



(51) International Patent Classification:
F01M 1/00 (2006.01)

(21) International Application Number:
PCT/IB2017/055297

(22) International Filing Date:
04 September 2017 (04.09.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
201641030357 06 September 2016 (06.09.2016) IN

(71) Applicant: **TVS MOTOR COMPANY LIMITED**
[IN/IN]; Jayalakshmi Estates, No.29 (old No.8) Haddows,
Road, Chennai 600006 (IN).

(72) Inventors: **JOSEPH, Sumith**; Tvs Motor Company Limited, Jayalakshmi Estates, No.29 (old No.8), Haddows Road, Chennai 600006 (IN). **UMATE, Mohan**; Tvs Motor Company Limited, Jayalakshmi Estates, No.29 (old No.8), Haddows Road, Chennai 600006 (IN). **SETHU, Chandrasekharan**; Tvs Motor Company Limited, Jayalakshmi Estates, No.29 (old No.8), Haddows Road, Chennai 600006 (IN). **KUMARESAN, Ponnusamy**; Tvs Motor Company Limited, Jayalakshmi Estates, No.29 (old No.8), Haddows Road, Chennai 600006 (IN).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,

(54) Title: LUBRICATION AND COOLING SYSTEM OF AN INTERNAL COMBUSTION ENGINE

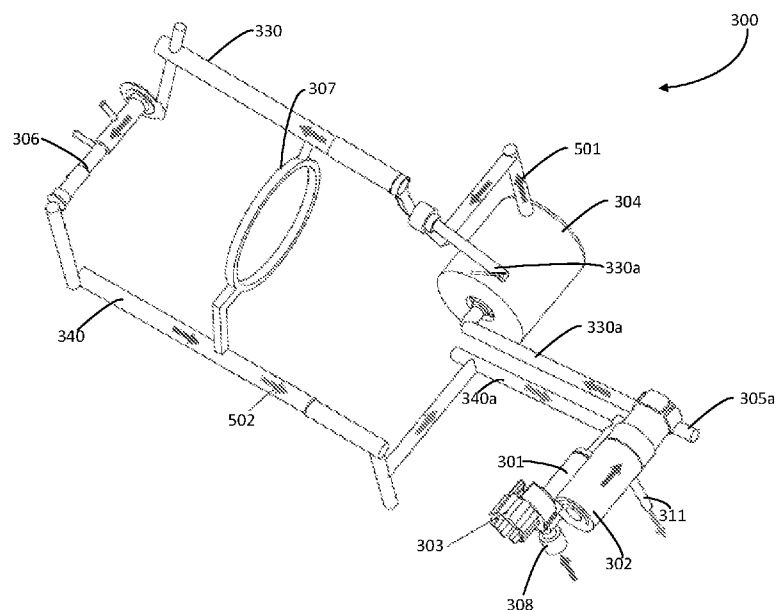


Fig. 3a

(57) Abstract: The present subject matter discloses a forced-feed lubricating system for an internal combustion (IC) engine (100) comprising a main-oil gallery circuit (300) supplying oil under pressure by an oil pump (303) to lubricate various components. The main-oil gallery circuit (300) comprises of a suction portion (330) for oil entry and a drain portion (340) to drain the oil after circulation. An oil-pressure control unit (301) is disposed upstream of the oil pump (303); and said oil-pressure control unit (301) is configured to control the pressure of oil in the main-oil gallery circuit (300) by limiting the suction of oil and bypassing the oil under excess pressure on the drain portion (340) to the suction portion (330) to enable continuous recirculation of oil in the main-oil gallery circuit (300). This ensures the maximum pressure in the main-oil gallery circuit to a certain limiting pressure value, which ensures that there is always a continuous flow of lubricating oil.



OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Declarations under Rule 4.17:

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

Published:

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

LUBRICATION AND COOLING SYSTEM OF AN INTERNAL COMBUSTION ENGINE

TECHNICAL FIELD

The present subject matter relates generally to an internal combustion engine.

- 5 More particularly, the present subject matter relates to a forced-feed lubrication and cooling system employed in the IC engine.

BACKGROUND

- [0001] An internal combustion (IC) engine converts thermal energy of air-fuel mixture to mechanical energy by transferring this thermal energy to a reciprocating piston inside a cylinder block. The reciprocating piston transfers this reciprocating motion to a rotary motion of a crankshaft by a connecting rod utilizing a slider-crank mechanism. IC engine contains many reciprocating, rotating and moving parts and such movements cause friction between all surfaces in contact. At points of movement and extreme loading serious damage can be caused without proper lubrication. Additionally, the thermal energy generated in the various components may also cause serious damage. Hence, it is essential to lubricate all the moving parts of the IC engine. A force-feed lubrication system circulates the oil to all the parts of the IC engine in oil passages. This reduces wear on moving parts, helps cool the various parts of the IC engine, and absorbs shock loads. Lubricating oil is pumped under pressure to be circulated throughout the IC engine, but there can be situations wherein the oil pressure may increase beyond what is necessary to maintain good oil circulation. It is very critical to maintain oil pressure to optimize lubrication requirements at different moving parts, to prevent leakage of oil, to protect oil sealing from damage and to minimize friction between moving parts. Further, it is necessary to ensure proper cooling of the oil. Generally, in forced-feed oil system a pressure release valve is used to maintain the oil pressure. But conventional pressure release valve cannot maintain continuous flow of oil and also is usually located outside the crankcase. Hence, in order to address the drawbacks faced in the existing system, a forced-feed lubrication system is proposed which is incorporated within the crankcase of
- 10
15
20
25
30

the IC engine to maintain continuous flow of oil and also to ensure effective cooling.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The detailed description is described with reference to the accompanying
5 figures. The same numbers are used throughout the drawings to reference like features and components.

[0003] **Fig. 1a.** illustrates the perspective view of an internal combustion (IC) engine employing a oil-pressure control unit and thermostat unit according to an embodiment of the present subject matter.

10 [0004] **Fig. 1b.** and **Fig. 1c.** illustrates an exploded view of a crankcase assembly of the IC engine accommodating the oil-pressure control unit and the thermostat unit respectively according to the embodiment of the present subject matter.

[0005] **Fig. 2a.** illustrates the perspective view of the IC engine having a forced-feed lubrication system according to the embodiment of the present subject
15 matter.

[0006] **Fig. 2b.** illustrates the enlarged cut sectional view (X-X) of the IC engine employing an embodiment of the present subject matter.

[0007] **Fig. 3a.** illustrates the forced-feed lubrication system indicating the direction of oil flow when oil-pressure control unit and thermostat unit are not
20 actuated according to the embodiment of the present subject matter.

[0008] **Fig. 3b.** illustrates the forced-feed lubrication system indicating the direction of oil flow when oil-pressure control unit and thermostat unit are actuated according to the embodiment of the present subject matter.

[0009] **Fig. 4.** illustrates the exploded view of the oil-pressure control unit
25 according to the embodiment of the present subject matter.

[00010] **Fig. 5a.** and **Fig. 5b.** illustrates an enlarged cut sectional view of the oil-pressure control unit in closed state and open state respectively according to embodiment of the present subject matter.

[00011] Fig. 6. illustrates the exploded view of the thermostat unit according to the embodiment of the present subject matter.

[00012] Fig. 7a. and Fig. 7b. illustrates a cut sectional side view of the thermostat unit in closed state and open state respectively according to the embodiment of the present subject matter.

DETAILED DESCRIPTION

[00013] Various features and embodiments of the present subject matter here will be discernible from the following further description thereof, set out hereunder. According to an embodiment, an internal combustion engine (IC) described here operates in four cycles. Such an IC engine is installed in a step through type two wheeled vehicle. It is contemplated that the concepts of the present invention may be applied to other types of vehicles within the spirit and scope of this invention. Further "front" and "rear", and "left" and "right" referred to in the ensuing description of the illustrated embodiment refer to front and rear, and left and right directions as seen from a rear portion of the IC engine and looking forward. Furthermore, a longitudinal axis unless otherwise mentioned, refers to a front to rear axis relative to the engine, while a lateral axis unless otherwise mentioned, refers generally to a side to side, or left to right axis relative to the engine. The detailed explanation of the constitution of parts other than the present subject matter which constitutes an essential part has been omitted at suitable places.

[00014] IC engines come in various wide variety and design. Typically, an IC engine comprises a cylinder block having one or more cylinder bores, a piston reciprocating in each cylinder bore, a cylinder head located above the cylinder block and a combustion chamber. The combustion chamber is formed between the cylinder head, a top surface of the piston, and walls of the cylinder bore. Charge is ignited in the combustion chamber which expands imparting reciprocating motion to the piston which is converted to rotary motion of a crankshaft through a connecting rod. Further, the motion from the crankshaft is transmitted to wheels of the vehicle through a drive train. The burning of charge in the combustion chamber imparts reciprocating motion to the piston which transmits into rotary

motion of the crankshaft by a connecting rod. Typically, IC engines have a lot of reciprocating and moving parts. It is essential that such moving parts remain well lubricated for its operation under all conditions of operation. Additionally, the lubrication system also has to perform cooling to critical parts of the IC engine.

- 5 Hence, an effective lubrication system is essential in all IC engines, for example, multi-cylinder engines of smaller capacity, and in case of opposed-piston engines. A good lubrication system ensures long life of the IC engine, maximizes power output, increases efficiency, and improves reliability.

