the pistons and the manufacturing

process for the same is also not cost effective. Therefore, in accordance with the present disclosure, a piston cooling arrangement is envisaged to that overcomes the drawbacks of the prior art and provides following features but not limited to:

- minimal machining operations;
- superior structural stability;
- effective cooling of the piston surface;
- simple in construction;
- easy to manufacture and cost effective; and
- easy to mount on an engine during engine assembling and post engine servicing.

A preferred embodiment of the piston cooling arrangement of the present disclosure will now be described in detail with reference to the accompanying drawings. The preferred embodiment does not limit the scope and ambit of the disclosure. The description provided is purely by way of example and illustration.

The embodiments herein and the various features and advantageous details thereof are explained with reference to the non-limiting embodiments in the following description. Descriptions of well-known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

The following description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

Referring to the accompanied drawings, the piston cooling arrangement, in accordance with this disclosure is generally indicated by the reference numeral 10 and is particularly shown in **Figure 1** to **Figure 3** of the drawing.

Figure 1 to **Figure 3** illustrates a piston cooling arrangement (10) for cooling a piston/plunger of an engine, typically a V-shaped engine. The piston cooling arrangement (10) includes an inlet pipe (12) and a body portion (14) defining a hub (16).

The inlet pipe (12) is configured to direct cooling oil/fluid towards a corresponding piston/plunger. The inlet pipe (12) is made of metal, typically steel. The inlet pipe (12), having an inlet end portion (13a) and an outlet end portion (13b), is bent to a predetermined shape, forming a curve with an arcuate portion at the center, defining a passage for cooling

oil/fluid. The inlet pipe (12) is bent such that an arcuate portion (17), shown in **Figure 3**, is formed at the center of the inlet pipe (12). After bending the inlet pipe (12) to the predetermined shape, a secondary operation of knurling is carried out on the inlet pipe (12) at a plurality of locations in order to ensure proper gripping of the inlet pipe (12). The predetermined shape of the inlet pipe (12) is dependent on the desired flow rate of the cooling oil/fluid and constraints involved in packaging and/or manufacturing of the piston cooling arrangement (10).

Subsequent to the knurling operation, the inlet pipe (12) is positioned in a mould for casting the body portion (14) so as to locate the inlet pipe (12) within the body portion (14) as an insert. The inlet pipe (16) is positioned within the mould of the body portion (14) such that when the cast and cooled body portion (14) is withdrawn from the mould, the inlet end portion (13a) and the outlet end portion (13b) of the inlet pipe (13) projects from opposite ends of the body portion (14). The body portion (14), typically made of aluminum, is cast to a predetermined shape depending on the engine on which it is to be mounted.

In accordance with one embodiment of the piston cooling arrangement (10), illustrated in **Figure 1** to **Figure 3**, the cast and cooled body portion (14), with the inlet pipe (12), insert molded therewithin, includes a hub (16), bolting holes (15) and at least one dowel (18) which are integrally formed on the cast body portion (14).

The body portion (14), with the inlet pipe (12) positioned within the body portion (14), after being withdrawn from the mould, is required to be machined to define a hollow (20), shown in **Figure 3**, of the hub (16) for forming a guide for the piston/plunger. The hollow (20) has a diameter

equal to the diameter of an imaginary circle (24), shown in **Figure 4**. The bolting holes (15) are formed by performing machining operation on the body portion (14). The dowels (18) are typically tapering in shape and enable orientation of the piston cooling arrangement (10) on the engine. The inlet pipe (12) is positioned within the body portion (14) such that the hollow (20) of the hub (16) is at least partially encompassed by the arcuate portion (17) of the inlet pipe (12).

In the process of defining the hollow (20), the arcuate portion (17) of the inlet pipe (16) is cut out along the imaginary circle (24), as shown in **Figure 4**, to form an opening (22), illustrated on **Figure 5**. The opening (22), typically arcuate in shape, is defined along the length of the curve of the inlet pipe (12) for supplying cooling oil/fluid for substantially uniformly applying the cooling oil/fluid to the surface of the piston/plunger and enable targeted cooling of the piston/plunger.

