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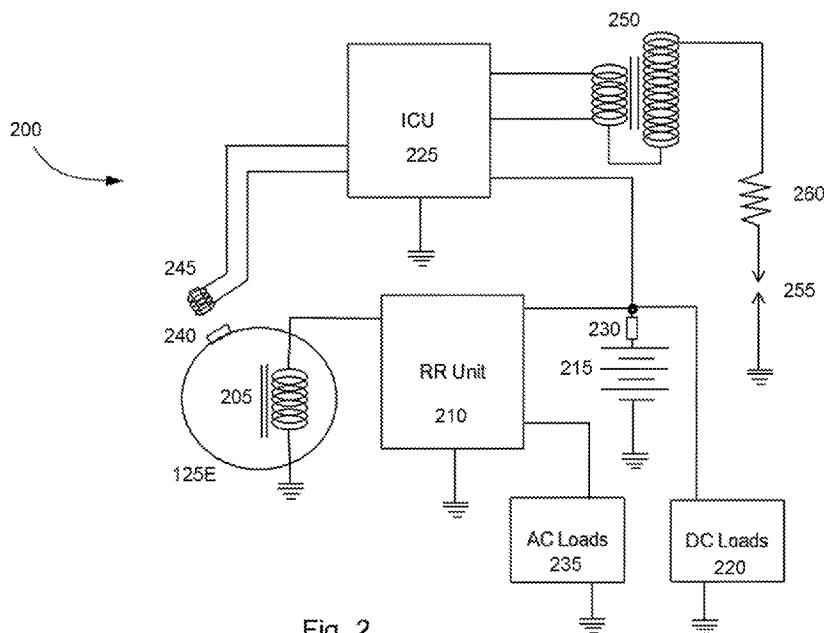


Fig. 2

(57) Abstract: The present subject matter provides an ignition system (200) for an internal combustion engine (125). An electrical machine (125E) functionally coupled to a rotating member (125B) of the internal combustion engine (125). An ignition control unit (225) initially enables triggering of the ignition means (250, 255) at a first angle of the rotating member (125B). An engine speed is calculated and is compared with a first reference speed. The ignition control unit (225) modifies triggering of the ignition means (250, 255) at a second angle depending on the engine speed. The ignition control unit (225) subsequently checks the engine speed and modifies triggering of the ignition means (250, 255) at a third angle upon detection of the engine speed being less than a second reference speed, which is less than the first reference speed.

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AN IGNITION METHOD AND A SYSTEM THEREOF

TECHNICAL FIELD

[0001] The present subject matter relates generally to an internal combustion engine, and more particularly but not exclusively, to an ignition method for starting an internal combustion engine for a vehicle.

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BACKGROUND

[0002] Generally, in a two-wheeled or a three-wheeled vehicle, an internal combustion (IC) engine either is mounted to a frame assembly or is swingably supported by a frame assembly of the vehicle. Typically, the IC engine is a four-cycle type acting as powerhouse of the vehicle that helps in providing motion for the vehicle. Generally, the IC engine has to be cranked for it to start. For cranking the engine, a mechanical force is to be provided by the user or through a source of electrical energy. Typically, a kick-start mechanism or an electric start mechanism is provided for cranking the engine. In case of electrical system, an auxiliary power source drives an electrical machine for cranking the engine.

10 [0003] In addition to cranking system, the vehicle is provided with an ignition system for combustion of air-fuel mixture in a combustion chamber of the IC engine. Generally, a spark plug is used for providing timely combustion of air-fuel mixture. Therefore, the ignition system plays an important role in the combustion process, which is essential for generating desired power and torque output from the IC engine.

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BRIEF DESCRIPTION OF DRAWINGS

[0004] The detailed description of the present subject matter is described with reference to the accompanying figures. Same numbers are used throughout the drawings to reference like features and components.

25 [0005] Fig. 1 (a) illustrates a left side view of an exemplary vehicle, in accordance with an embodiment of present subject matter.

