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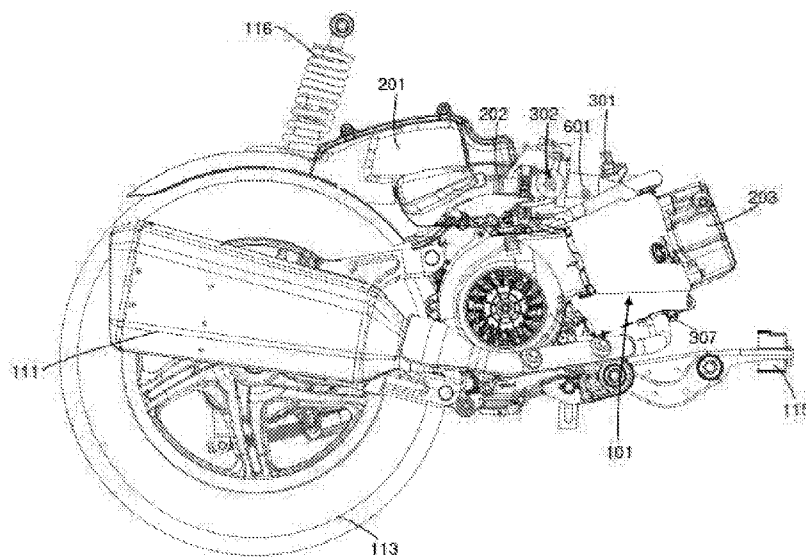


FIG. 2.

(57) Abstract: The cylinder head (204) of an internal combustion engine (101) comprises of two intake valves namely swirl intake valve (308) and tumble intake valve operating within a swirl port (501) and a tumble port (502). Charge is sprayed through a fuel injection valve (301) into the swirl port and the tumble port respectively. A mixing region (620) is facilitated by position of the fuel injection valve, wherein the fuel spray is squirted into the mixing region (620) towards the swirl port and tumble port. The ratio of vertical distance (a) from between the point of fuel spray (P) and base of the port end (Y-Y) and the cross-sectional width (E, F) of at least one of the two intake ports is between 1.5 to 3. The present invention provides charge entry from both the swirl port and the tumble port to ensure adequate charge distribution and avoid undesirable engine noise.



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AN AIR INDUCTION SYSTEM FOR A TWO WHEELED VEHICLE

Technical Field

[1] The present subject matter relates generally to a two or three wheeled saddle type vehicle. More particularly, the present subject matter relates to an intake pipe
5 of an air induction system for the two wheeled vehicle.

Background

[2] An Intake system plays a significant role in an internal combustion (IC) and affects driveability, provides increased mileage and to generates desired and torque. Induction system comprises of pressurised fuel pump, fuel injection
10 valve, ECU, throttle valve, intake pipe, air cleaner and various sensors to provide input to the ECU. The fuel injection valve introduces fuel in metered quantity directly either inside the IC engine or inside the intake pipe in the form of a fuel spray formed by atomization of the fuel through a small nozzle under high Intake system having fuel injection has a lot of advantages like cleaner and
15 complete combustion, minimal loss of fuel, better throttle sensitivity and prevent excess amount of fuel entering the IC engine. Overall, this improves IC engine performance and has better cold start characteristics. The location and orientation of fuel injection valve is very important as it provides advantages in terms of improved combustion, accessibility of the fuel injection valve and ease of
20 connectivity of various inputs to the fuel injection valve. Typically, to improve combustion efficiency and to obtain desirable air fuel mixture combustion characteristics in the IC engine, the IC engine comprises a cylinder head having inlet ports. In a two wheeled vehicle such as a scooter type vehicle having

head with two inlet ports, the mounting and placement of the fuel injection valve is a challenge. However, mounting of the fuel injection valve in an air induction system setup is challenging due to presence of two intake ports and loss of fuel during fuel spray by fuel injection valve into the two intake ports. The two wheeled vehicles having the cylinder head with two inlet ports has the attractive feature of increased mileage and fuel efficiency improved IC engine performance and is of great importance.

Summary of the Invention

- [3] The present invention has been devised in view of the above circumstances.
- 10 [4] An internal combustion engine comprises of a cylinder head. The cylinder head comprises of two intake valves namely swirl intake valve and tumble intake valve operating within a swirl port and a tumble port. Atmospheric air from a throttle body and fuel sprayed through a fuel injection valve enters the swirl port and the tumble port respectively. A short circuiting part forming a mixing region
- 15 facilitates the position of the fuel injection valve, wherein the fuel spray is squirted into the mixing region towards the swirl port and tumble port. To facilitate the mounting of the fuel injection valve, the intake pipe is provided with an injector region having a mounting flange and an opening to allow access of the fuel injector valve. The dimensions of the mixing region of the intake pipe and
- 20 suitably designed such that the ratio of the vertical distance from the end of intake pipe to the tip of the partition wall in the mixing region to the cross-sectional width of at least one of the two intake ports is between **1.5 to 3**.

[5] It is an object of the present invention of providing charge entry from both the swirl port and the tumble port to ensure adequate charge distribution and avoid undesirable engine noise.

[6] Summary provided above explains the basic features of the invention and
5 does not limit the scope of the invention. The nature and further characteristic features of the present invention will be made clearer from the following descriptions made with reference to the accompanying drawings.

Brief Description of Drawings

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

[8] **Fig. 1.** illustrates the left side view of a two wheeled vehicle employing an embodiment of the present subject matter.

[9] **Fig. 2.** illustrates an enlarged & right side view of an internal combustion
15 engine with an air induction system according to one embodiment of the present subject matter.

[10] **Fig. 3.** illustrates the cut sectional view of the internal combustion engine and the intake pipe according to an embodiment of the present subject matter.

[11] **Fig. 4.** illustrates the exploded view of the cylinder head, intake pipe and
20 fuel injection system according to the embodiment of the present subject matter.

[12] **Fig. 5.** illustrates the front view of the cylinder head according the embodiment of the present subject matter.

[13] Fig. 6a. illustrates the isometric view of the intake pipe according to the embodiment of the present subject matter.

[14] Fig. 6b. illustrates another isometric view of the intake pipe according to the embodiment of the present subject matter.

5 **[15]** Fig. 6c. illustrates the front view of the intake pipe according to the embodiment of the present subject matter.

[16] Fig. 7. illustrates the cut sectional view of the intake pipe with the fuel injection system according to the embodiment of the present subject matter.

Detailed Description

10 **[17]** 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
15 be applied to other types of vehicles within the spirit and scope of this invention. 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.

[18] Supply of optimum air and fuel mixture is essential for proper combustion inside the IC engine. If the mixture is not proper (lean mixture or rich
20 mixture) it leads to improper combustion which affects IC engine performance and leads to increase of exhaust emissions. Maintaining proper ratio of mixture of air and fuel is essential and varying this ratio and rate of supply based on IC engine real-time operational data improves the IC engine performance

tremendously. An intake system can essentially be of two types namely, a fuel injection system and carburetor system. The fuel injection system electronically injects and controls the air fuel mixture based on certain parameters determined by various plurality of sensors. The carburetor mechanically controls the air fuel mixture based on the throttle applied by a rider of the two wheeled vehicle. For the IC engine to have smooth drivability, increased mileage, improved power and torque, the intake system and fuel injection system plays a significant role.