In an alternate embodiment of the piston cooling arrangement (10), shown in **Figure 6**, the bolting holes (15) and the hub (16), illustrated in **Figure 2**, are formed by using bolting hole insert (31) and hub insert (32) respectively, as shown in **Figure 7**. The hub insert (32) defines the hollow (20) of the hub (16). Two inlet pipes (34 and 36) having a predetermined length and a predetermined shape are press-fitted into the hub insert (32) so as to be diametrically opposite each other. The two inlet pipes (34 and 36) are positioned diametrically opposite to cause the cooling oil/fluid to flow with an increased plume angle through the inlet pipes (34 and 36) into the hollow (20), along the direction of the arrows, illustrated in **Figure 8**, for cooling the piston/plunger. The bolting hole insert (31), the hub insert (32) and the inlet pipes (34 and 36), made of metal, are precisely located within a mould for casting a body portion

(38) such that the bolting hole insert (31), the hub insert (32) and the inlet pipes (34 and 36) are positioned within the body portion (38), as shown in **Figure 6**. The body portion (38) is cast from a polymeric material, typically plastic.

The delivery of the cooling oil/fluid to the surface of the piston is governed by the shape of the opening (22), as illustrated in Figure 5, or the plume angle of the cooling fluid formed between the inlet pipes (34 and 36). Further the quantity of the cooling fluid is governed by the passage defined within the inlet pipe (12) and the inlet pipes (34 and 36) for flow of the cooling oil/fluid and the restrictions provided to the flow of the cooling oil/fluid within the inlet pipe (12) and the inlet pipes (34 and 36). The restriction to the flow of the cooling oil/fluid through the inlet pipe (12) and the inlet pipes (34 and 36) is caused by a plurality of bends and sharp turns defined thereon. Depending on the quantity of cooling oil/fluid required to be supplied to the surface of the piston/plunger, the dimension of the inlet pipe (16) and the inlet pipes (34 and 36) are varied. Alternatively, in order to control the quantity of the cooling fluid/oil supplied through the piston cooling arrangement (10), a check valve (not shown in Figure) is provided to ensure adequate supply of cooling oil/fluid to the piston/plunger when the pressure of the oil in an oil gallery exceeds the cracking pressure of the piston/plunger surface.

TECHNICAL ADVANCEMENTS

The technical advancements offered by the present disclosure include the realization of:

- accurately maintaining close clearances between moving components such as connecting rod, crankshaft and piston/plunger;
- minimal machining operations;
- superior structural stability;
- effective cooling of the piston surface;
- supplying accurate quantity of cooling oil/fluid for controlling the temperature of the surface of the piston and the piston pin boss;
- lubricating the piston pin bore area and the connecting rod bushing;
- simple construction;
- easy to manufacture and cost effective; and
- easy to mount on an engine during engine assembling and engine servicing.

Throughout this specification the word “comprise”, or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The use of the expression “at least” or “at least one” suggests the use of one or more elements or ingredients or quantities, as the use may be in the embodiment of the disclosure to achieve one or more of the desired objects or results.

The numerical values given of various physical parameters, dimensions and quantities are only approximate values and it is envisaged that the values higher or lower than the numerical value assigned to the physical parameters, dimensions and quantities fall within the scope of the disclosure unless there is a statement in the specification to the contrary.

Wherever a range of values is specified, a value up to 10% below and above the lowest and highest numerical value respectively, of the specified range, is included in the scope of the disclosure.

The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a", "an" and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

When an element or layer is referred to as being "on", "engaged to", "connected to" or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to", "directly connected to" or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or"

includes any and all combinations of one or more of the associated listed items.

Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

Spatially relative terms, such as “inner,” “outer,” “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

CLAIMS

1. A piston cooling arrangement for delivering cooling fluid to a piston of an internal combustion engine, said arrangement comprising:
 - a hub defining a hollow;
 - at least one inlet pipe feeding cooling fluid within said hollow of said hub, said inlet pipe provided with at least one opening for feeding the cooling fluid;
 - a body portion defining said hub, said body portion cast and configured to be mounted on the internal combustion engine; and
 - at least one bolting hole provided on said body portion.
2. The piston cooling arrangement as claimed in claim 1, wherein said hub is integrally formed during casting of said body portion.
3. The piston cooling arrangement as claimed in claim 1, wherein a single inlet pipe is insert molded within said body portion, said body portion being machined to define said hollow of said hub.
4. The piston cooling arrangement as claimed in claim 3, wherein a portion of said inlet pipe within said hollow is deformed to form said at least one opening during the machining process.
5. The piston cooling arrangement as claimed in claim 1, wherein said hub is formed by precisely positioning an insert and molding said insert during casting of said body portion.
6. The piston cooling arrangement as claimed in claim 1, wherein two inlet pipes are insert molded within said body portion.
7. The piston cooling arrangement as claimed in claim 6, wherein said two inlet pipes are positioned diametrically opposite each other to direct the cooling fluid within said hollow.

8. The piston cooling arrangement as claimed in claim 1, wherein at least one dowel is integrally formed on said body portion during casting.
9. The piston cooling arrangement as claimed in claim 1, wherein said at least one bolting hole is defined on said body portion by machining.
10. The piston cooling arrangement as claimed in claim 1, wherein said at least one bolting hole is formed by insert molding at least one bolting hole insert during casting of said body portion.
11. The piston cooling arrangement as claimed in claim 1, wherein said at least one inlet pipe extends from either ends of said body portion.
12. The piston cooling arrangement as claimed in 1, wherein the size of said at least one inlet pipe is variable corresponding to the quantity of cooling fluid to be supplied to said hollow.
13. A method for manufacturing a piston cooling arrangement for delivering cooling fluid to a piston, said method comprising the steps of:
 - configuring at least one inlet pipe to a predetermined shape;
 - precisely positioning said at least one inlet pipe within a mould;
 - pouring casting material into the mould for casting a body portion;
 - defining at least one bolting hole and a hollow hub on said body portion; and
 - providing at least one opening on said inlet pipe for feeding cooling fluid within said hollow hub.
14. The method as claimed in claim 13, wherein the step of configuring is followed by a step of knurling the tubes.

15. The method as claimed in claim 13, wherein the step of pouring casting material includes integrally forming at least one dowel on said body portion.
16. The method as claimed in claim 13, wherein the step of defining said at least one bolting hole is carried out by machining said body portion.
17. The method as claimed in claim 13, wherein the step of defining said hollow hub is carried out by machining said body portion.
18. The method as claimed in claim 13, wherein the step of providing said at least one opening includes the step of deforming a portion of said at least one inlet pipe to form said at least one opening.
19. The method as claimed in claim 13, wherein the step of pouring is preceded by the step of precisely positioning at least one bolting hole insert and a hub insert for respectively defining said at least one bolting hole and said hollow hub on said body portion.
20. The method as claimed in claim 13, wherein the step of providing includes insert molding two inlet pipes positioned diametrically opposite each other to direct the cooling fluid within said hollow hub.