[0006] Fig. 1 (b) illustrates a left side of an exemplary power unit, in accordance with the embodiment of Fig. 1 (a).

[0007] Fig. 2 depicts a schematic view of an ignition system, in accordance with the embodiment of Fig. 1 (b).

5 [0008] Fig. 3 illustrates a method of operation of the ignition system, in accordance with the embodiment of Fig. 2.

[0009] Fig. 4 depicts a graph for ignition timing and engine speed plotted against time, in accordance with another embodiment of the present subject matter.

10 **DETAILED DESCRIPTION**

[00010] Generally, it is cumbersome for the user to start the vehicle using kick-start mechanism, which requires exertion of force on a kick-rod of the kick-start mechanism. This is hectic when the user is starting the vehicle for the first time during the day, which is typically referred to as a cold start. Therefore,
15 an electrical machine functioning as a motor for starting the IC engine is generally provided, which is referred to as electric starting system. Such electric starting systems are also implemented in small capacity vehicles such as scooter or motorcycles. Generally, a battery is provided on the vehicle for driving the electrical machine as motor. Also, another electrical machine is provided in the
20 vehicle that is used as a generator, which is a magneto. The generator/magneto is functional during the operation of the IC engine and the output of the generator is used to charge the battery and/or to drive vehicle loads. However, with the advent of technology, a single electrical machine has come to use that is capable of operating as both a starter and a generator, which is called integrated starter
25 generator. Depending on application, the magneto or the integrated starter-generator is used.

[00011] Generally, the IC engine is provided with an ignition system with one or more spark plugs provided for generation of sparks. Timing of spark generation is an essential aspect of the spark ignition systems as the ignition system is functional during entire running state of the IC engine including during start of the IC engine. The ignition system is capable of affecting the performance, efficiency, fuel consumption, and exhaust emission of the IC engine as the spark can be generated at any moment during the four-stroke cycle. Especially, spark timing plays an important role in case of starting the vehicle at conditions like cold start. Generally, the ignition system uses throttle position sensor information to accordingly produce high voltage across electrodes of the spark plug(s), which in turn generates spark for initiating combustion of air-fuel mixture process towards the end of a compression stroke of the IC engine.

[00012] To this end, a two-wheeled or three-wheeled vehicle is a low cost vehicle having a compact layout. Such vehicles are provided with either a carburetor or fuel injector for mixing and providing the air from intake path and fuel from fuel tank, thereafter delivering the air-fuel mixture to the intake manifold of the IC engine. During engine starting, the ignition timing will be close to the Top Dead Center (TDC) of a piston of the IC engine to generate maximum power during the power stroke. Generally, with the increase in engine speed, the ignition timing is advanced to complete combustion process before the start of the power stroke.

[00013] However, during starting of the engine, especially during cold-start, friction will be high in combustion chamber and the air-fuel mixture condensation will also be high affecting smooth start of the engine. Conventionally, a choke provided in the carburetor, which can be either manually or automatically controlled, is used to increase air-fuel mixture quantity during starting so that the engine can warm up. Nevertheless, this increases fuel consumption due to

provision of rich mixture due to operation of choke during starting. Moreover, in smaller vehicles with a manual choke, it is required that the rider has to operate the choke during engine starting, which is cumbersome. Also, there is a possibility that the user may attempt starting the vehicle without activating the choke. In addition, repeated starting attempts without application of choke further results in cold start emissions and also fuel consumption. Whereas, use of an automatic choke control increases the cost of the system and also the carburetor design becomes complicated in the low-cost and the compact two-wheeled or three wheeled vehicles. Further, in cold start condition, engine speed is unstable which may lead to engine speed reducing intermittently causing engine stalling. Also, in the conventional systems ignition timing is varied erratically in a closed loop engine speed control due to which starting is not achieved quickly. Also, hydrocarbon and carbon monoxide emissions from engines are produced during the engine warm-up period and this is caused by difficulties in obtaining stable and efficient combustion under these conditions. Even though a catalytic converter is used, it is ineffective due to the low engine temperature.