- [00015] Typically in modern IC engines, force feed type lubrication system is used. The system has three continuous steps of operation. Oil lubricating the IC engine components is collected and sent to the oil reservoir; the oil pump draws lubricating oil by suction from the oil reservoir and forced through oil galleries (passageways) around the combustion chamber and other IC engine components, and the oil from the IC engine components is collected and sent to the oil reservoir. The various IC engine components include crankshaft, inner walls of cylinder bores, bearings, such as the main bearings, connecting rod, camshaft, and other components such as cam lobes rocker arms etc. The oil reservoir is usually disposed in the lower part of the IC engine crankcase. To ensure complete draining for cleaning and oil changes, the crankcase has a drain connection located at or near the bottom of the oil reservoir. An oil filter is also used in this lubrication circuit shown which filters the lubricating oil from foreign particles. A relief valve is typically located before on this filter to protect the system from getting clogged. If the filter becomes clogged, the relief valve will permit the unfiltered oil to bypass the oil filter so that the IC engine components continue to receive lubricating oil. Filter elements can be either cleanable and reusable or disposable. The oil pump is usually a positive-displacement pump or a gear pump which is capable of delivering oil to the oil paths. The oil pump can be mounted at any suitable location of the crankcase and driven by the crankshaft, or independently mounted with an electric motor.
- 10
15
20
25

[00016] The secondary function of the lubrication system is to provide heat extraction from the surrounding parts of the cylinder head and cylinder block by the lubricating oil. Adequate cooling of the lubricating oil is necessary to maintain lubricating oil viscosity and oil quality. To operate the forced-feed system efficiently, the system can include thermostatic controls so that the oil is not cooled unnecessarily. This lubricating oil is usually controlled by passing hot lubricating oil through a radiator system. Such a radiator system must be capable of achieving the required oil temperature drop when exposed to the maximum ambient air temperature anticipated for the application. There can two types of radiator systems used namely, water/coolant cooling and air cooling. In water cooling system hot oil gives up heat to water or coolant, and in air cooling system radiators are used to blow cooling air over cooling system. The thermostat unit also contributes in maintaining the pressure in the force-feed system to limiting pressure value by maintaining the temperature of lubricating oil. The lubricating oil should always have correct viscosity to flow easily to all parts of the IC engine, otherwise if temperature is high the fluid film becomes thinner and some of the forces maybe transmitted between the surfaces of the moving parts.

[00017] Conventionally in forced-feed lubrication system, there is a long oil gallery to circulate oil around the engine. The radiator system also contains small long winding oil passages acting as a heat exchanger to circulate the oil. This results in requirement of a larger capacity oil pump and greater chance of blockage of the oil galleries. Additionally, very high oil pressures are required to flow through the cooling system oil passages. In case of small/partial blockage of any of the oil galleries or oil passages, the oil pressure can increase in the entire lubrication oil gallery circuits. Another drawback is that, when the oil filter is blocked by impurities, the filter may impede the smooth flow of oil which can increase oil pressure. Also, in most cases the oil pump is directly connected with the crankshaft and rotates at the same speed as that of the crankshaft. Hence, higher engine speeds will drive the oil pump to run faster and push more oil through the oil galleries and this increases the pressure of oil tremendously in the oil galleries and lubrication circuit which is undesirable. The pressure of oil is also

higher when the engine temperature is cold due to the increased viscosity of the oil. The effect of all the above drawbacks is that oil pressure increases in the lubrication circuit which is undesirable and has a detrimental effect on the various IC engine components. Maintaining oil pressure is essential to optimize lubrication requirements at different IC engine components, to prevent leakage of oil through seals outside the IC engine and hence prevent damage of oil seals, and to minimize friction in reciprocating and moving parts. Too much oil pressure can unnecessarily increase work for the IC engine and even add air which has a detrimental effect on performance. Increased oil pressure also damages filter element in the oil filter resulting to frequent replacement of the filter element causing frequent serviceability issues. In IC engines, usually accessibility of oil filter is difficult during servicing; hence it is undesirable to permit clogging of filter element as it is difficult to replace the same. Additionally, reciprocating and moving parts require proper lubrication and control of temperature. In order to optimize the lubrication of the reciprocating and moving parts and to provide effective cooling, it is essential to control oil pressure and oil temperature.

[00018] Conventional oil pressure control mechanisms utilize separate oil gallery to bypass the oil under excess pressure through the separate bypass oil gallery back to the oil reservoir and then is recirculated to the suction portion. However, the present subject matter eliminates the drawback by completely removing the need for a separate oil gallery, as the oil under excess pressure directly goes to the suction portion instead of going back to the oil reservoir and then to the suction portion, enabling a continuous recirculation of lubricating oil.

[00019] The present subject matter aims to address the above drawbacks by providing a forced feed lubrication system that ensures the maximum pressure in the oil galleries to a certain limiting pressure value, which ensures that there is always a continuous flow of lubricating oil around the oil galleries. The system has less number of parts and integrated with the crankcase of the IC engine. The system ensures that the oil filter is not damaged reducing the recurrence of servicing the oil filter. Further, a separate bypass oil gallery to the oil reservoir is

not required. Additionally, the system also comprises an automatic thermostat unit which can control the movement of lubricating oil to the radiator.

5 [00020] With the above design changes, the following advantages can be obtained such as reduced number of parts, improved lubrication of all the IC engine components, compact engine layout and ease of serviceability.

[00021] According to the present subject matter to attain the above mentioned objectives, a first characteristic of the present invention provides, a forced-feed lubricating system circulating oil for an internal combustion (IC) engine comprising: an oil reservoir to store oil, disposed on a lower portion of the IC engine; a main-oil gallery system including a main-oil gallery, and a plurality of
10 oil passages branching out and supplying oil under pressure to lubricate IC engine components, said main-oil gallery system comprising a suction portion for oil entry from the oil reservoir and a drain portion to drain the oil to the oil reservoir after circulation; an oil pump driven by the IC engine and supplying oil under
15 pressure to the suction portion of the main-oil gallery system and a oil-pressure control unit associated with the main-oil gallery system operative to control the oil under pressure. The oil-pressure control unit is disposed before the oil pump in the main-oil gallery system, and the oil-pressure control unit is configured to control the pressure of oil in the main-oil gallery system by limiting the suction of oil
20 from the oil reservoir by bypassing the oil under pressure on the drain portion of the main-oil gallery system to the suction portion to enable continuous recirculation of oil in the main-oil gallery system.

[00022] In addition to the configuration of the first characteristic, the second characteristic of the present subject matter is the forced-feed lubricating system
25 comprising of a radiator disposed on the main oil gallery to cool the oil under circulation, an oil filter disposed on the main oil gallery to filter the oil under circulation, and the drain portion and suction portion is connected by a bypass oil gallery, said pressure control unit disposed on the bypass oil gallery.

[00023] In addition to the configuration of the second characteristic, the third
30 characteristic of the present subject matter is the oil-pressure control unit

comprises: a plunger with a pressure receiving surface at one end, a housing supporting the plunger, an elastic member connecting the plunger to the housing and configured to press the plunger in a direction of the peripheral wall; and said plunger and elastic member energized to move to permit oil from the drain side to
5 flow towards the suction side when the oil pressure exceeds the predetermined value.

[00024] In addition to the configuration of the second characteristic, the forth characteristic of the present subject matter is the forced-feed lubricating system further comprises a thermostat unit disposed upstream of the oil filter, and is
10 configured to control the temperature of oil in the main-oil gallery system by diverting the oil to the radiator before re-circulating it back to the main-oil gallery system, and wherein the thermostat unit comprising: a thermostat element configured to be move on exceeding the temperature of oil to a predetermined value, a thermostat housing supporting the thermostat element, an elastic member
15 connecting the thermostat element to the thermostat housing and configured to press the thermostat element in a direction of a peripheral wall of the crankcase; and said thermostat element and elastic member energized to move on exceeding a predetermined temperature to divert the oil from the upstream side of the main-oil gallery system to the radiator before re-circulating it back to the main-oil
20 gallery system on the downstream side. The movement of the thermostat element is achieved by a wax thermostat element disposed on the inner periphery of the thermostat element which is configured to expand on exceeding a predetermined temperature.

[00025] In addition to the configuration of the second characteristic, the fifth characteristic of the present subject matter is the oil-pressure control unit and the thermostat elements is coaxially mounted in a bore of the crankcase connecting the oil galleries.

[00026] The present subject matter along with all the accompanying embodiments and their other advantages would be described in greater detail in conjunction
30 with the figures in the following paragraphs.

[00027] Fig. 1a illustrates the isometric view of the IC engine (100) having forced-feed lubrication, according to an embodiment of the present subject matter. According to one embodiment, the IC engine (100) is a single cylinder IC engine for a step-through (scooter) type two wheeled vehicle (hereafter referred to as IC engine). However the present subject matter can be applicable to other multi
5 cylinder IC engines without deviating from the scope of the current invention.

[00028] The IC engine (100) comprises a cylinder head (101b), a cylinder head cover (101a), a cylinder block (101) and crankcase assembly (110). The cylinder block (101) is mounted on the crankcase (110) and extends almost horizontally to
10 the vehicle central plane. The cylinder head (101b) is mounted over the cylinder block (101) and the cylinder head (101b) is covered by the cylinder head cover (101a). The force-feed lubrication system also comprises a radiator (305) which is mounted at a suitable location of the two wheeled vehicle where it can be exposed to atmospheric air. The crankcase assembly (110) comprises a LH crankcase
15 (102), a RH crankcase (104) and a CVT cover (103). A oil-pressure control unit (301) and the thermostat unit (302) are disposed in two enclosed chambers formed by two bores (301a, 301b & 302a, 302b) on the inner surface of the crankcase assembly (110).