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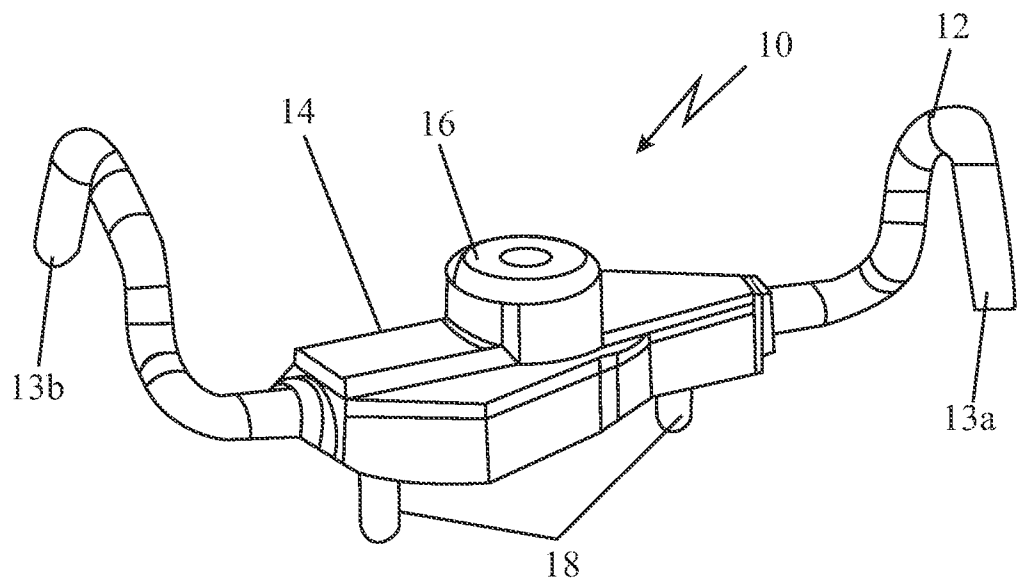