[00014] Generally, electronically controlled intake system, coolant/engine temperature based ignition controls are known in the art to address aforementioned problem. For example in take air heaters or coolant flow restricting valve mechanism are used in the art. For example, implementation of the aforementioned system requires major engine modification; say the cooling jacket is to be deployed around the combustion chamber region requiring engine modifications. Such system cannot be accommodated in compact vehicles like two-wheelers or three-wheelers with limited space. Additionally, such systems require electronic control units that are used for taking data from various systems of the vehicle, which makes it costlier. For example, a temperature sensor is to be additionally provided in case of temperature base ignition control either in the

power unit or in the coolant path which complicates the engine design and also adds additional cost of using a temperature sensor or any other sensor and a control unit for processing the data from the additional component provided on the vehicle. This affects the compact layout of the IC engine in small vehicles and
5 also increases cost of the system due to various sensors etc.

[00015] Also, provision of such complex starting/ignition system complicates servicing. The service personnel have to be specially trained for maintaining and servicing the power unit with the modified layout. This adds additional cost to the manufacturer. Moreover, some vehicles use high capacity batteries to provide
10 higher driving force. This requires a larger high capacity battery to be accommodated in the compact two-wheeled or three-wheeled vehicle thereby compensating on space and requiring engine or vehicle layout modifications.

[00016] Thus, there is a need for an ignition system that can start the engine quickly. Also, the ignition system should be deployable in the current engine
15 configurations without increasing cost of the system. Moreover, the ignition control should enable retaining of the current engine design without the need for engine modifications.

[00017] Hence, it is an object of the present subject matter to address the aforementioned and other problems in the prior art. Therefore, the present subject
20 matter provides an ignition method and a system thereof for starting an internal combustion engine.

[00018] It is an aspect of the present subject matter that the ignition method modifies ignition timing or triggering of ignition means at an ignition angle with reference to piston reaching top dead center thereby providing improved
25 startability.

[00019] In one embodiment, the ignition method includes triggering of an ignition means at a first angle of the crankshaft before the piston reaches top dead

center. Then, calculating an engine speed and comparing the engine speed with a target reference speed. The target reference speed is a first reference speed, wherein the first reference speed is the speed beyond which the vehicle reaches a start condition.

- 5 **[00020]** It is a feature of the present subject matter that the ignition control system modifies triggering of the ignition means at a second angle of the crankshaft depending on the calculated engine speed, wherein the second angle is one of an advanced angle or a delayed angle depending on the engine speed. Thus, the combustion process is either advanced or delayed depending on the force
10 applied on the piston due to combustion when the piston reaches top dead center or is moving away from top dead center.

- [00021]** It is a feature that subsequently checking the engine speed and accordingly delaying triggering of the ignition means at a third angle upon detection of said engine speed being less than a threshold reference speed,
15 wherein the threshold reference speed is the speed at which the piston motion is unstable and the IC engine tends to stall. It is an advantage that the stalling of the engine is avoided by delaying the triggering.

- [00022]** Herein, the term "angle" is angle of the crankshaft from a reference. The change in angle of the crankshaft enables the piston to reach the top dead
20 center or to move away from top dead center towards bottom dead center.

- [00023]** It is another feature of the present subject matter that the system initially starts the vehicle by triggering at a base angle, which is a first angle. Subsequently, if the engine speed is greater than a hardware-trigger speed then the system changes the angle to a second angle, which is either advanced or delayed.

- 25 **[00024]** It is an aspect that the engine speed is calculated from the engine speed data acquired from a rotor/rotating member coupled to the crankshaft. It is

an advantage that a temperature sensor or the like to be mounted to the engine, which would have mandated engine design modification, is avoided.

[00025] It is an aspect of the present subject matter that the threshold reference speed is less than said target reference speed, wherein the threshold
5 reference speed is the speed below which the piston experiences retarding force.

[00026] It is advantage that the ignition method eliminates stalling of the engine during starting by reducing retarding force acting on the piston before reaching top dead center.