[00029] Fig. 1b illustrates the enlarged exploded view of the crankcase assembly and cylinder block (101) in accordance with the embodiment of the present
20 subject matter. According to an embodiment the oil-pressure control unit (301) is configured to be located on a bore located on either side of the LH crankcase (102) and RH crankcase (104). The LH crankcase (102) and RH crankcase (104) are configured to have a first bore (301a, 301b) drilled on either side of the inner
25 face such that, when the LH crankcase (102) and RH crankcase (104) are mated together, the two first bores (301a, 301b) on either side are mated together to form an enclosed chamber which can house the oil-pressure control unit (301). The oil-pressure control unit (301) is located such that, the oil reservoir passage (308) and the oil pump is located on the LH crankcase (102), and the oil reservoir exit
30 passage is located on the RH crankcase (104). This location is advantageous due

to the following reasons. The oil reservoir (309) storing lubricating oil is located on the lower half of the inner surface of the RH crankcase (104) and LH crankcase (102).

[00030] Fig. 1c. illustrates the enlarged exploded view of the crankcase assembly (110) and cylinder block (101) in accordance with the embodiment of the present subject matter. Due to similar advantages of locating the oil-pressure control unit (301), a thermostat unit (302) is also located next to the oil-pressure control unit (301) on two thermostat bores (302a, 302b) on the LH crankcase (102) and RH crankcase (104) which when mated together to form an enclosed chamber which can house the thermostat unit (302). The thermostat unit (302) controls the lubricating oil temperature by diverting the lubricating oil to a radiator (305) when temperature is increased and then back to the main-oil gallery system.

[00031] Fig. 2a. illustrates the IC engine comprising the force-feed lubrication system. Fig. 2b. illustrates the enlarged cut section of the IC engine (100) comprising the oil reservoir (309) located on the bottom-most part of the crankcase assembly, and a oil strainer (309a). The force-feed lubrication system comprises various components circulating oil throughout the various components of the IC engine (100) and will be explained in detail with reference to Fig. 2a. and Fig. 2b. respectively. The oil reservoir (309) stores the lubricating oil to be circulated and can be filled externally through an oil entry portion (309b). There is also a drain plug (309c) located on the underside of the LH crankcase (102) through which the lubricating oil can be drained. The main oil gallery system begins from the oil reservoir (309) and it has an oil strainer (309a) on its end submerged inside the oil stored in the oil reservoir (309). The oil reservoir passage (308) is a hollow tube slightly projecting outwards from the inner side of the LH crankcase surface (see 102a) through which the oil strainer (309a) is assembled from the underside. The drain plug (309c) is a nut and has a rubber seal around its threading which when assembled from the underside of the LH crankcase (102) and tightened with a suitable tool, the oil strainer (309a) is held in position firmly and securely inside the oil reservoir (309). The oil strainer (309a)

comprises a filter material (not shown) such a filter paper or wire mesh which filters large particles and impurities in the oil and prevents them from entering the main oil galleries. The force-feed lubrication system comprises a main oil gallery which is the path the lubricating oil takes circulating throughout the various components of the IC engine (100). It is a network of passageways found in both the LH crankcase (102) and RH crankcase (104) of the IC engine (100) (in crankcase sidewalls) and its individual components, like the crankshaft. The force-feed lubrication system is a closed loop system of circulation of lubrication oil comprising of a suction portion (330) and a drain portion (320) as illustrated in Fig. 3a. The suction portion (330) comprises of those elements, components and oil galleries of the main oil gallery wherein the lubricating oil is drawn and introduced to circulate around the forced-feed lubrication system. The drain portion (320) comprises of those elements, components and oil galleries of the main-oil gallery system wherein the lubricating oil is drained back to the oil reservoir (309). For representative purposes, the part of main oil gallery carrying lubricating oil to lubricate and cool IC engine components is referred to as suction portion (330), and the part of the main oil gallery carrying lubricating oil back to the oil reservoir (309) after cooling and lubrication of IC engine components is referred to as drain portion (340). Lubricating oil enters the suction portion oil gallery (330) through the oil reservoir passage (308) and oil-pressure control unit (301). An oil pump (303) operates upstream of the oil-pressure control unit (301) on the suction portion to circulate the oil throughout the entire force-feed lubrication system. The oil pump (303) can operate as a plunger-type oil pump or gear-feed oil pump which may be coupled directly to one of the crankshaft of the IC engine (100). Additionally an oil pump (303) is disposed just above the oil-pressure control unit (301). The location is also suitable due to ease of serviceability, as the oil-pressure control unit (301) can be easily accessed, removed and replaced by just disassembling the RH crankcase (104) and there is no need of disassembling any other components to access the same. A thermostat unit is disposed downstream of the oil-pressure control unit (301) which is capable to directing the lubricating oil to a radiator to control temperature. There

is oil filter (304) located downstream after the thermostat unit (302). The oil filter (304) comprises either a disposable filter elements such as paper. In another embodiment the filter element can be a wire mesh. The lubricating oil flows through the centre of the paper element to the other end wherein oil flows to lubricate the engine parts. The use of check valve is not required in the oil filter (304) as oil-pressure control unit (301) controls the pressure of lubricating oil suitably in the entire forced-feed system such that the requirement of check valve before the oil filter (304) is eliminated.

[00032] Lubricating oil is circulated through a series of oil passageways to cool and lubricate IC engine components such as combustion chamber oil gallery (307) around the combustion chamber, crank-train oil gallery (330a) to lubricate cranktrain systems (such as crankshaft, crankshaft bearing, connecting rod, connecting rod bearing and piston skirt through splash lubrication), and cylinder head oil gallery (306) to lubricate cylinder head systems (such as camshaft, rocker arms, camlobe and camshaft bearings). The combustion chamber oil gallery (307) also cools the exhaust pipe connection zone. The crank-train oil gallery (330a) directs the lubricating oil to small oil galleries (not shown) bored through the both the crankshaft of the IC engine (100), through which lubricating oil penetrates and lubricating the crankshaft and by unit of splash lubrication lubricates the piston as it reciprocates around the cylinder bores. Once, the lubricating oil is circulated around the various oil galleries highlighted above, the lubricating oil is directed to the drain portion oil gallery. On the drain portion, the lubricating oil drains into the oil reservoir through the oil drain passage (311) which connects to the drain portion oil gallery. A bypass oil gallery (503) connects the oil drain passage (311) to the oil-pressure control unit (301). A thermostat unit (302) is disposed on the suction portion oil gallery upstream of the oil-pressure control unit (301). The thermostat unit (302) operates to divert the lubricating oil to a radiator (305). Depending on the temperature of the lubricating oil, the thermostat unit (302) diverts the lubricating oil to the radiator (305) through the radiator input (305a) and supply cooled lubricating oil to the suction portion oil gallery (330).

[00033] Fig. 3a. illustrates the working of the force-feed lubrication system when the oil-pressure control unit and thermostat unit are not in actuation, this position can be representatively called as closed state. Fig. 3b. illustrates the working of the force-feed lubrication system when the oil-pressure control unit and thermostat unit are actuated, and this position can be representatively called as open state. It is to be noted that, for the sake of brevity, the working of forced-feed lubrication system as illustrated in Fig. 3a and Fig. 3b, the oil-pressure control unit (301) and thermostat unit (302) are shown to be not actuated together in Fig. 3a, and actuated together in Fig. 3b. But, this does not limit in any way, the actuation of either the oil-pressure control unit (301) or the thermostat unit (302) to operate independent of the other. It is an essential feature of the present subject matter that it is operated independently of each other. In the closed state, lubricating oil is accumulated in the bypass oil gallery (503) and is kept stagnant by the oil-pressure control unit (301) which prevents flow. Hence, during closed state of the oil-pressure control unit (301), the lubricating oil drains back to the oil reservoir (309) through the oil drain passage (311). The thermostat unit (302) is not actuated, and the lubricating oil directly circulates from the oil-pressure control unit (301) passes through the suction portion oil gallery and enters the IC engine components to be lubricated and cooled. Fig. 3b. illustrates the working of the force-feed lubrication system in open state. During conditions of pressure increase the system, the oil-pressure control unit (301) is in open state and the lubricating oil on the drain portion (340) is diverted back to the suction portion oil gallery (330) through the bypass oil gallery (503) and oil-pressure control unit (301). The thermostat in open state, the lubricating oil is directed to the radiator (305) and lubricating oil circulates around the cooling passages before entering the suction portion oil gallery on the upstream side of the oil filter.

[00034] Fig. 4 illustrates the exploded view of the oil-pressure control unit (301) according to one embodiment of the present subject matter. The oil-pressure control unit (301) comprises a plunger (401), an elastic member (403) attached to the plunger (401), a housing (402) enclosing the said elastic member (403), and a bung (404) forming the outer base supporting the housing (402) and the elastic

member (403). The plunger (401) comprises a pressure receiving surface (401a) at one end which encloses the opening of the bypass oil gallery (503). The elastic member (403) is connected to the plunger (401) and configured to press the plunger (401) in the direction of the opening of the bypass oil gallery (503) to keep is closed. In an embodiment the elastic member (403) is a helical spring whose spring stiffness is calibrated based on the limiting pressure value in the oil gallery as required. The elastic member (403) is enclosed in the housing (402) which also encloses the plunger (401) such that the outer axial surface of the plunger (401) is in contact with the inner axial surface of the housing (402) and there is a sliding fit between the two surfaces. Hence, the plunger (401) has single degree of freedom and constrained to slide inside the housing (402). The other end of the elastic member (403) is supported by the bung (404). The bung (404) comprises two portions. The inner projection (405) and the outer countersunk hole 407. The inner projection (405) provides a base surface to support the elastic member (403) such that inner surface (405) can be inserted in the inner annular portion of the elastic member (403). The outer portion (407) of the bung comprises a countersunk hole in which fasteners can be inserted to hold the bung (404) fixedly. The housing (402) has two openings (402a and 402b) on its radial surface located in close proximity to the plunger (401) such that, when the plunger (401) slides inside the housing (402) the two openings (402a and 402b) can be opened and closed. The openings (402a and 402b) allow the movement of oil to the oil pumps (303) when the plunger (401) slides backwards and provides a path from the bypass oil gallery (503) to the oil pump (303).