FIGURE 1

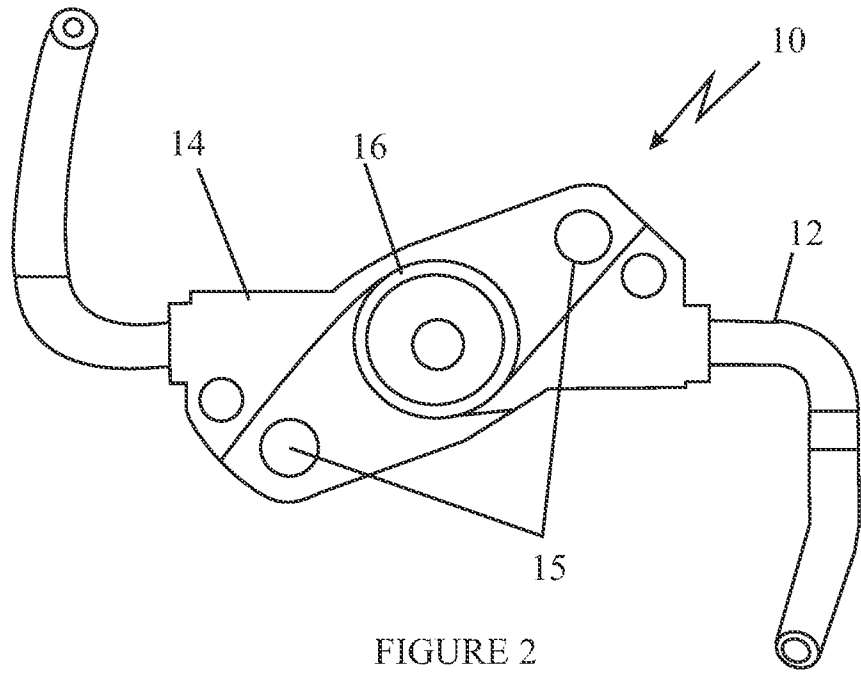


FIGURE 2

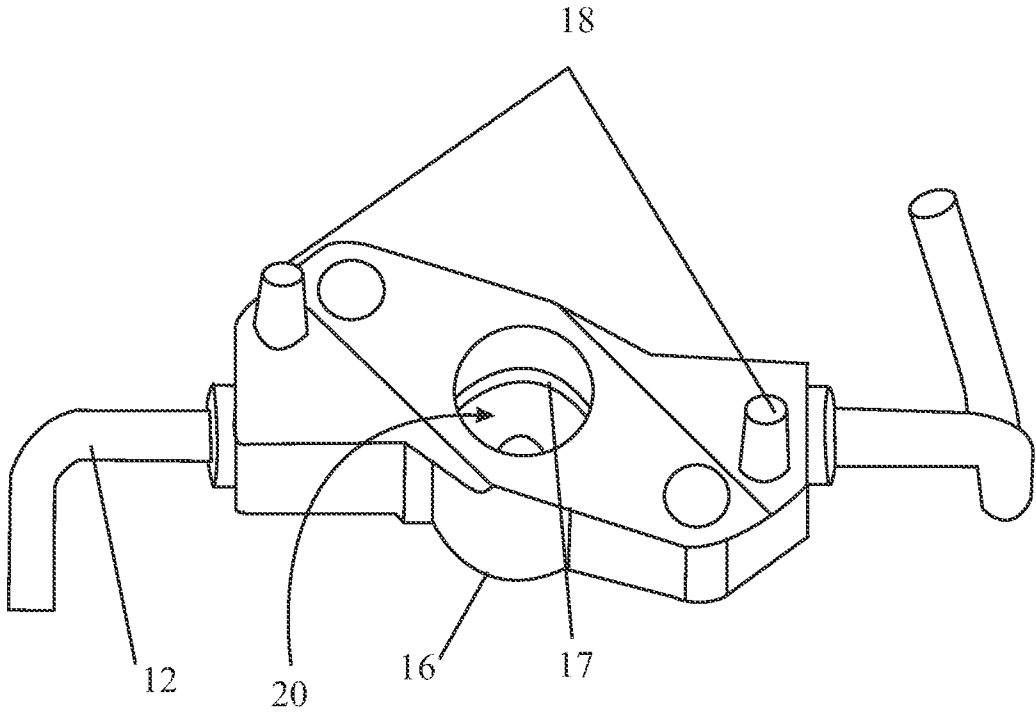


FIGURE 3

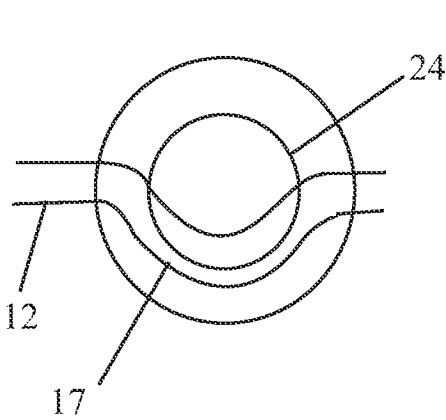