[00027] It is an effect of the present subject matter that the ignition method
10 improves stability of the engine speed thereby enabling improved and faster starting of the IC engine.

[00028] It is yet another feature that the present system provides a closed loop engine speed control thereby accelerating the engine speed to its target idling speed by varying ignition timing to second angle based on the error in engine
15 speed. Furthermore, the unstable combustion is monitored by measuring engine deceleration below a threshold reference speed and ignition timing is changed to a third angle, which is a predetermined value thereby avoiding engine stalling.

[00029] The system of the present subject matter enables quick starting of the engine during first attempt itself in a cold start condition of the vehicle, thereby
20 providing improved user experience.

[00030] It is an additional feature that the any undesired effects like knocking due to early combustion is eliminated. Conventionally, a throttle position sensor is used to sense the throttle opening and ignition timing is retarded based on the amount of throttle opening.

[00031] It is an aspect of the present subject matter that the ignition system is cost effective as the ignition system uses crankshaft speed sensor like a pulser coil and a pip. Any additional systems like air heater or coolant flow controls are
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avoided. This not only eliminates additional components or system in the vehicle but also costlier components like temperature sensors and complex computing controllers are used. Further future being, the present system can be deployed and retro-fitted into all engines without the need for any engine modifications.

5 **[00032]** It is an additional aspect that the present subject matter retains the current engine design, as the system does not require additional sensors like temperature sensor or actuators such as intake air control actuator.

[00033] It is yet another aspect that the ignition system is compact and is implementable in a compact vehicle like scooter, motorcycle, or a three-wheeler.

10 **[00034]** It is yet another additional aspect that the present subject matter that the ignition system provides improved starting thereby providing ease of starting and improved vehicle usage experience to user.

[00035] It is also another aspect that the ignition system of the present subject matter reduces any retarding forces acting on the piston thereby eliminating engine stalling during start and also improving durability & life of the parts thereof.

[00036] The present subject matter is applicable to both carburetor based and fuel injector based systems.

20 **[00037]** The aforesaid and other advantages of the present subject matter would be described in greater detail in conjunction with the figures in the following description.

[00038] In relation to the following description of embodiment(s), arrows as and where provided in the top right corner of each figure depicts direction with respect to the vehicle, wherein an arrow F denotes front direction, an arrow R indicates rear direction, an arrow Up denotes upward direction, an arrow Dw denotes downward direction. Also, an arrow with LH denotes a left side, and an

arrow with RH denotes a right side. All aforementioned directions are with respect to the vehicle.

[00039] Fig. 1 (a) illustrates a left side view of an exemplary two-wheeled vehicle, in accordance with an embodiment of the present subject matter. The vehicle 100 has a frame assembly 105 that includes a head tube 105A, a main tube 105B extending rearwardly downward from the head tube 105A, and a pair of railing 105C extending inclinedly rearward from a rear portion of the main tube 105B. A handlebar assembly 110 is connected to one or more front wheel(s) 115 through one or more front suspension(s) 120. A steering shaft (not shown) connects the handlebar assembly 110 to the front suspension(s) 120. The steering shaft is rotatably journaled about the head tube 105A. A power unit 125 including at least one of an internal combustion engine and/or a traction motor is disposed in a posterior portion of the vehicle 100. In the present embodiment, the IC engine is forwardly inclined i.e. a piston axis of the IC engine is forwardly inclined. In other embodiment, the IC engine can be a vertical type with the power unit being fixedly mounted to the frame assembly 105. Hereinafter, the terms power unit 125 and the IC engine 125 are interchangeably used. The power unit 125 is functionally connected to a rear wheel 130 through a transmission system (not shown). The transmission system includes a continuously variable transmission or a fixed gear ratio transmission or automatic-manual transmission.

[00040] Further, the rear wheel 130 is connected to the frame assembly 105 through one or more rear suspension(s) 135. In the depicted implementation, the power unit 125 is swingably mounted to the frame assembly 105 through a toggle link or the like. A seat assembly 140 is disposed above a utility box (not shown) and is supported by the pair of railing(s) 105C. A passenger grip 145 is provided posterior to the seat assembly 140 for pillion/passenger support.