[19] Generally, the air induction system comprises an air cleaner, an intake passage, a throttle body, a fuel injection valve and an intake pipe. The air cleaner draws air from the atmosphere and filters it before supplying air to the downstream components. The air cleaner passage directs the air flow from the air cleaner through a throttle body which comprises a venturi through which the air is throttled and a butterfly valve to control the rate of entry of air based on the throttle control by the rider. The throttled air is directed to a plurality of intake ports of the IC engine by the intake pipe. The plurality of intake ports forms the part of a cylinder head of the IC engine which directs air fuel mixture to a combustion chamber. The outlet of the plurality of intake ports is controlled by equal number of intake valves configured to be operably connected to open and close to match the IC engine four cycles. The fuel injection valve is disposed such that, fuel is sprayed to the throttled air in the intake pipe after throttling. The fuel injection valve introduces fuel in metered quantity directly either inside the IC engine or inside the intake pipe in the form of a fuel spray formed by atomization of the fuel through a small nozzle under high pressure. The fuel injection valve

can be mounted on the throttle body or the intake pipe. There are various sensors which determine the IC engine running state and riding conditions and an electronic Control Unit (ECU) adjusts the air fuel mixture based on these inputs. There is a fuel pump which is configured to supply pressurized fuel to the fuel
5 injector so that the fuel can be injected easily. The pressure helps to atomize the fuel at the tip of the fuel injection valve which comes out as a mist of fuel spray. The IC engine running state and riding conditions measured by different sensors are stored in the memory block of the ECU called maps. The ECU is programmed for certain preset modes and fuel delivery quantities when the values are of certain
10 quantity, and the ECU determines how much fuel to deliver based on these quantities. The various sensors are throttle position sensor, idling sensor, crankshaft revolution sensor etc.

[20] Typically to improve fuel efficiency and obtain efficient combustion characteristics inside the combustion chamber the motion of air fuel mixture inlet
15 inside the combustion chamber plays an important role and the combustion characteristics are affected depending on the type of air fuel mixture inlet. The type and direction of air fuel mixture inlet depends on the profile and geometry of the inlet port. It is desirable to obtain swirl motion of the air fuel mixture at lower ranges of engine revolutions and tumble motion of the air fuel mixture at higher
20 engine revolutions. It is further desired that inlet motion of air fuel mixture has combined swirl and tumble motion due to which the IC engine is able to extract the combined advantages of both swirl motion and tumble motion at all ranges of engine revolutions. The swirl motion and tumble motion of the air fuel mixture

cannot be achieved in single port. Hence, a two intake port cylinder head for an IC engine is known in prior art in which two different intake ports will assist air fuel mixture for swirl motion and tumble motion in each intake port. The port geometry (direction and curvature) determines the direction of air fuel mixture entry to the combustion chamber. The swirl port opening is at the centre of cylinder head bore and tumble port opening is offset from the centre of the cylinder bore and placed beside one above the other.

[21] There are many designs for air induction system in supplying air fuel mixture to IC engines having two intake ports (swirl port and tumble port). One such design involves use of a split intake pipe connecting the throttle body to the two intake ports. The intake pipe has a partition wall which divides the flowing air path into two separate paths which can supply smooth and turbulent free flow of air and fuel to the two intake ports. In this regard, controlled burn rate concept is also used. Controlled Burn Rate is a port deactivation concept wherein turbulent kinetic energy of air fuel mixture is created at the correct time and place in the combustion chamber and a rapid and stable combustion occurs which allows to run the engine well above a Lambda Excess Air Ratio of **1.5**. This provides low exhaust gas emissions and good fuel economy. The two different intake ports, one swirl port and one tumble port is used to obtain controlled burn rate. Additionally, the throttle body is used for port deactivation. At part loads and lower engine speeds the tumble port is disconnected and only swirl port is activated. Further, due to optimum position of spark plug, lean burn with no difference in performance and fuel economy can be obtained.

[22] Hence, during part load operations, the butterfly valve in the throttle body is designed to allow air fuel mixture only through one of the paths in the intake pipe to supply air fuel mixture only to swirl port. During, full throttle operation, air fuel mixture is allowed to enter both the paths. In this manner, efficient operation in all ranges of throttle position can be obtained. However, implementing fuel injection is essential to obtain optimum velocity of air, provide fuel spray to both the paths of the intake pipe and in addition ensure fuel is injected as close to the intake port as possible, and the fuel spray path in each intake port should be such that wall wetting is minimized. A fuel injection system for such a cylinder head is challenging, mounting is difficult, lesser accessibility and difficult to accommodate it in the existing vehicle layout.

[23] Further, in cylinder head with three ports (two intake ports and one outlet port) usually a centre spark plug is used. But, during part throttle condition, air fuel mixture enters from only one port (swirl port), and hence combustion occurs only one side, while there is late combustion on the tumble port side. This creates undesirable engine noise. Hence, to ensure adequate charge distribution, it is desirable to permit some air fuel mixture through the tumble port.

[24] Hence, in order to implement fuel injection system in such a two wheeled vehicles, various models of fuel injection valve mountings are proposed in art. Typically, one solution is to provide two fuel injection valves to direct air fuel mixture into two different intake ports. Such designs have the drawbacks of use of additional fuel injection valves, increased complexity of mechanism and use of different ECU maps to control two fuel injection valves, and increased capacity of

fuel pump. Replacing two fuel injection valves with single fuel injection valve is difficult due to inherent drawbacks of providing fuel spray to both the intake ports effectively. The vehicle layout constraints due to space limitations in various frame designs and vehicle layouts, makes the mounting and locating the fuel injection valve and throttle body in two wheeled vehicles such as one described in the preceding paragraphs a challenging task.

[25] Hence, to obviate the problems associated with the above design of the intake port, the current invention discloses the intake path equipped with a short-circuited region by removing a small portion of partition wall separating them right before the valve in the fuel-air intake passage itself. Further, the intake pipe is designed to accommodate a fuel injection valve positioned to squirt fuel. This allows the fuel to be sprayed in proportion directly to each of the two intake ports. At the entrance of each port the charges mix efficiently and create uniform charge distribution. Additionally, even during part throttle operation, air fuel mixture enters both swirl and tumble ports. Hence, it serves dual functionality of making the start of combustion early and helps in noise reduction while adopting fuel injection. The described invention relates to adapting a fuel injection system in the intake pipe in a split intake pipe design. Secondly, the short-circuiting of the otherwise separate streams that helps in supplying adequate fuel to the tumble port that is normally non-operational during part throttle condition. This ensures near uniform charge inside the cylinder. In addition, this ensures that the charge flow is adequate near the central spark plug tip. This helps in earlier, faster and complete

combustion, thereby reducing chances of knocking and helps to make combustion much leaner by allowing further ignition advances.