FIGURE 4

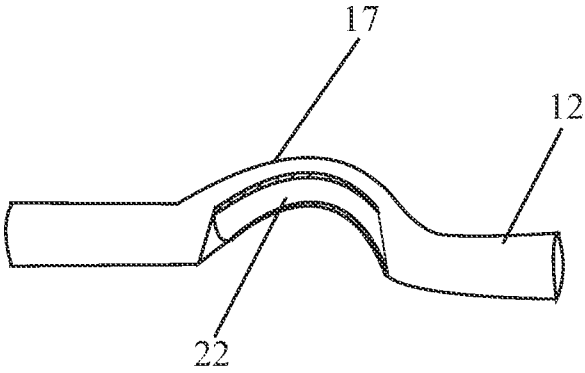


FIGURE 5

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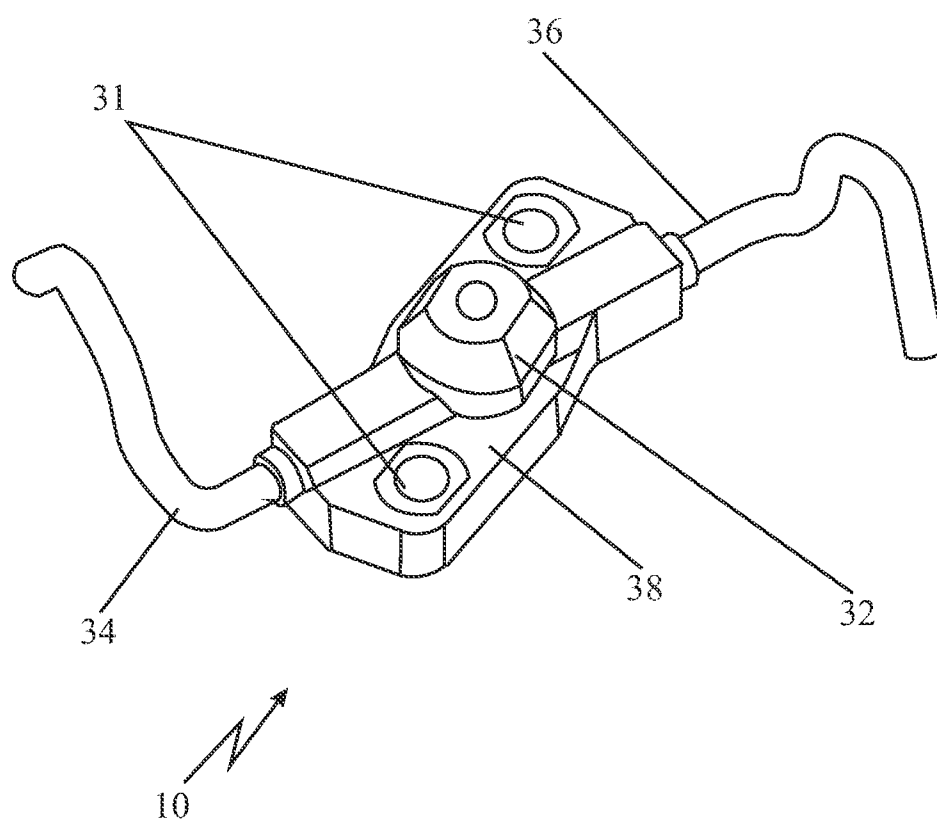