[00041] Further, the vehicle 100 includes a front fender 150 covering at least a portion of the front wheel 115. In the present embodiment, a floorboard 145 is disposed at a step-through space formed between the handle bar assembly 110 and the seat assembly 140 and the floorboard 145 is supported by the main tube 105B.

5 The user can operate the vehicle 100 by resting feet on the floorboard 145, in a sitting position. In an embodiment, a fuel tank (not shown) is disposed below the seat assembly 140. A rear fender 155 is covering at least a portion of the rear wheel 130. The vehicle 100 comprises of plurality of electrical/electronic components including a headlight 160A, a tail light 160B, a battery (shown in Fig. 10 2 (a)), a transistor controlled ignition (TCI) unit (not shown), and may include an alternator (not shown) and a starter motor (not shown). Further, the vehicle 100 includes a synchronous braking system, an anti-lock braking system, or the like.

[00042] The vehicle 100 includes plurality of panels 170 that include a front panel disposed in an anterior portion of the head tube 105A, a leg shield is 15 disposed in a posterior portion of the head tube. A rear panel assembly 170 extending downwardly of the seat assembly 140 and extends rearward from a rear portion of the floorboard 145 towards a rear portion of the vehicle 100. The rear panel assembly 170 encloses the utility box. Also, the rear panel assembly 170 partially encloses the power unit 125. The IC engine 125 includes an air intake 20 system (not shown), an air fuel supply system (not shown) that are coupled to an intake side of the IC engine 125 and are disposed on the IC engine 125. Also, an exhaust system (not shown) is coupled to exhaust side of the IC engine 125 and the exhaust system extends towards one lateral side of the vehicle 100.

[00043] Fig. 1 (b) depicts a left side view of the power unit, in accordance 25 with the embodiment depicted in Fig. 1 (a). The power unit 125 includes a crankcase 125A comprising at least two portions including plurality of apertures and mounting portion for rotatably supporting various components including a

rotating member like crankshaft 125B. The crankshaft 125B, a rotatable member, is rotatably supported by the crankcase 125A and the crankshaft 125B is connected to a piston (not shown) having a reciprocating motion about a cylinder portion CP therein. The reciprocating motion of the piston is converted into a
5 rotating motion of the crankshaft 125B. The cylinder portion CP includes a cylinder body 125CA and a cylinder head 125CB that are supported by the crankcase 125A. The power unit 125 is swingably connected to the frame assembly 105 through an aperture portion 125F provided on the crankcase 125A. Further, the power unit 125 includes an air-fuel supply means 125D that includes
10 a carburetor or a fuel injector. Furthermore, an ignition means including a spark plug (not shown) is provided for creation of spark for combustion of air-fuel mixture. One or more spark plug(s) are provided in the IC engine 125.

[00044] Further, the electrical machine 125E is mounted to the crankshaft 125B. In one embodiment, the electrical machine 125E is disposed on a shaft
15 parallel to the crankshaft 125B and is connected to the crankshaft 125B through gear or a belt. In a preferred embodiment, the electrical machine 125E is a magneto 125E. However, the electrical machine can be an integrated starter generator that is capable of functioning as a starter and also as a generator. Hereinafter, the terms electrical machine 125E and magneto 125E are
20 interchangeably used for brevity. The magneto 125E includes a rotor and a stator (not shown). The rotor is connected to the crankshaft 125B. The rotor includes magnetic members and the stator is provided with plurality of windings (not shown). The starter motor enables rotation of the crankshaft 125B for cranking the IC engine 125 and an ignition system 200 (shown in Fig. 2) enables triggering of
25 spark.

[00045] Fig. 2 depicts a schematic view of an ignition system for the power unit of the vehicle, in accordance with the embodiment of Fig. 1 (b). The ignition

system 200 includes a magneto 125E coupled to the crankshaft 125B for generating electricity based on mechanical energy available at the crankshaft 125B of the IC engine 125. In another embodiment, an integrated starter generator (ISG) is coupled to the crankshaft 125B of the IC engine 125.