[26] With the above design changes, the following advantages can be obtained such as improved performance with fuel injection system, minimal fuel wall wetting in intake port while injecting fuel, improved IC engine performance, better fuel efficiency, and lesser exhaust emissions. Additionally, minimal layout changes are required to accommodate the fuel injection valve and throttle body. Further, fuel pressure loss to fuel injection valve is minimal. Also, the serviceability and accessibility of fuel injection valve and throttle body is easier and permits easy tool movement, and access to connecting members access (such as fasteners). Further, two types of fuel injection valves can be used. In the present embodiment, single fuel spray is squirted from the fuel injection valve which gets divided by the wall of the cylinder head. In another embodiment twin spray type fuel injection valve can be used which squirts the fuel in two different angles at different directions.

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

[28] Fig. 1 illustrates the two wheeled vehicle in accordance with one embodiment of the present invention. The vehicle comprises of a frame assembly which is conventionally an underbone chassis frame which provides a generally open central area to permit "step-through" mounting by a rider. Typically, the frame assembly comprises of a head tube (102), a main tube (107), and a pair of

side tubes **109** (only one shown). The two wheeled vehicle extends from a front portion (F) to a rear portion (R) in a longitudinal axis. The head tube (**102**) is disposed towards the front portion (F). The main tube (**107**) extends downwardly and rearwardly from the head tube (**102**) forming a flat horizontal

5 step-through portion (**117**). The other end of the main tube (**107**) is connected with the pair of side-tubes (**109**) through a bracket (not shown). The head tube (**102**) is configured to rotatably support a steering tube (**104**) and further connected to the front suspension system (**121**) at the lower end. A handlebar support member (not shown) is connected to an upper end of the steering tube

10 (**102**) and supports a handlebar assembly (**106**). Two telescopic front suspension system **121** (only one is shown) is attached to a bracket (not shown) on the lower part of the steering tube (**104**) on which is supported the front wheel (**119**). The upper portion of the front wheel (**119**) is covered by a front fender (**103**) mounted to the lower portion of the steering shaft (**104**). The pair of side-tubes (**109**)

15 extends from the other end of the main tube and are disposed parallel on either side of the vehicle width direction. Each of the said side tube (**109**) includes a down frame section (**109a**) inclined and extending from the main tube (**109**) and gradually after a certain length extending rearward in a substantially horizontal direction to the rear of the vehicle. A plurality of cross pipes (not shown) is

20 secured in between the pair of side-tubes (**109**) at selected intervals to support vehicular attachments including a utility box (not shown), a seat assembly (**108**) and a fuel tank assembly (not shown).

- [29] A seat (108) is supported on the pair of side-tubes (109) on which a rider may sit. Generally, the utility box (not shown) is supported between the front portions of the left and right end of the pair of side-tubes (109) so as to be disposed below the seat (108). A fuel tank assembly (not shown) is disposed on
- 5 between the rear portions of the pair of the side-tubes (109). There is front brake (not shown) and rear brake (114) arranged on the front wheel (119) and a rear wheel (113) respectively. The rear wheel (113) is supported towards the rear side of the frame by the internal combustion (IC) engine (101) which is horizontally coupled swingably to the rear of the frame assembly of the two wheeled vehicle
- 10 through a rear suspension system (not shown). The IC engine transfers the drive directly to the rear wheel (113) as it is coupled directly to it through a continuously variable transmission (CVT) system. The IC engine comprises CVT system, said CVT system disposed leftward of the IC engine (101) in the vehicle width direction.
- 15 [30] Fig. 2 illustrates the side view of the rear portion of the two wheeled vehicle illustrating the IC engine swingably supported to the pair of side tubes (109) in accordance with the embodiment of the present subject matter. Further, Fig. 2. illustrates the air induction system supplying air fuel mixture to the IC engine. The air induction system comprises an air cleaner (201), an air cleaner
- 20 passage (202), a throttle body (302), an intake pipe (601) and the fuel injection valve (301). The air cleaner (201) is on the rear portion (R) of the two wheeled vehicle above the rear wheel (113) and the direction of air flow is from the rear portion of the two wheeled vehicle to the front portion. The throttle body (302) is

disposed advantageously in the space formed below the storage box and above the crankcase of the IC engine (101). The air cleaner passage (202) connects the air cleaner (201) outlet to the throttle body (302). The entire arrangement is assembled to have ease of accessibility in assembling and disassembling as it permits tool movement to access clips tightened by the screwdriver once the utility box is removed. The intake pipe (204) connects the throttle body (302) to the cylinder head (not shown). The fuel injection valve (301) is suitably disposed on the intake pipe (601) and it is this mounting of the fuel injection valve (201) which is an important aspect of the present subject matter.

10 **[31]** Fig. 3 illustrates a cut section of the IC engine (101) showing the main components of the IC engine (101) and representatively illustrates the entry of fuel by the fuel injection system according to the embodiment of the present subject matter. The IC engine (101) comprises a cylinder block (205) on which a cylinder head (204) is disposed forming a combustion chamber (306) at the
15 junction. Air fuel mixture is burnt in the combustion chamber (306) which causes a piston (not shown) to reciprocate within the cylinder block (205) and transfers mechanical energy to a rotatable crankshaft (not shown) which generates power due to the slider crank mechanism. The cylinder head (204) comprises of two intake valves namely swirl intake valve (308) and tumble intake valve (not
20 shown) operating within the swirl port (501) and the tumble port (502). The valves are operated by means of rocker arms (310) actuated by a camshaft (309). Generally, the swirl intake valve (308) and tumble intake valve are actuated by a single rocker arm. A cam-chain (not shown) operably connects the rotatable

crankshaft (not shown) and camshaft (309) to drive the it in the cylinder head (204). Atmospheric air from the throttle body (302) and fuel sprayed through a fuel injection valve (301) enters the swirl port (501) and the tumble port (502) respectively. The cylinder head (204) also comprises an exhaust port (307) whose
5 end facing the combustion chamber (306) is controlled by the exhaust valve (not shown) and the exhaust port (307) directs the exhaust gases out of the combustion chamber (306) to a muffler (111) which is connected to the outer portion of the cylinder head (204). In the embodiment of the present invention, the engine operates in four cycles namely, intake stroke, compression stroke, power, and
10 exhaust stroke. Combustion of air fuel mixture occurs at the end of compression stroke and beginning of power stroke. After combustion, exhaust gases are generated which are expelled out of the cylinder block (204) during the exhaust stroke.

[32] In the exemplary embodiment, the throttle body (302) comprises a
15 throttle housing (not shown), idle air controlled valve (302b), a throttle position sensor, and throttle control system. The throttle housing comprises a housing having a venturi used for throttling inlet atmospheric air flowing towards the IC engine (101) under pressure. A butterfly valve (not shown) is disposed downstream of the venturi which can be swiveled about an axis. Controlling this
20 swivel, the control of air towards the first path (602) or both the first path (602) and second path (603) can be controlled. The idle air control valve (302b) comprises an electronic actuator and a separate idle air flow circuit which is used to control and maintain idling state of the IC engine (101). The throttle position

sensor (in an exemplary embodiment, working on the principle of Hall Effect) is capable of detecting the real-time positions of the throttle state and transmits the signals to a control unit (not shown).