[00035] Fig. 5a further illustrates an enlarged cut sectional view of the oil-pressure control unit (301) when pressure in the oil gallery is within the limiting pressure value. This state is hereafter referred to as closed state. When the oil-pressure control unit (301) is in closed state, the oil in the bypass oil gallery (503) remains stagnant as the oil flow is blocked by the biasing action of the elastic member (403) on the opening. Hence, the oil freely flows back to the oil reservoir (309) through the oil drain passage and a small amount of oil remains stagnant and pressurized inside the bypass oil galley (503). Fig. 5b illustrates the enlarged

cut sectional view of the oil-pressure control unit (301) when the pressure in the oil gallery is above limiting pressure value. In one embodiment the pressure can be between 1.5 to 2 bar which is set as limiting pressure. This state is hereafter referred to as open state. In the open state, since the pressure is above limiting

5 pressure, the pressure exceeds the force exerted by the elastic member (403). This causes the plunger (401) to slide backwards exposing the openings (402a and 402b) in the housing (402) to the bypass oil gallery (503). The two openings (402a and 402b) are located opposite in direction of the housing (402) such that one opening (402a) permits entry of oil from oil reservoir inlet (308) and other

10 opening (402b) permits oil to flow to the oil pump (303). The openings (402a and 402b) are designed such that, if the plunger (401) slides backwards in the housing (402), the two opening are left open to provide a path from the bypass oil gallery (503) to the oil pump. Due to the excess pressure, the oil pump (303) extracts majority of oil from the drain side through the bypass oil passage (503) as

15 compared to oil reservoir inlet (308). The other opening (402a) permits flow of oil from oil reservoir inlet (308) to oil pump (303). Once, the pressure in the oil is equalized, the elastic member (403) is energized to slide the plunger (401) back to closed state, thus closing the openings. This way for the oil-pressure control unit (301) selectively controls the back pressure from the oil bypass gallery (503), for

20 managing changes in pressure of oil due to changes in the oil gallery to maintain a virtually constant pressure.

[00036] Fig. 6 illustrates the exploded view of the thermostat unit (302) according to one embodiment. The thermostat unit (302) uses wax thermostat element (601b) to transform heat energy into mechanical energy using the thermal

25 expansion of the wax thermostat element (601b) when it melts. When the wax thermostat element (601b) melts, it undergoes solid to liquid transition which results in expansion and large increase in volume. The thermostat unit (302) comprises a thermostat element (601), a thermostat elastic member (603) attached to the thermostat element (601), a thermostat housing (602) enclosing said elastic member (thermostat) (603) and the thermostat element, and a thermostat bung 604

30 forming the outer base supporting the elastic member (thermostat) (603). The

thermostat element (601) has a cylindrical bore on one of its flat sides and said cylindrical bore comprises a chamber enclosing a wax thermostat element (601b) which is capable of expanding under heat. The temperature of operation is determined by the specific composition of the wax thermostat element. The wax

5 thermostat element (601b) is specially manufactured and designed to have a particular temperature of operation. The cylindrical bore also further encloses a pin (601a) which is a long slender part of which one half is enclosed in the cylindrical bore and the other half is fixed to the inner end of the thermostat bore (302a, 302b) in the second RH crankcase (104). The elastic member (thermostat)

10 (603) is connected to the thermostat element (601) and configured to press the thermostat element (601) in the direction towards the interior of the cylindrical bore to keep apply pressure on the pin (601a) and the wax thermostat element (601b) In an embodiment the elastic member (thermostat) (603) is a helical spring whose spring stiffness is calibrated based on the temperature of operation value in

15 the oil gallery. The elastic member (thermostat) (603) is enclosed in the housing (602) which also encloses the thermostat element (601) such that the outer axial surface of the thermostat element (601) is in contact with the inner axial surface of the thermostat housing (602) and there is a sliding fit between the two surfaces. Hence, the thermostat element (601) has a single degree of freedom and

20 constrained to slide inside the thermostat housing (602). The other end of the elastic member (thermostat) (603) is supported by the thermostat bung (604). The outer projected surface of the thermostat bung (604) comprises external threads located on the outer axial surface of the thermostat bung 604 which match with corresponding internal threads located on the thermostat bore (302a, 302b) on the

25 LH crankcase (102). The housing (602) has an opening (602a) on its axial surface located in close proximity to the thermostat element (601) configured to change the path of flow of oil between two paths.

[00037] Fig. 7a illustrates an enlarged cut section of the IC engine (100) showing a thermostat unit (302) when the temperature of operation is within its limiting

30 value. This state is hereafter referred to as thermostat closed state. Fig. 7b illustrates an enlarged cut section of the IC engine (100) showing a thermostat

unit (302) when the temperature of operation is above its limiting value. In one embodiment the temperature can be between 70 degrees centigrade to 80 degrees centigrade which is set as limiting value of temperature. This state is hereafter referred to as thermostat open state. The thermostat comprises one oil input
5 namely, the oil input from oil-pressure control unit (301) and two oil outputs which the thermostat unit (302) has to control namely, suction side oil gallery, and outlet to a radiator input (305a). In closed state, the elastic member is constantly exerting a biasing force towards the pin (601a), which results in the thermostat housing (602) receiving oil from the oil-pressure control unit, which flows
10 through the interior of the thermostat housing (602) and proceeds towards the suction portion oil gallery. Since, the pressure in closed loop force-feed lubrication system is constant, the lubricating oil takes the high pressure/ least resistive path and enters the suction portion oil gallery only and does not enter the outlet towards the radiator input. During this oil flow, if temperature increases, the
15 thermostat actuates to thermostat open state wherein, the wax thermostat element (601b) contained in the cylindrical bore transfers pressure to the thermostat element (601) by means of the pin (601a). The thermostat element (601) being held tightly in position to the thermostat housing (602) moves along with the thermostat element (601) and thus blocking the output to the suction portion oil
20 gallery. This forces the lubricating oil to enter the radiator through the radiator input (305a). The lubricating oil after radiator circulation emerges from the radiator output (305b) and flows towards the suction portion oil gallery (330). On cooling, the initial position of the thermostat housing (602) is obtained by means of biasing force by the elastic member (603).

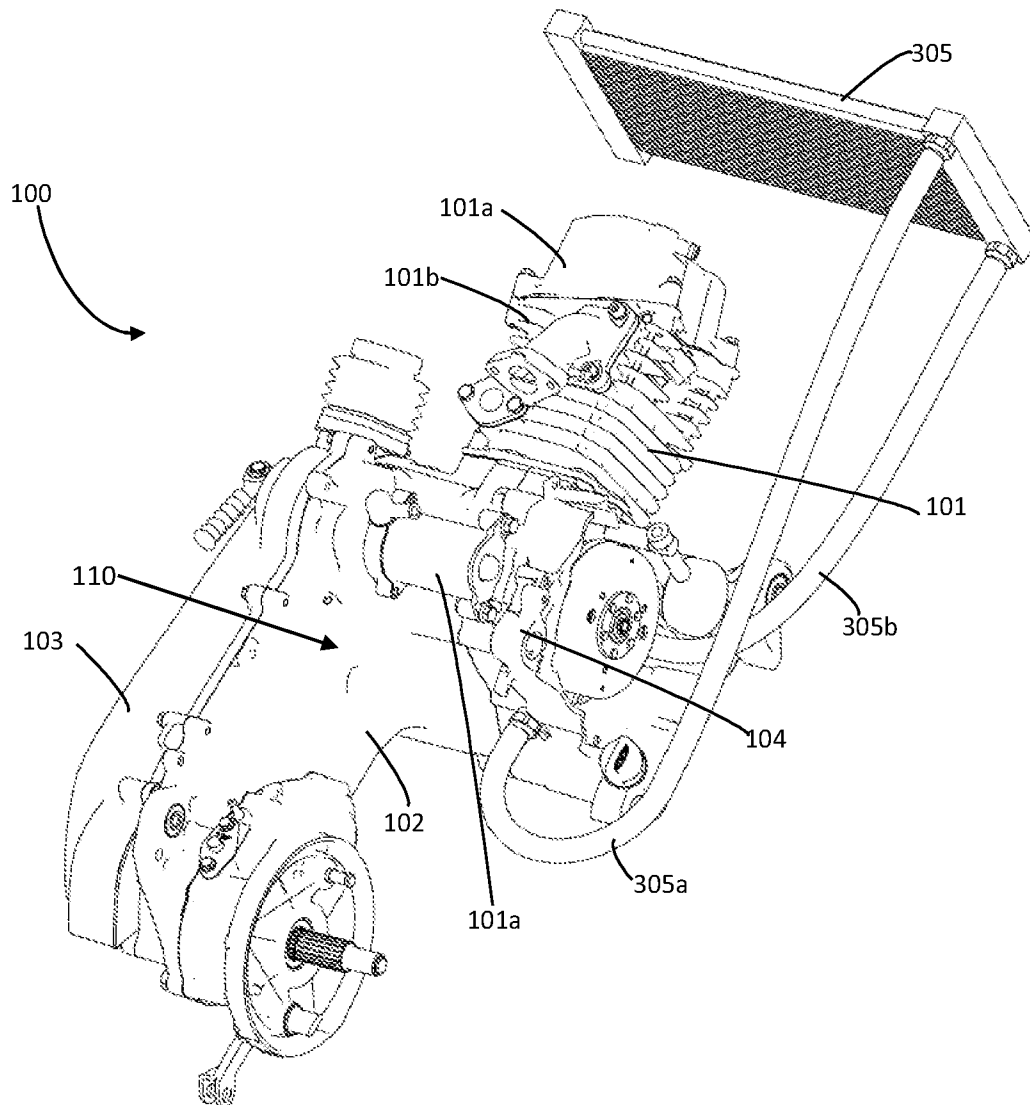
25 [00038] Many modifications and variations of the present subject matter are possible in the light of above disclosure. Therefore, within the scope of claims of the present subject matter, the present disclosure may be practiced other than as specifically described.