FIGURE 6

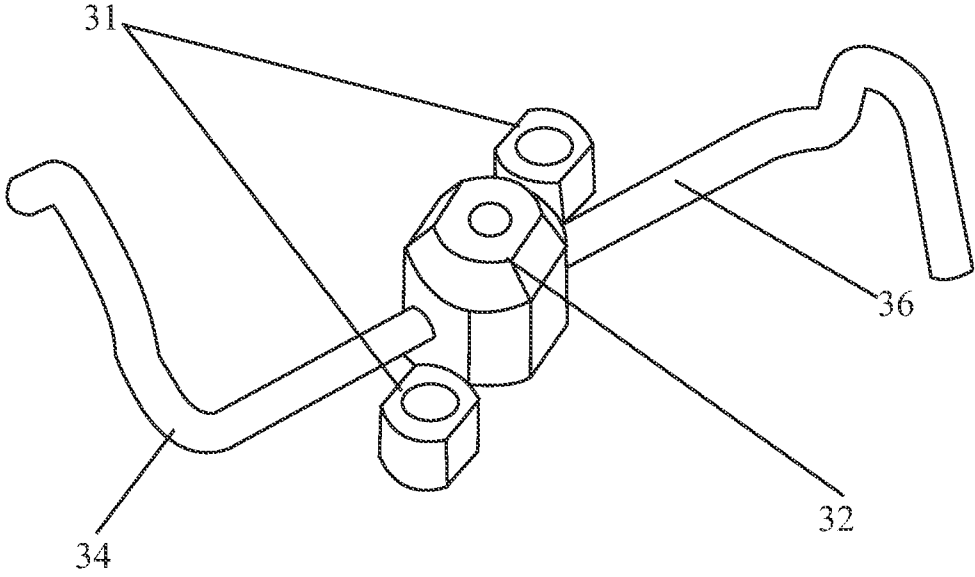


FIGURE 7

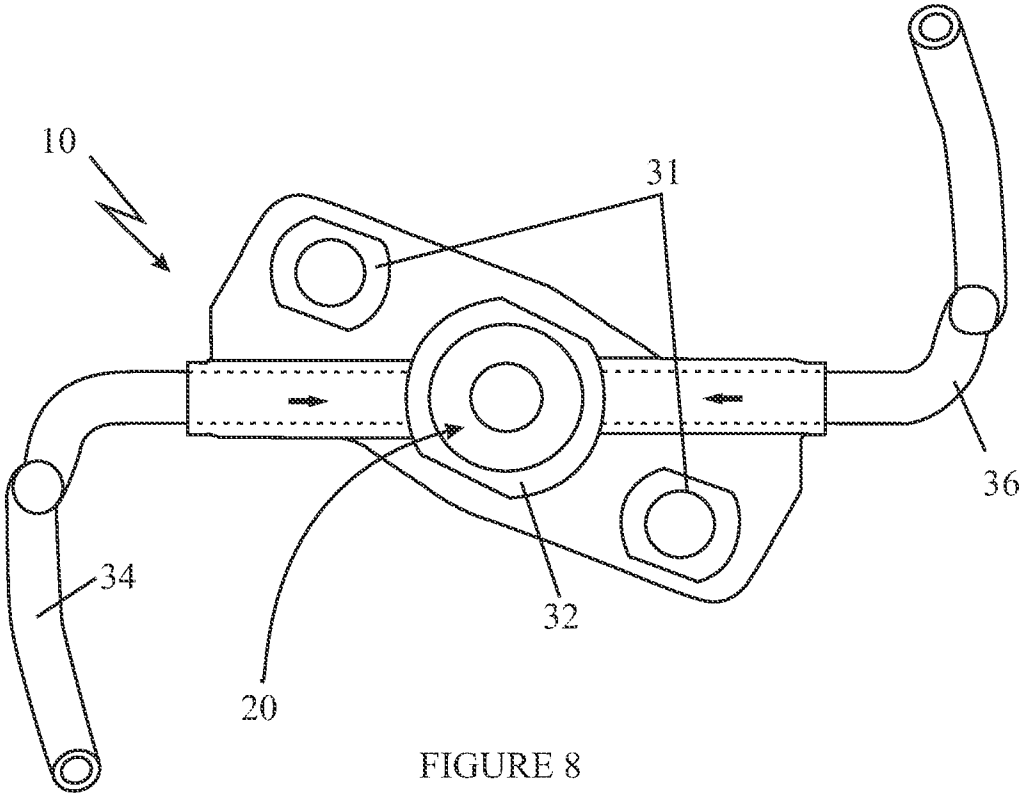


FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/062788**A. CLASSIFICATION OF SUBJECT MATTER****F02F 3/22(2006.01)i, F01P 3/06(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)

F02F 3/22; B05B 1/30; F01M 1/06; F01M 1/02; F01M 1/08; F01P 3/08; F01P 1/04; B23P 17/00; F01P 3/06

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: piston, cooling, fluid, oil, lubrication, nozzle, inject, eject, spray, jet, cast, bolt, opening

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-163265 A (DAIHATSU MOTOR CO., LTD.) 25 August 2011 See abstract; paragraphs [0016],[0017],[0020]; figures 1-3.	1-20
Y	US 4,508,065 A (SUCHDEV, JAGAN N.) 02 April 1985 See abstract; column 4, lines 11-18; figures 3,4.	1-20
A	US 2010-0001103 A1 (NETO et al.) 07 January 2010 See abstract; paragraphs [0035],[0036]; figure 4.	1-20
A	US 2004-0040520 A1 (BONTAZ et al.) 04 March 2004 See abstract; paragraphs [0036],[0037]; figure 3.	1-20
A	US 2009-0235895 A1 (HISATOMI, KENJI) 24 September 2009 See abstract; paragraph [0004]; figure 2.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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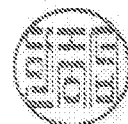
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INTERNATIONAL SEARCH REPORT

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