[33] Fig. 4 illustrates the exploded view of the cylinder head, intake pipe and fuel injection system according to the embodiment of the present subject matter. The intake pipe (601) is placed on the cylinder head intake mounting face (204a) of the cylinder head (204). An insulator pad (304) is placed between the intake pipe (601) and the cylinder head intake mounting face (204a). The insulator pad (304) acts as a flame trap preventing the transfer of flame and heat from the combustion chamber (306) back to the intake pipe (601). The intake pipe (601) comprises a port flange (608) which has threaded holes (608a). The port flange (608) has a profile that matches with the surface of the cylinder head intake mounting face (204a) when assembled, and the threaded holes (608a) match corresponding thread holes on the insulator pad (304) and cylinder head intake mounting face (204a) through which fasteners can be inserted.

[34] Fig. 5. Illustrates the side view of the cylinder head (204) according to the embodiment of the present subject matter. The cylinder head (204) comprises a cylinder head intake mounting face (204a) on one side facing the top of the two wheeled vehicle whose surface is capable of receiving the intake pipe (601). The cylinder head (204) includes two intake ports namely, swirl port (501) and tumble port (502), that control the flow of the air-fuel mixture into a combustion chamber (306), and whose opening are defined on the cylinder head intake mounting face (204a). The tumble port (502) opening is placed offset from the swirl port opening

(501) and disposed above the swirl port (501) opening. The swirl port (501) runs parallel to the tumble port (502) separately up to the combustion chamber (306). The swirl port (501) and tumble port (502) opening have an oval shape while the exit at the combustion chamber (306) is circular. This oval shape increases the surface area of the port opening to allow inlet of more air and fuel while occupying lesser space on the cylinder head intake mounting face (204a). The swirl port (501) is designed to have a profile with stronger curvature as compared with the profile of the tumble port (502), but the swirl port (501) has a lower inclination towards the valve axis.

10 [35] Fig. 6a. illustrates a front isometric view, Fig. 6b. illustrates a side isometric view, Fig. 6c illustrates a front view, and Fig. 7 illustrates a cross sectional view of the of the intake pipe (601) according the embodiment of the present invention. The short circuiting pocket as described in the current invention is located in the bent portion of intake pipe so that larger droplets of fuel, due to centrifugal effect enters into the tumble port and make swirl port flow leaner than usual and free of larger droplets, This helps to reduce loss of fuel due to fuel sticking onto cylinder walls and helps in scraping down the fuel to oil sump by oil control ring on the piston, while charge is in swirl motion inside the cylinder, This short circuiting pocket also reduces carbon monoxide and NOx emission, knocking, fuel loss, oil dilution. While tumble port flow, which otherwise gives no flow during part throttle, will carry the remniscent fuel and burn completely to yield better combustion. The present invention is also applicable where the intake pipe is straight. In IC engine (101) with straight intake pipe, the centrifugal action

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would be absent, but there also, tumble action is significantly improved. The short circuiting pocket created is just adequate to allow a small amount of charge through tumble port (502) and remaining through the swirl port (501) during part throttle condition. This helps achieve better low-end torque due to sufficient
5 turbulence created inside the combustion chamber (306) and combustion efficiency is improved.

[36] Swirl port (501) creates swirl motion in the charge while it enters the combustion chamber (306) from the first path (602) of the intake pipe (601). Tumble port (502) creates tumble motion in the charge while it enters the
10 combustion chamber (306) from the second path (603) of the intake pipe (601). The air from the throttle body (302) is divided when the flow exits the throttle body (302) and enters the intake pipe (601). The air is then maintained in separate streams due to the partition wall (604) until they get mixed inside the combustion chamber (306), except for the mixing region (620) on the separation in partition
15 wall (604) on the intake pipe (601). The contact between the butterfly valve inside the throttle body (302) and the partition wall (604) during part throttle conditions ensures that there is no charge flow in the second path (603) of the intake pipe (601). After the throttle position rises past the partition wall (604), charge is allowed to enter the second path (603). This effectively ensures that the swirl port
20 (501) alone is operational during part throttle conditions and both ports are operational during higher and full throttle positions.

[37] The short circuiting pocket provides a bypass between those two streams, the flow may not be completely exclusive of each other. Near the interface of

intake pipe and cylinder head intake mounting face (204a), the port end (610) of the intake pipe is provided with a cut/passage on its partition wall. This allows the charge to be bypassed from the first path (602) to the second path (603) especially during lower part throttle operation. Spark plug (305) is mounted on cylinder head (204) so that the tip of spark plug is central to the combustion chamber (306). Otherwise, without bypass cut, there have to be two spark plugs offset in the opposite direction to the centre. During lower part throttle conditions, the charge enters the cylinder through bottom swirl port (501). Due to the short circuiting region, some amount of charge also enters through tumble port (502). The charge flow from tumble port (502) reaches the central spark plug more easily than the swirling charge does. This ensures that the combustion starts early, flame propagates faster, and combustion is complete because of more uniform air-fuel mixture. In addition, this enables advancing of ignition timing without knocking and lean burning to have lower Brake Specific Fuel Consumption (BSFC) etc.

[38] The short circuiting part forming the mixing region (620) facilitates the position of the fuel injection valve, wherein the fuel spray is squirted into the mixing region (620) towards the swirl port (501) and tumble port (502). To facilitate the mounting of the fuel injection valve (301), the intake pipe (601) is provided with a injector region (605) having a mounting flange and an opening to allow access of the fuel injector valve (301). The dimensions of the mixing region (620) of the intake pipe (601) and suitably designed such that the ratio of the vertical distance (D) from the end of intake pipe (601) to the tip of the partition

wall (604) in the mixing region (620) to the cross-sectional width of the any of the two intake ports E & F (501 & 502) is between 1.5 to 3.

[39] Fig. 3 and Fig. 7 illustrates the fuel spray path taken when the fuel injector is arranged in the intake pipe (601) to direct fuel in the embodiment of the present subject matter. In the present engine layout, the IC engine is inclined such that its cylinder bore axis is at an angle between 0° to 15° inclination with respect to the horizontal. The swirl port (501) and tumble port (502) is facing upper direction of the two wheeled vehicle. The intake pipe (601) is so designed to enable the position and mounting of the fuel injection valve (301) and is one of the important aspects of the present subject matter. The fuel injection valve (301) is mounted angularly at a predetermined angle (θ) to the horizontal plane Y-Y to achieve the fuel spray target on both the swirl port (501) and tumble port (502). In one embodiment, the fuel injection valve (301) is placed at the predetermined angle (θ) of between 75° to 88° to the vehicle horizontal axis (Y-Y). The fuel injection valve (301) is of single fuel spray type that can squirt fuel spray in one angular direction. In one embodiment the angle of squirt is in the range 8° to 15° from the fuel tip.