We Claim:

1. A forced-feed lubricating system for an internal combustion (IC) engine (100) comprising:
 - an oil reservoir (309), disposed on a lower portion of the IC engine (100);
 - 5 a main-oil gallery circuit (300) supplying oil under pressure to lubricate components of the IC engine (100);
 - said main-oil gallery circuit (300) comprising a suction portion (330) for oil entry from the oil reservoir (309) and a drain portion (340) to drain the oil to the oil reservoir (309) after circulation; and
 - 10 an oil pump (303) driven by the IC engine (100) and supplying oil under pressure to the main-oil gallery circuit (300);
 - an oil-pressure control unit (301) is associated with the main-oil gallery circuit (300) to control the pressure of oil when pressure within the main-oil gallery circuit (300) exceeds a certain predetermined value;
 - 15 said oil-pressure control unit (301) is disposed within a crankcase (110) of the IC engine (100) and upstream of the oil pump (303); and
 - said oil-pressure control unit (301) is configured to control the pressure of oil when it exceeds the predetermined value in the main-oil gallery circuit (300) by bypassing the oil on the drain portion (340) to the suction portion
 - 20 (330) and limiting the suction of oil from the oil reservoir (309) to enable continuous recirculation of oil in the main-oil gallery circuit (300).
2. The forced-feed lubricating system as claimed in claim 1, wherein said drain portion (340) and suction portion (330) is connected by a bypass oil gallery (503), and said oil-pressure control unit (301) is disposed on the bypass oil
- 25 gallery (503).
3. The forced-feed lubricating system as claimed in claim 1, wherein the oil-pressure control unit (301) comprises:
 - a plunger (401) with a pressure receiving surface at one end (401a);

- a housing (402) supporting the plunger (401);
an elastic member (403) connecting the plunger (401) to the housing (402)
and configured to press the plunger (401) in a direction of the far wall;
said plunger (401) and elastic member (403) energized to move and permit
5 oil from the drain portion (340) to flow towards the suction portion (330)
when the oil pressure exceeds the predetermined value.
4. The forced-feed lubricating system as claimed in claim 3, wherein the elastic member (403) is a helical spring, and the stiffness of the helical spring is calibrated according to the predetermined value.
- 10 5. The forced-feed lubricating system as claimed in claim 3, wherein said housing (402) comprises a bung (404) disposed adjacent to said plunger (401) for regulating displacement of said plunger (401).
6. The forced-feed lubricating system as claimed in claim 1, wherein the oil-pressure control unit (301) is coaxially mounted in a first bore (301a, 301b) on a
15 crankcase (110) of the IC engine (100), said first bore connecting the bypass oil gallery (503) to the main-oil gallery circuit (300).
7. The forced-feed lubricating system as claimed in claim 3, wherein the predetermined pressure value is between 1.5 to 2 bar.
8. The forced-feed lubricating system as claimed in claim 1, wherein the wherein
20 the forced-feed lubricating system further comprises a thermostat unit (302) disposed upstream of the oil filter (304), and is configured to control the temperature of oil in the main-oil gallery circuit (300) by diverting the oil to the radiator (305) before recirculating it back to the main-oil gallery circuit (300).
9. The forced-feed lubricating system as claimed in claim 8, wherein the
25 thermostat unit (302) is coaxially mounted in a thermostat bore (302a, 302b) of the crankcase (110) of the IC engine (100) connecting the main-oil gallery circuit (300) to a radiator input (305a) and a radiator output (305b).

10. The forced-feed lubricating system as claimed in claim 8, wherein a thermostat unit (302) comprises:
- a thermostat element (601) configured to be move on exceeding the temperature of oil to a predetermined value, said thermostat element (601) having a wax thermostat element (601b) disposed on its inner periphery which is configured to expand on exceeding a predetermined temperature and causing the movement of the thermostat element (601);
 - a thermostat housing (602) supporting the thermostat element (601);
 - a thermostat elastic member (603) connecting the thermostat element (601) to the thermostat housing (602) and configured to press the thermostat element (601b) in a direction of a peripheral wall of the thermostat bore (302a, 302b); and
 - said thermostat element (601) and thermostat elastic member (603) energized to move, on exceeding a predetermined temperature to divert the oil from the upstream side of the main-oil gallery circuit (300) to the radiator (305) before recirculating it back to the main-oil gallery circuit (300) on the downstream side.
11. The forced-feed lubricating system as claimed in claim 10, wherein the thermostat elastic member (603) is a helical spring, and the stiffness of the helical spring is calibrated according to the predetermined temperature.
12. The forced-feed lubricating system as claimed in claim 10, wherein said first bore (301a, 301b) and thermostat bore (302a, 302b) of the crankcase is located on a rearward side of the IC engine (100) located in close proximity to the oil pump (303).
13. The forced-feed lubricating system as claimed in claim 10, wherein the predetermined temperature is between 70 degrees to 80 degrees centigrade.