[40] Further, the injector tip (P) is disposed at a predetermined vertical distance (a) from the cylinder head intake mounting face (204a) such that, the ratio of the vertical distance (a) between the tip of the fuel injection valve (301) and the port end (608) and the cross-sectional width E & F of the any of the two intake ports (501 & 502) is between 2.5 to 3, and the extrapolation of the fuel injector axis (X-X) does not intersect the partition wall (604). This ratio helps in

directing the fuel injection to the port end (608) to enter both the swirl port (501) and tumble port (502) efficiently & in a required manner. The fuel injection valve is disposed in that position on the intake pipe (204) such that fuel spray is optimized so that the fuel spray target is on a sharp edge element (304a) of the insulator pad (304) to divide a fuel spray cone (606) from the fuel injection valve (301) to enter both the swirl port (501) and tumble port (502). The fuel injection valve (301) is also mounted on the end of a curved portion (621) of the intake pipe (601) such that the fuel spray travels the shortest distance to reach the outlet of the swirl port (501) and tumble port (502) with minimum wall wetting. The intake pipe (601) has a nonlinear curved profile and divided into a curved portion (621) and straight portion (622), and wherein the curved portion extends from the port end (608) to the tip of the fuel injection valve (301), and substantially straight portion (622) extends from the tip of the fuel injection valve (301) to the throttle end (607). The intake pipe (601) has the partition wall (604) disposed such that, the width (B) of the first path (602) at the throttle end (607) is greater than the width (A) of the first path (602) at the port end (608), and wherein the width (H) of the second path (603) at the throttle end (607) is lesser than or equal to the width (G) of the second path (603) at the port end (608) whereby the partition wall (604) is biased more towards first path (602) than the second path (603).

[41] 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. An internal combustion (IC) engine (101), the internal combustion (IC) engine (101) comprising:

a cylinder head (204);

the cylinder head (204) comprising two inlet ports (501, 502) separated by a cylinder partition wall (503), and said two intake ports (501 & 502) configured to direct air fuel mixture inside the IC engine (101);

an air cleaner (201) disposed rearward of the IC engine (101);

an intake system connecting the air cleaner (201) and the two intake ports (501, 502), said intake system comprising:

a throttle body (302) configured to control air flow rate drawn from the air cleaner (201);

an air cleaner passage (202) connecting the air cleaner (201) and to the throttle body (302);

an intake pipe (601) disposed downstream of the throttle body (302) connecting the throttle body (302) to the two intake ports (501, 502); the intake pipe (601) has a nonlinear curved profile with a throttle body end (607) and a port end (608); said intake pipe (601) comprising a partition wall (604) which divides the intake pipe (601) into a first path (602) and a second path (603) and

the throttle body end (607) of the intake pipe (601) is connected to the throttle body (302) and the port end (608) of the intake pipe (601) is connected to the cylinder head (204) whereby the partition wall (604) of the intake pipe (601) and the cylinder head partition wall (503) are in tandem,

characterized in that:

the first path (602) and second path (603) supplies air fuel mixture to each of the two intake ports (501 & 502) on cylinder head (204) respectively and said intake pipe (601) being provided with a mixing region (620) through at least one relief provided in the partition wall (604);

the intake pipe (601) has a fuel injector valve (301) mounted on the intake pipe (601) along a fuel injector axis (X-X), said fuel injector valve (301) configured to direct fuel inside the two intake ports (501, 502) through the mixing region (620); and

said fuel injection valve (301) is mounted to have a ratio of the vertical distance (a) between the point of fuel spray (P) and base of the port end (Y-Y), and the cross-sectional width (E, F) of at least one of the two intake ports (501 & 502) is between 1.5 to 3.

2. The internal combustion (IC) engine (101) as claimed in claim 1, wherein said fuel injection valve (301) is mounted to have the fuel injector axis (X-X) at a predetermined acute angle (θ) with reference to a base of the port end (Y-Y), and wherein the fuel injector axis (X-X) does not intersect the partition wall (604).

3. The internal combustion (IC) engine (101) as claimed in claim 1, wherein the width (B) of the first path (602) at the throttle end (607) is greater than the width (A) of the first path (602) at the port end (608), and wherein the width (H) of the second path (603) at the throttle end (607) is lesser than or equal to the width (G) of the second path (603) at the port end (608) whereby the partition wall (604) is biased more towards first path (602) than the second path (603).

4. The internal combustion (IC) engine (101) as claimed in claim 1 or claim 3, wherein the fuel injector valve (301) is oriented to provide angle of squirt of fuel from the fuel injector valve (301) tip in the range 8° to 15° .

5. The internal combustion (IC) engine (101) as claimed in claim 1, wherein the ratio of the vertical distance (D) from the end of intake pipe (601) to the tip of the partition wall (604) in the mixing region (620) to the cross-sectional width E or F of the any of the two intake ports (501 & 502) is between 1.5 to 3.

6. The internal combustion (IC) engine (101) as claimed in claim 1, wherein the intake pipe (601) has a nonlinear curved profile and divided into a curved portion (621) and straight portion (622), and wherein the curved portion extends from the port end (608) to the tip of the fuel injection valve (301), and substantially straight portion (622) extends from the tip of the fuel injection valve (301) to the throttle end (607).

7. The internal combustion (IC) engine (101) as claimed in claim 1, wherein an insulator pad (304) is disposed between the intake pipe (601) and the cylinder head (204), said insulator

pad (304) has an element (304a) to divide a fuel spray cone (606) from the fuel injection valve (301) to enter both the intake ports (501 & 502).

8. The internal combustion (IC) engine (101) as claimed in claim 1, wherein the two intake ports comprising a swirl intake pipe and a charge intake pipe, said swirl intake pipe directing air fuel mixture to swirl intake port and said charge intake pipe directing air fuel mixture to charge intake port

9. The internal combustion (IC) engine (101) as claimed in claim 2, wherein the predetermined acute angle (θ) is between 75 to 88 degrees.

10. A vehicle with an internal combustion engine (101) as claimed in claim 1.

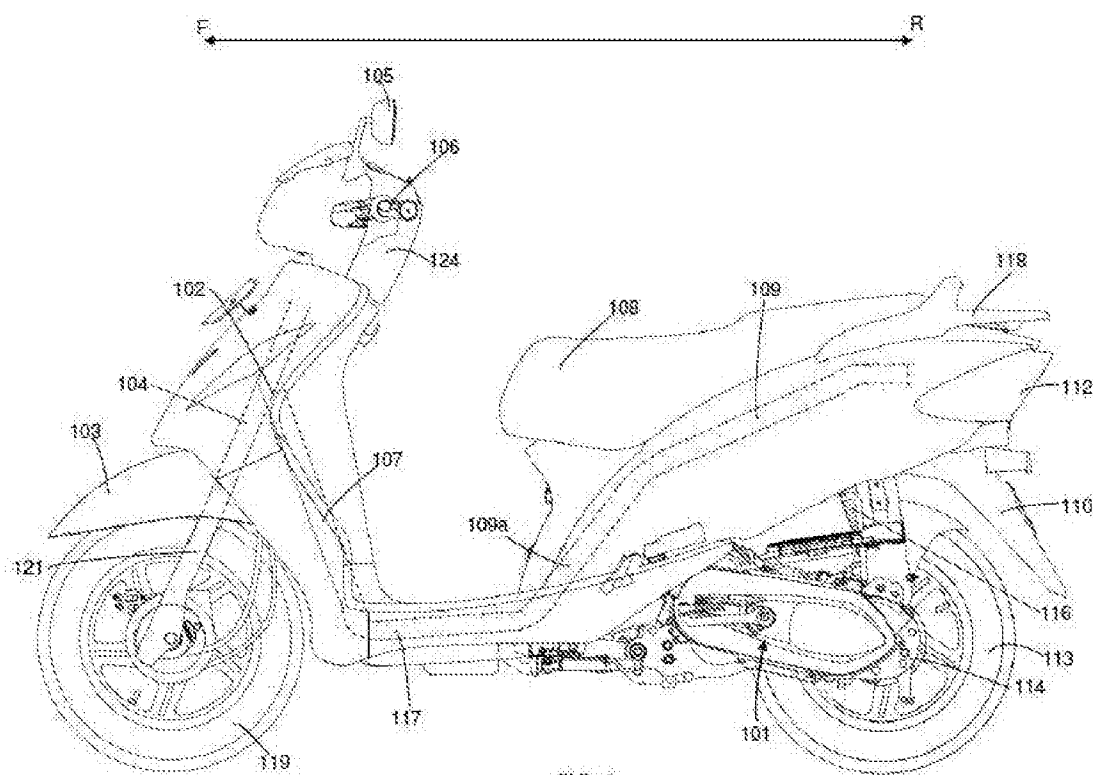


FIG. 1.

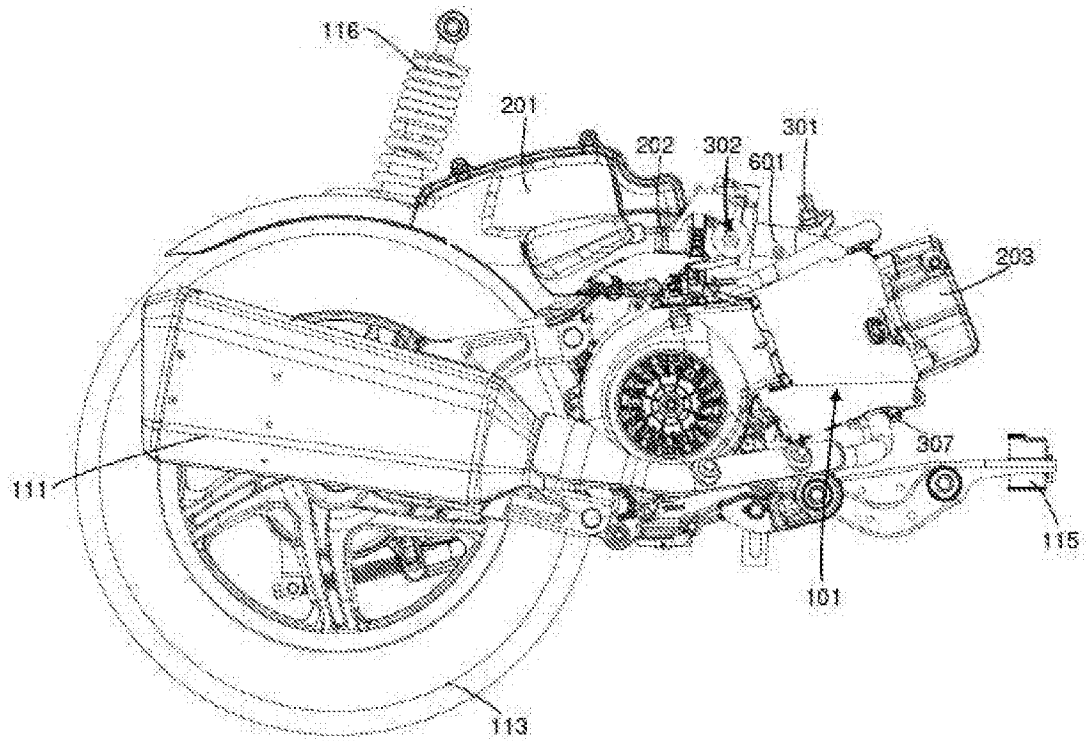


FIG. 2.

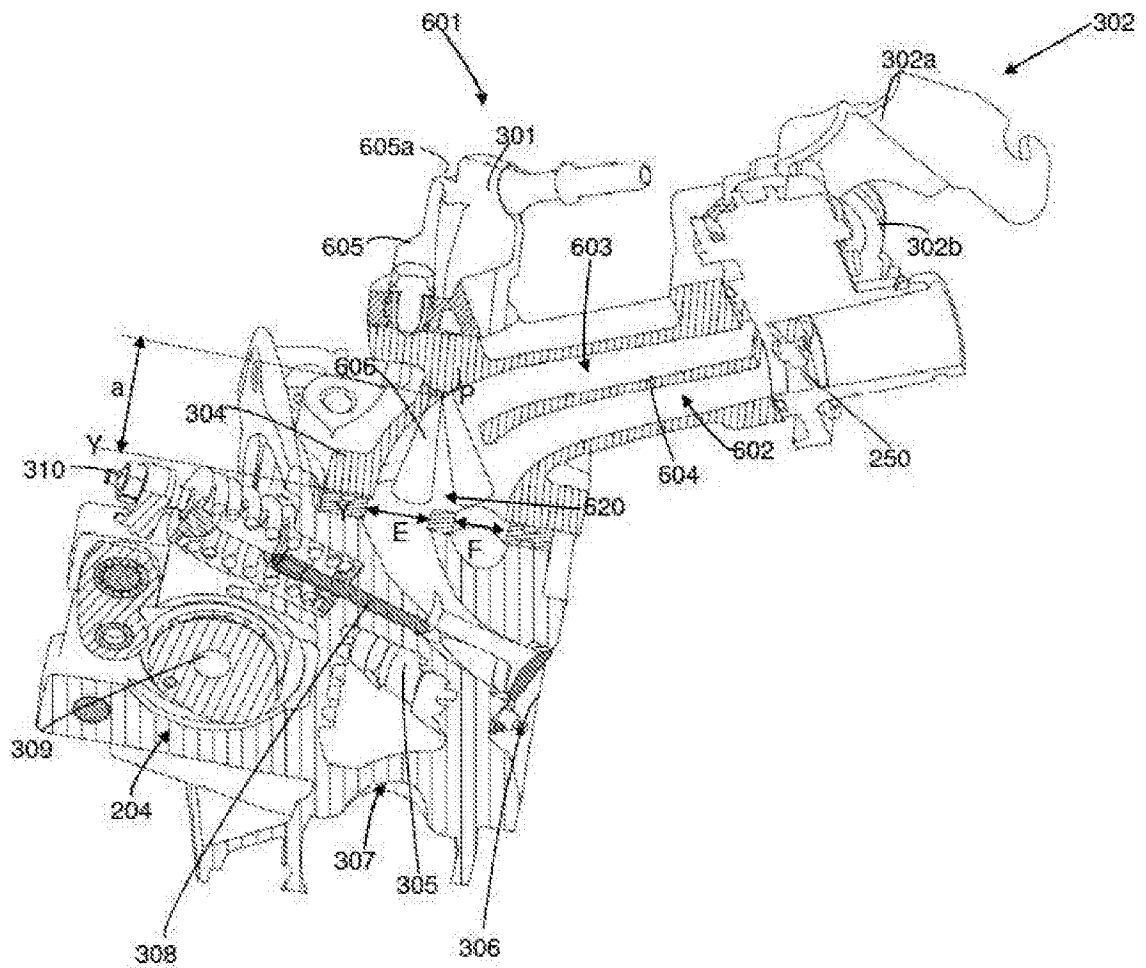


FIG. 3.