**Fig. 1a**

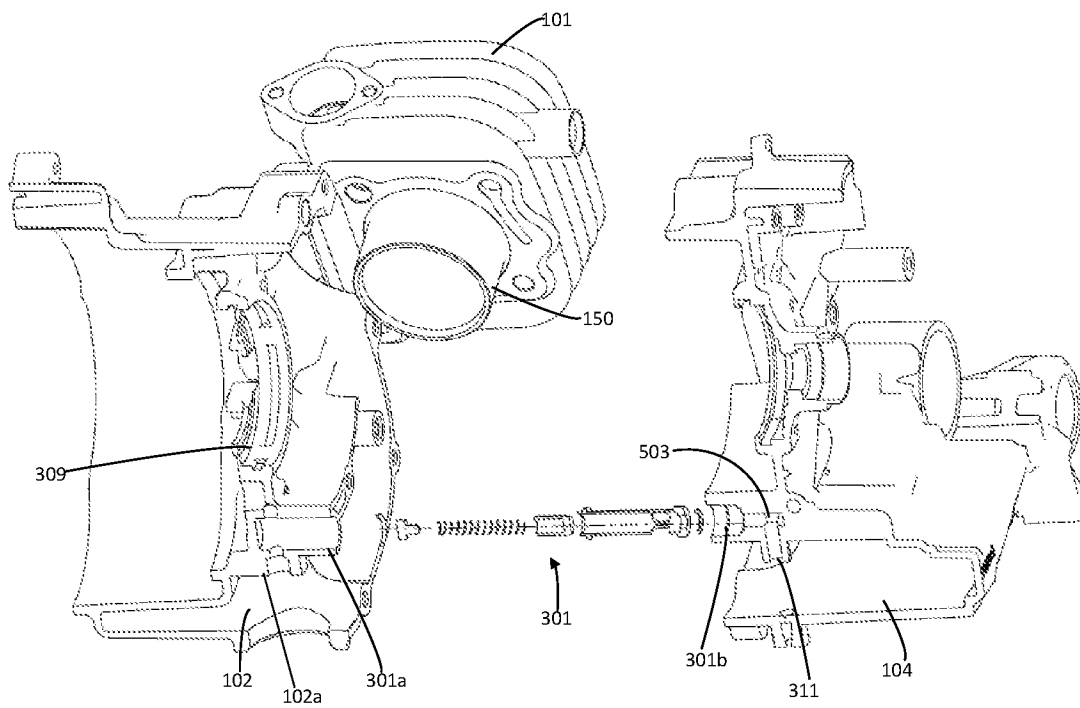


Fig. 1b

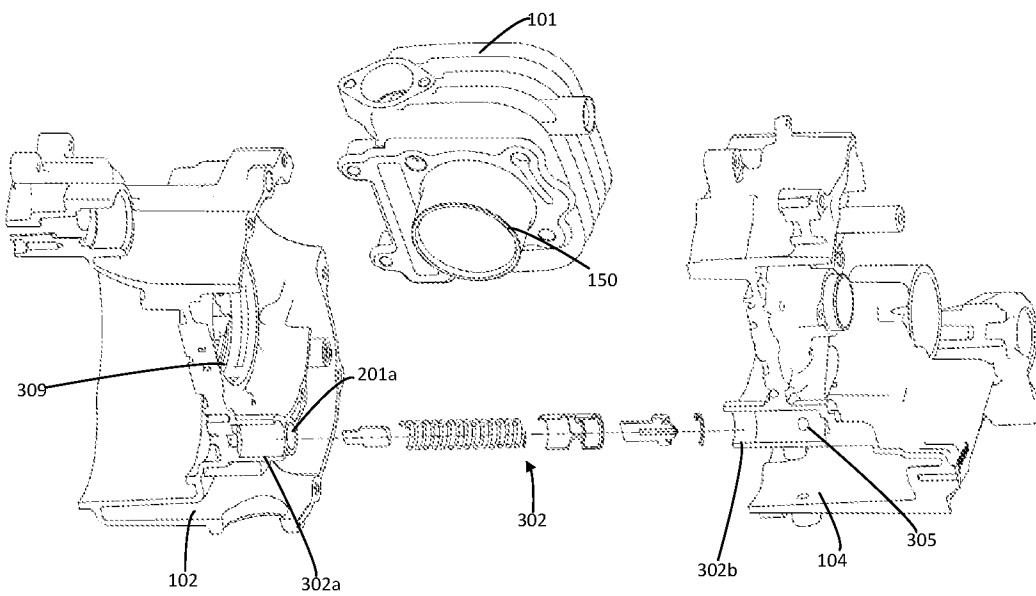


Fig. 1c

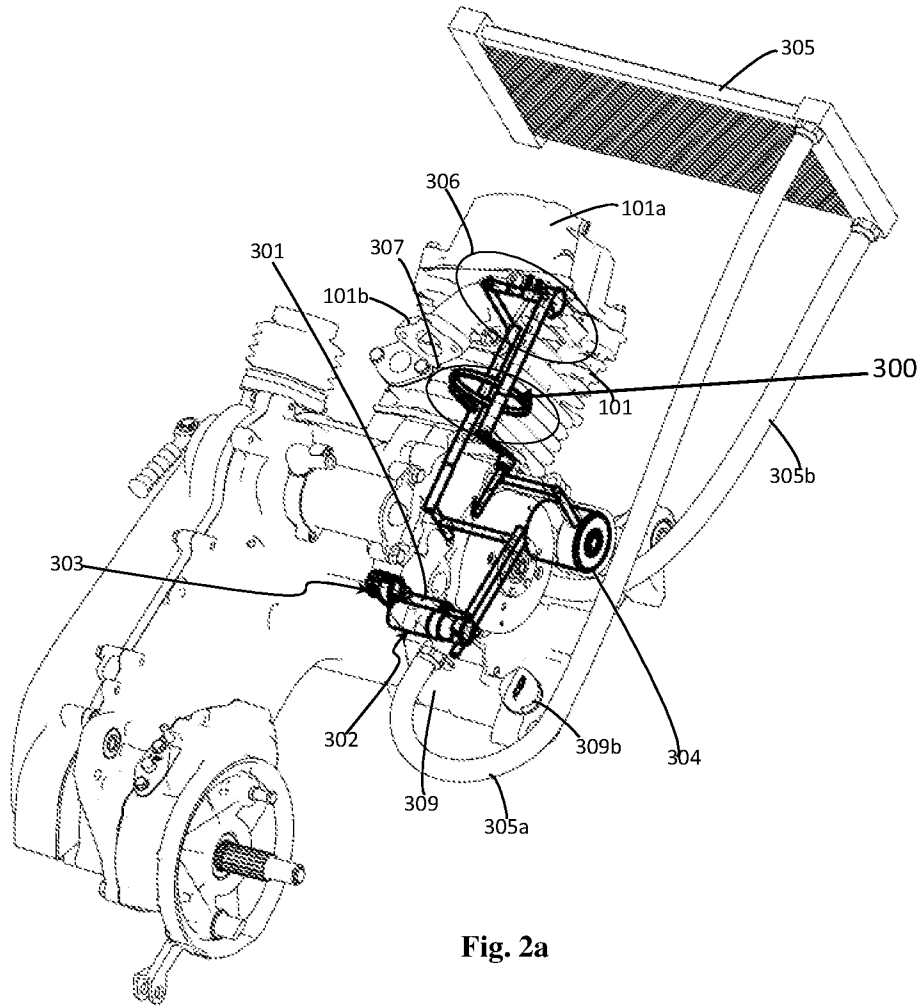


Fig. 2a

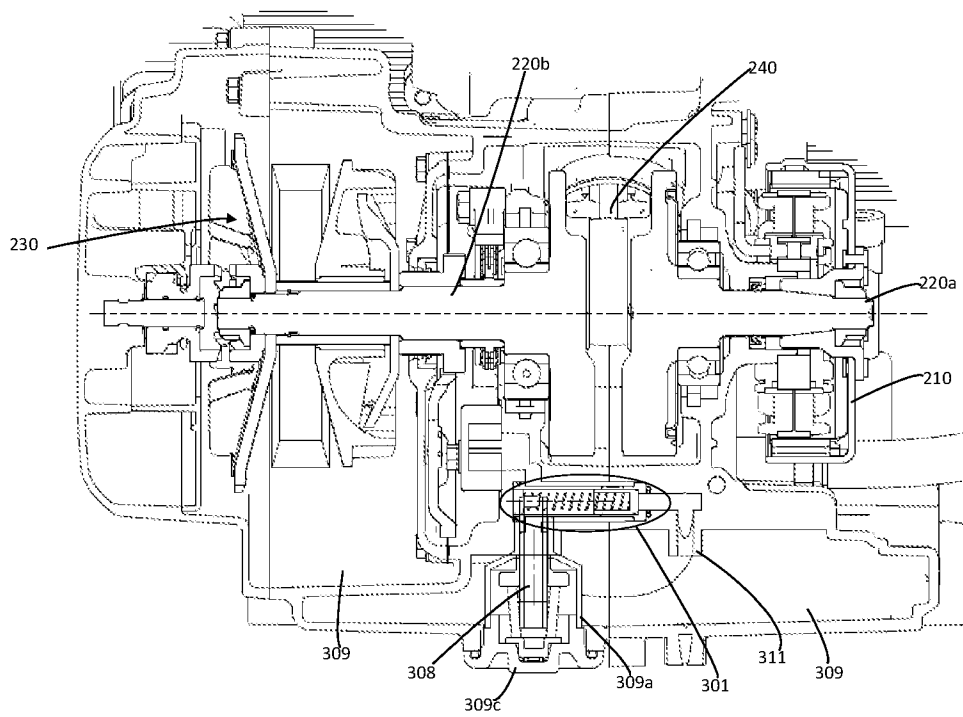


Fig. 2b