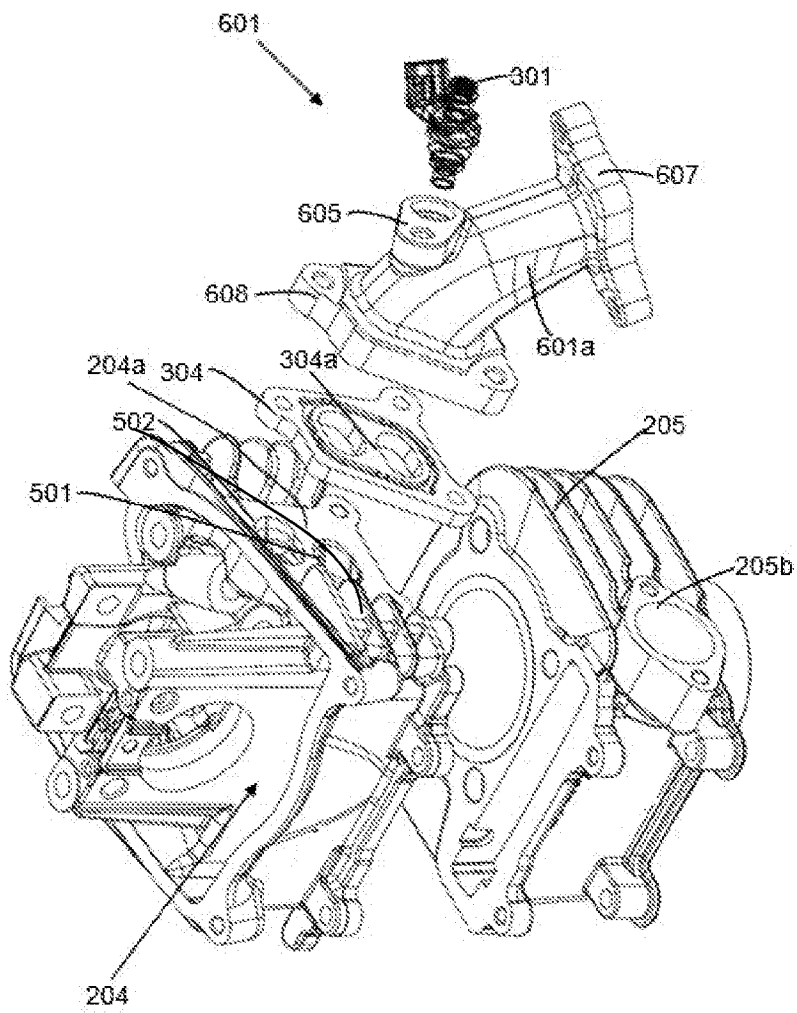


FIG. 4

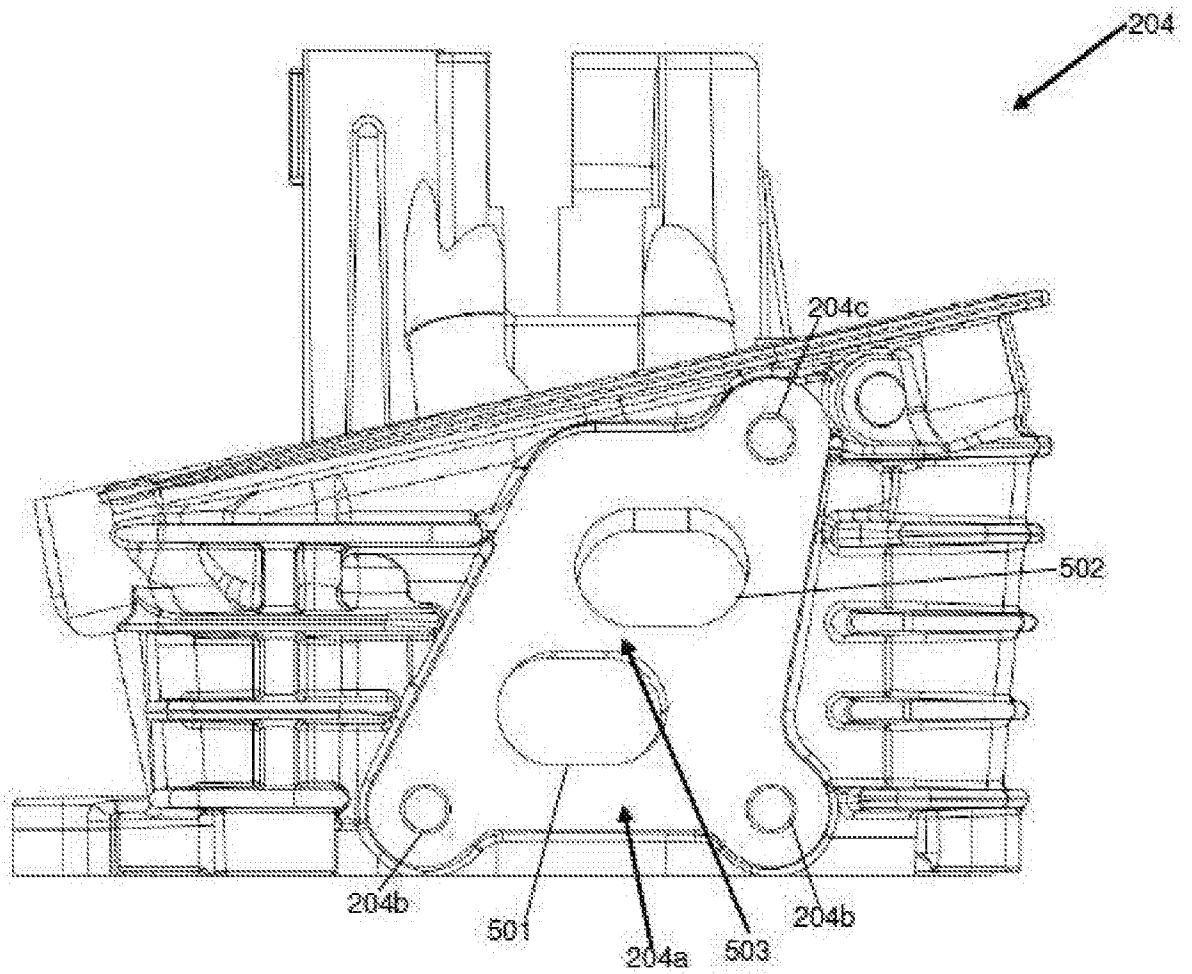


FIG. 5.

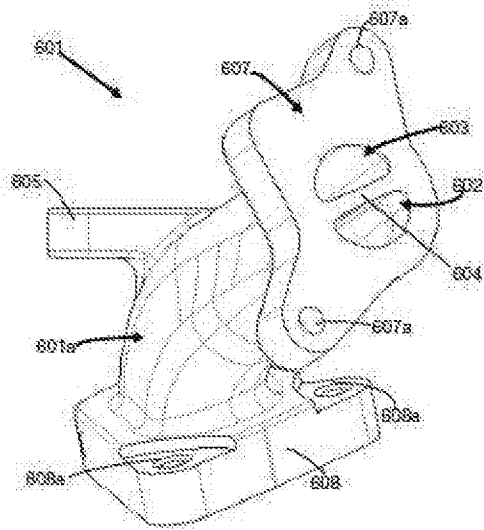


FIG. 6a.

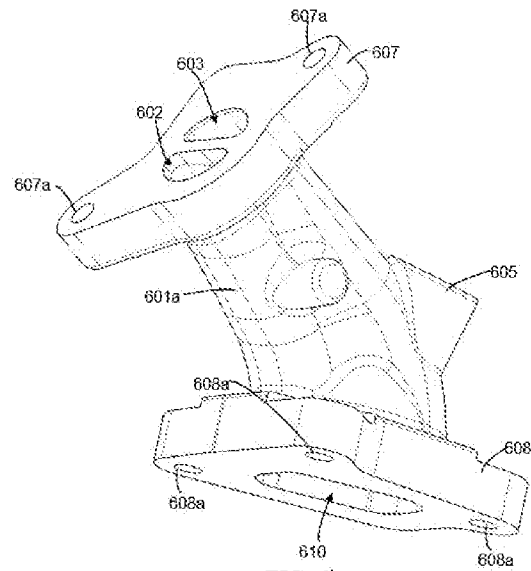


FIG. 6b

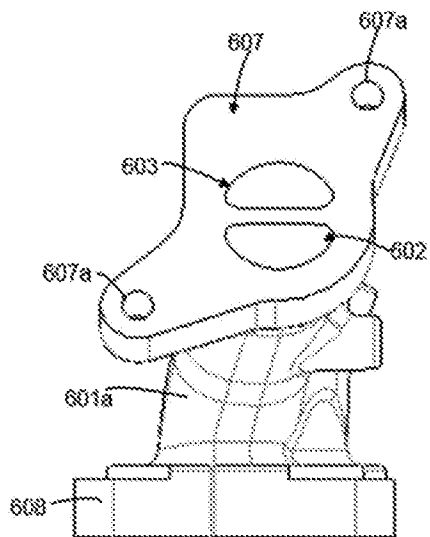


FIG. 6c

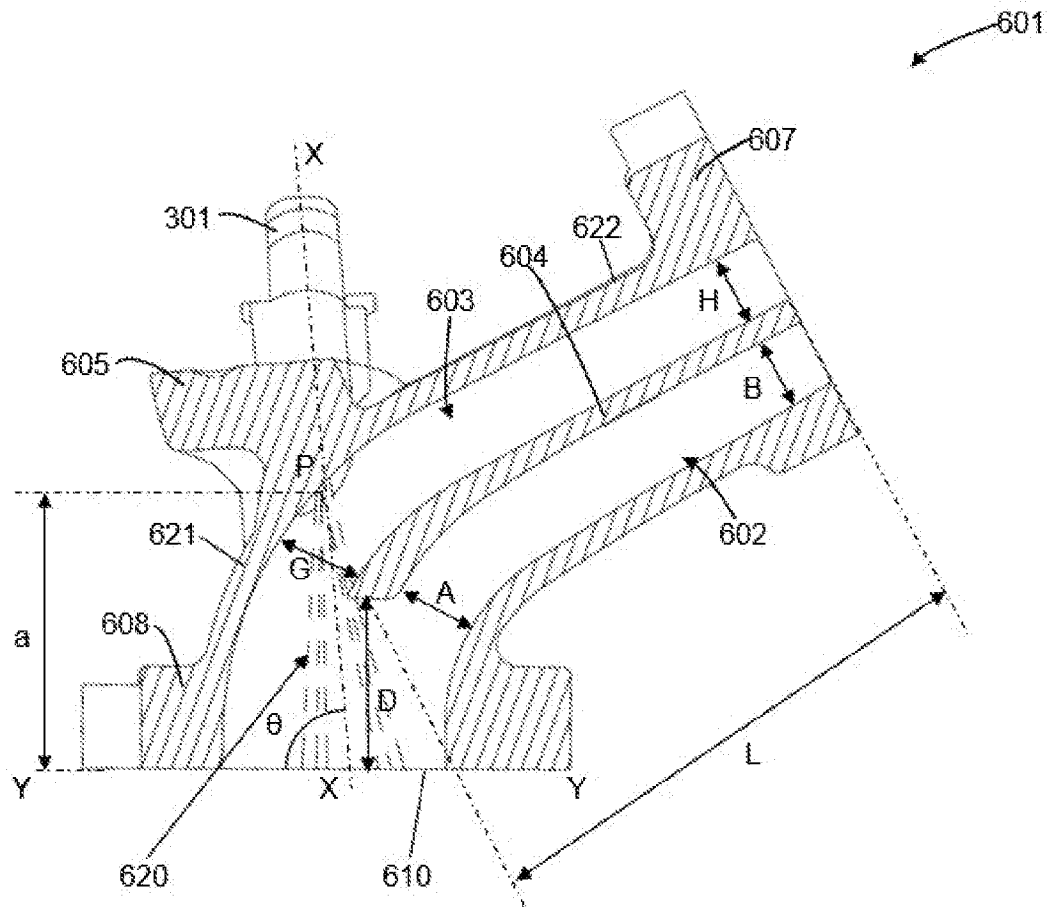


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2018/051270

A. CLASSIFICATION OF SUBJECT MATTER
F02M35/10 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)

F02M

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)

TotalPatent One, 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.
A	JP2016070206 A (HONDA MOTOR CO LTD) 09 May 2016 (09-05-2016) Abstract; Paragraphs [0006], [0007], [0022], [0041], [0042], [0050]; Figures 1, 2, 4, 5, 10	1-10
A	JP2000329016 A (YAMAHA MOTOR CO LTD) 28 Nov 2000 (28-11-2000) Abstract; Paragraphs [0008], [0009], [0018], [0021], [0022]; Figures 1-4	1-10

☐ 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
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"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)	"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
"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	"&" document member of the same patent family

Date of the actual completion of the international search

01-06-2018

Date of mailing of the international search report

01-06-2018

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