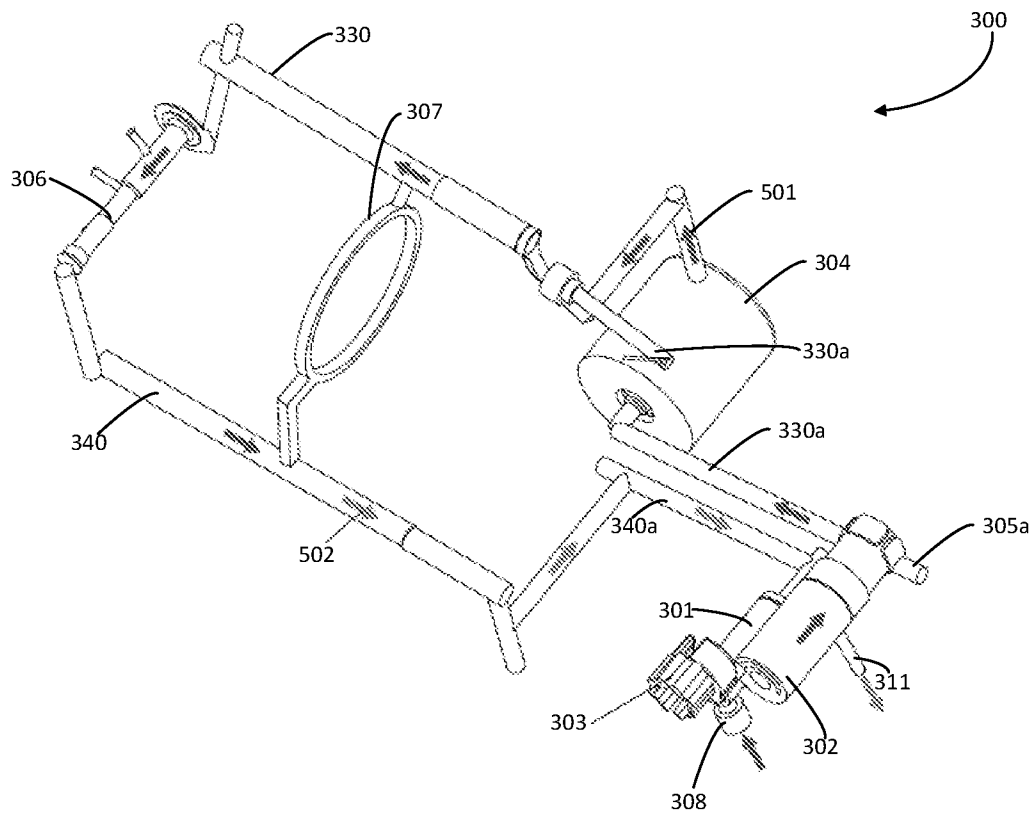


Fig. 3a

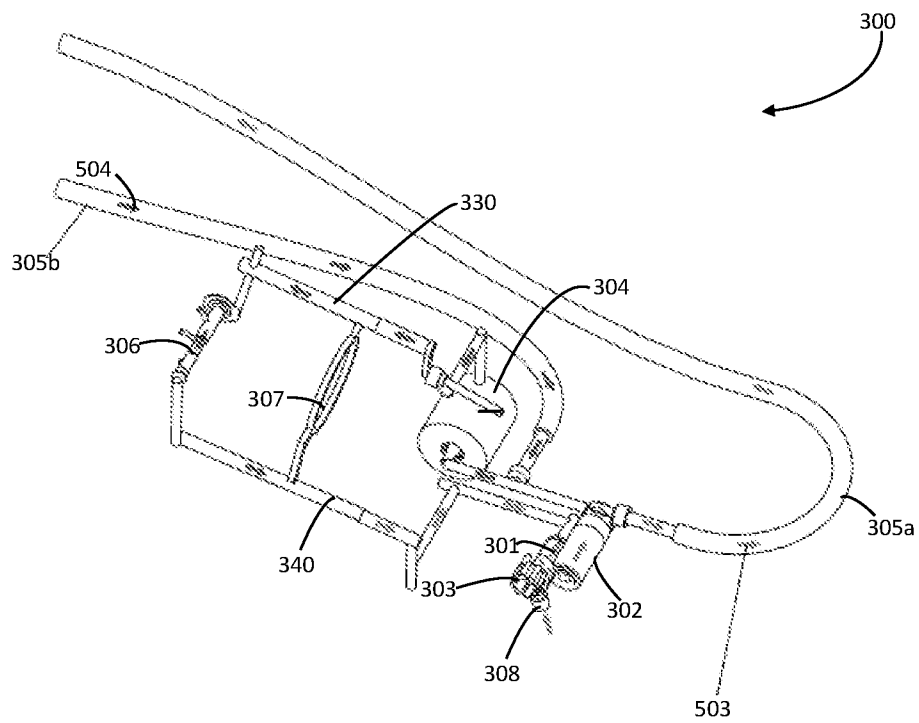
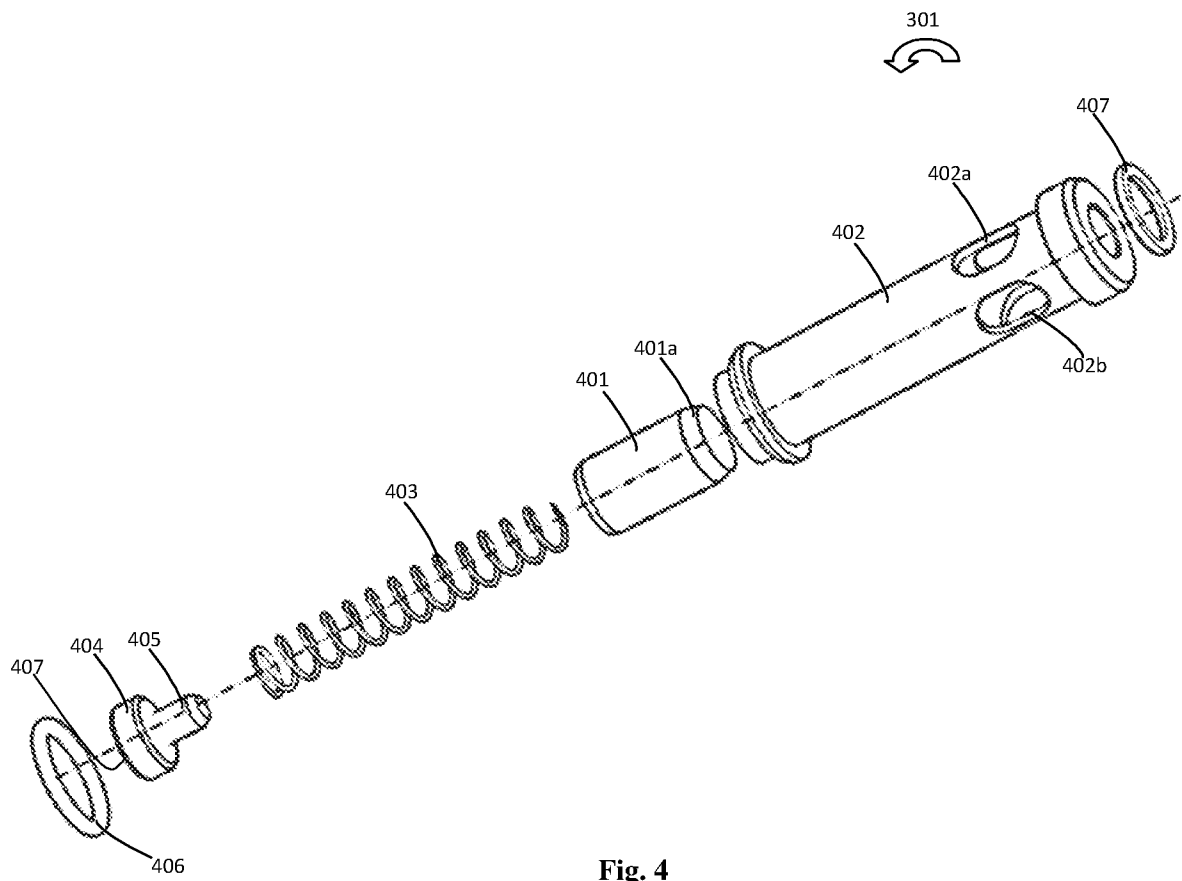
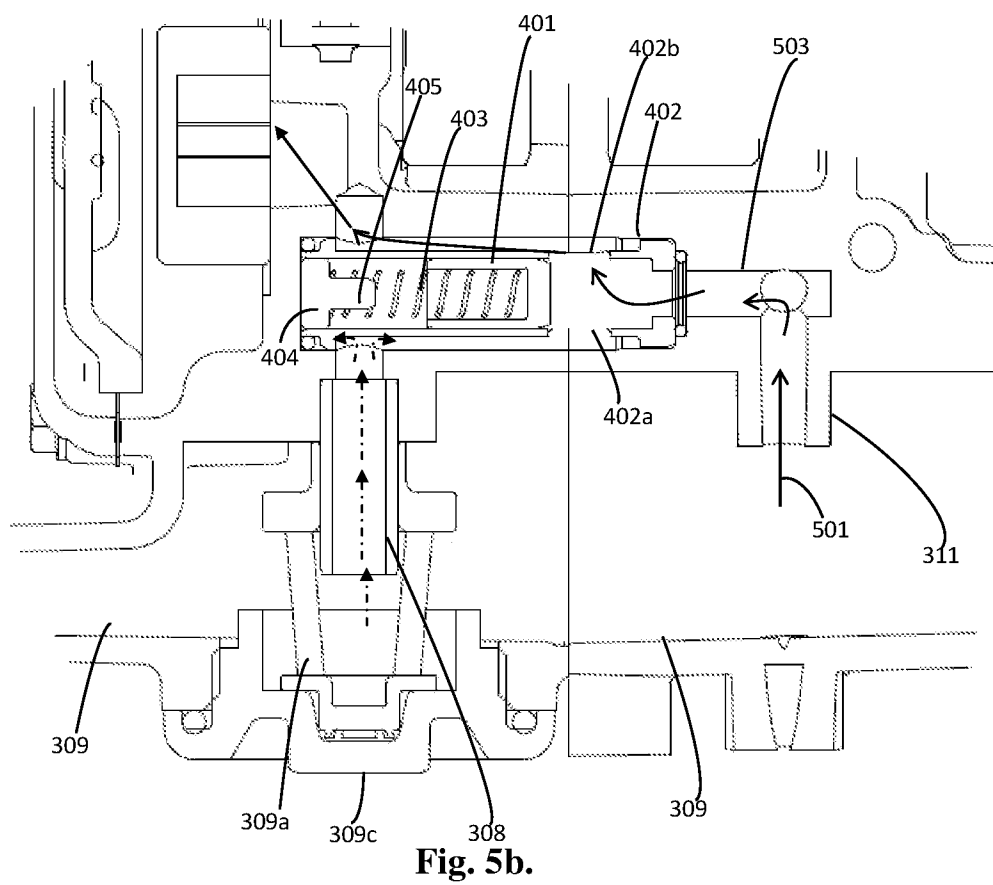
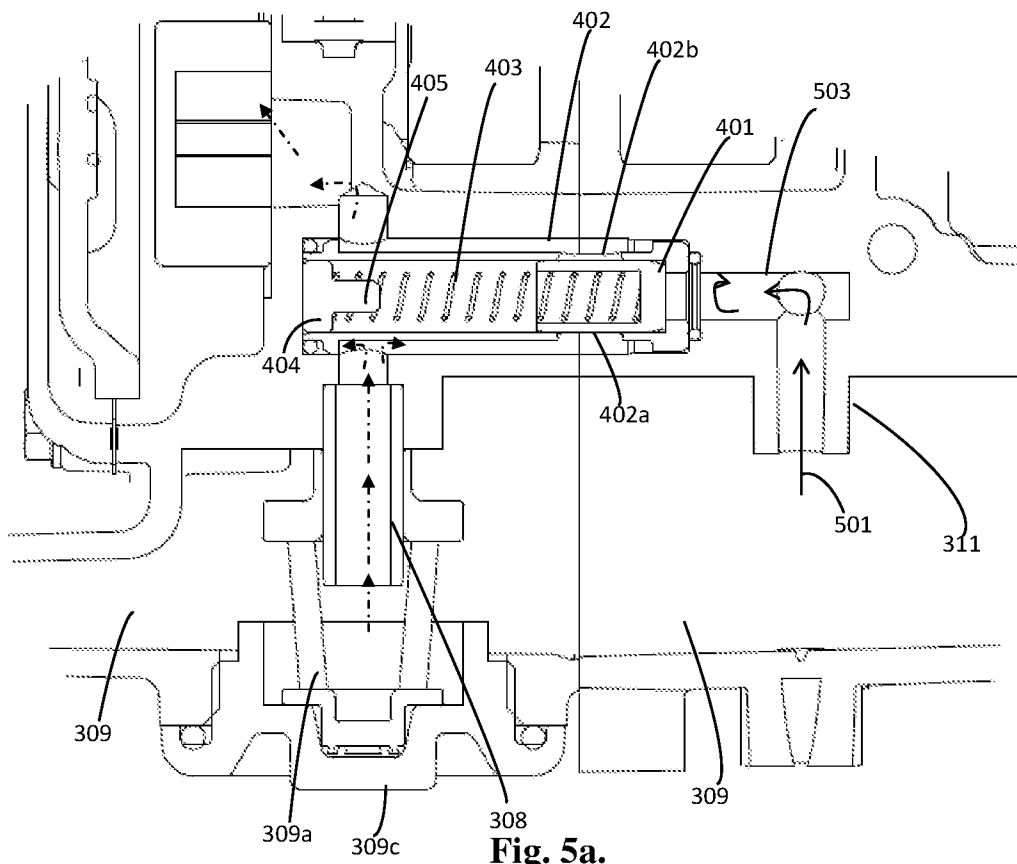


Fig. 3b





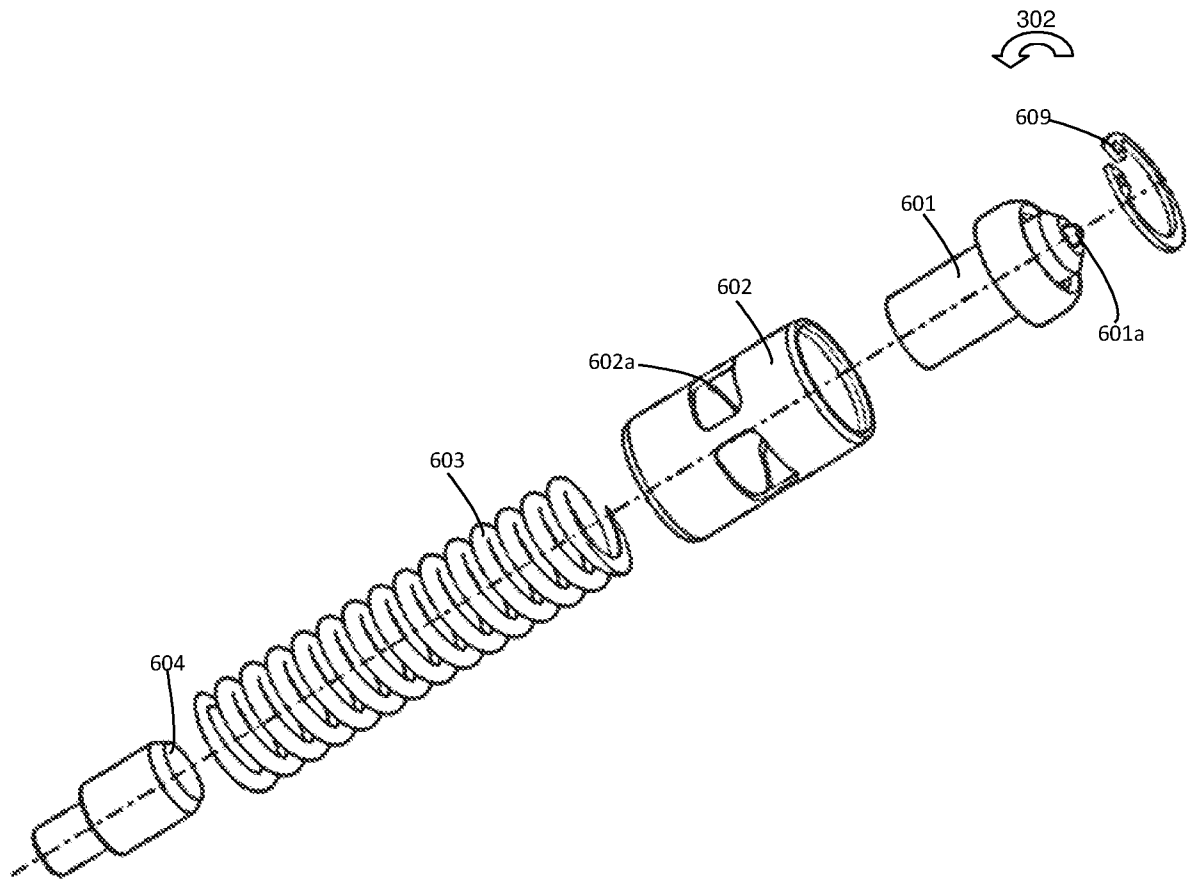


Fig. 6

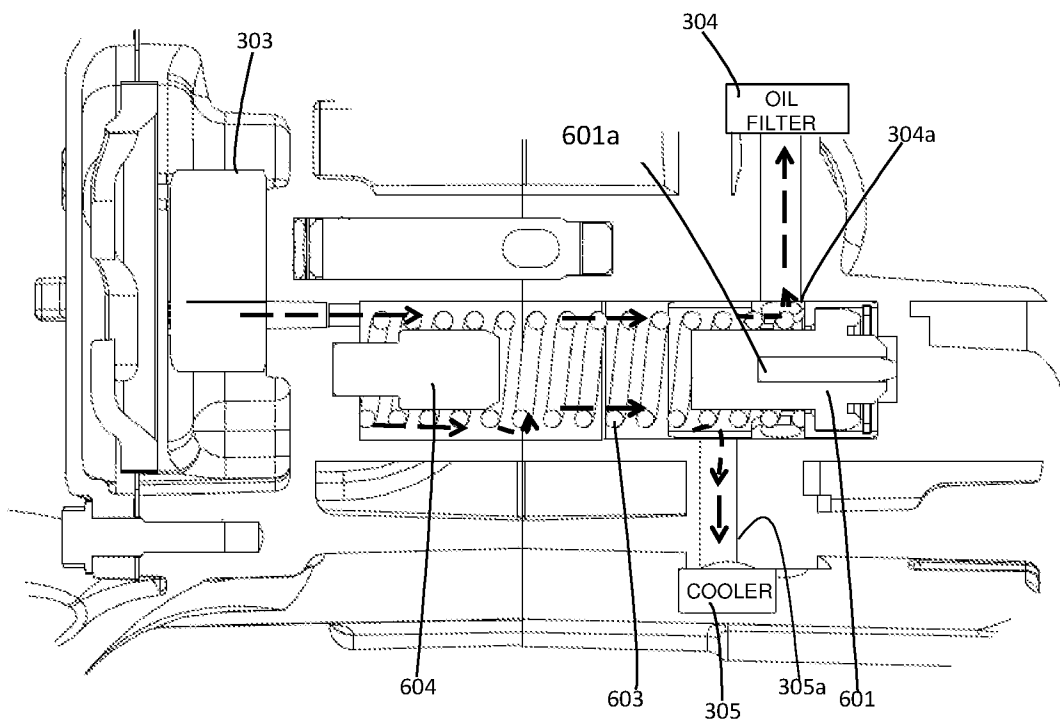


Fig. 7a

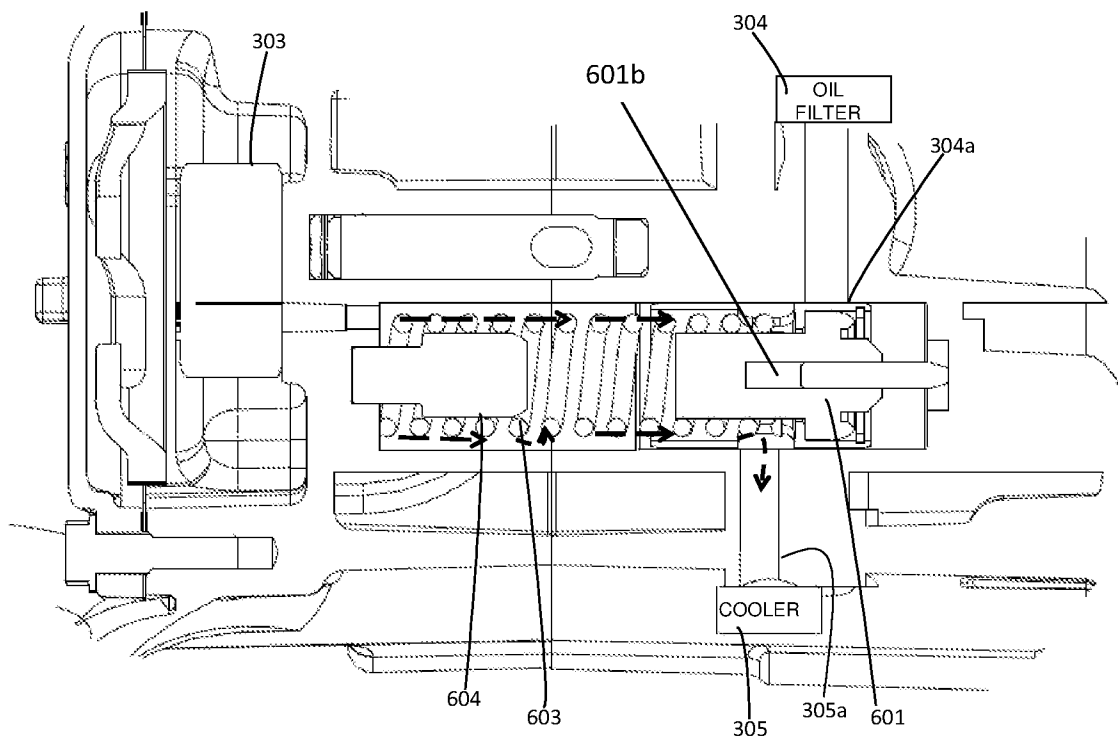


Fig. 7b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2017/055297

A. CLASSIFICATION OF SUBJECT MATTER
F01M1/00 Version=2018.01

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)

F01M1/00

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

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

Patseer, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP2010196636 A (HONDA MOTOR CO LTD) PUBLISHED ON 09 SEPTEMBER 2010 Whole document	1, 2
Y	JP2010196636 A (HONDA MOTOR CO LTD) PUBLISHED ON 09 SEPTEMBER 2010 Whole document	3-13
Y	DE10141786 A1 (PORSCHE AG) PUBLISHED ON 20 MARCH 2003 Para 9-13, 18, 23-25, Abstract, Figures	3-13
Y	DE19938285 A1 (PORSCHE AG) PUBLISHED ON 22 FEBRUARY 2001 Whole document	3-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

10-01-2018

Date of mailing of the international search report

10-01-2018

Name and mailing address of the ISA/

Indian Patent Office
Plot No.32, Sector 14, Dwarka, New Delhi-110075
Facsimile No.

Authorized officer

Ranjan Prakash

Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2017/055297

Citation	Pub.Date	Family	Pub.Date
JP 2010196636 A	09-09-2010	JP 5210206 B2	12-06-2013
DE 10141786 A1	20-03-2003	DE 10141786 B4	24-12-2008
DE 19938285 A1	22-02-2001	DE 1076164 A1	14-02-2001
		EP 1076164 B1	12-01-2005