5 **[00046]** The rotating magnetic field produced due to rotation of the crankshaft 125B generates alternating current (AC) voltage across coils 205 wound to the stator. The voltage from the coils 205 is rectified and regulated by a regulator and rectifier (RR) unit 210 that can be used for charging the auxiliary power source 215, which is a battery 215 in the present embodiment. In another embodiment,
10 the auxiliary power source can be a fuel cell or a hydrogen cell. The terms battery and auxiliary power source are interchangeably used. The battery 215 and the output of RR unit 210 are capable of driving various direct current (DC) loads 220 of the vehicle 100. Further, the ignition system 200 includes an ignition control unit (ICU) 225, wherein either the battery 215 or the RR unit 210 drives the
15 ignition control unit 225. Further, a fuse 230 is provided to protect wires and other components against a short circuit condition of the battery 215. Also, the vehicle 100 may include AC loads 235 that are driven by the RR Unit 210, wherein regulated AC voltage is supplied to the AC loads 235.

[00047] A reference member like the integrated starter-generator or a magneto
20 acts as a reference member that helps in identifying the rotation of the rotating member like crankshaft. Further, in a first embodiment, the rotor of the magneto 125E includes a ferromagnetic pip 240 provided on the outer periphery of the rotor. The pip 240 works in conjunction with a pulser coil 245, wherein the pip 240 and the pulser coil 245 enable detection of the position of the rotor of the
25 magneto 125E, which is analogous to position of the crankshaft 125B due to direct connection. Furthermore, the ignition system 200 includes an ignition coil 250 including a primary winding and a secondary winding used for stepping up

the voltage. The ignition control unit 225 is capable of actuating the primary winding that further generates high voltage across a spark plug 255 connected to the secondary winding. In one embodiment, a suppressor resistor 260 limits a spark current for reducing any electromagnetic interference. The stroke of the IC engine 125 or the piston position is determined by the ignition control unit 225 from the pulser coil 245 signal.

[00048] Fig. 3 depicts the method of operation of the ignition system 200, in accordance with the embodiment as depicted in Fig. 3. The vehicle 100 includes a key (not shown) for activating ignition of the IC engine 125 by an authorized user. The key can be a physical key, a biometric key, or a wireless key that is detected by the vehicle 100. Further, the vehicle 100 includes an ignition switch (not shown) to initiate ignition or cranking of the power unit 125. In one embodiment, the vehicle 100 is also provided with an electric start switch (ESS) (not shown). The electric start switch enables cranking of the IC engine 125. Upon receiving electric start input from the aforementioned means by the user, the ignition system 200 enables cranking of the IC engine 125.

[00049] The ignition control unit 225 receives data from the pulser coil 245. The rotor of the magneto 125E is provided with the magnetic pip 240. The four-cycles of the IC engine 125 results in two complete rotations of the crankshaft 125B. Therefore, the magnetic pip 240 working in conjunction with the pulser coil 245 provides the relative position of the piston depending on pip 240 detection timing. The piston has a reciprocating motion, moving between a top dead center (TDC) and a bottom dead center (BDC) within the combustion chamber. The pulser coil 245 provides corresponding crankshaft 125B data to the ICU 225 for triggering ignition at desired position of the piston. The battery 230 drives the starter motor that is connected to connected to the crankshaft 125B resulting in cranking of the engine 125.

[00050] In the subsequent explanation, the following terms are used. [Hardware-trigger speed], which is speed at which the ignition timing modification is triggered. [First reference speed], which can be the idling speed and the speed beyond which the power unit is considered to be started. [Second reference speed], which is the speed below which the power unit tends to stall. [Exit speed], which is the speed at which the engine is considered to be started. [First angle], which is base angle at which the initial triggering of ignition coil happens. [Second angle], which is an angle either advanced or delayed with respect to the first angle. [Third angle], which is a delayed angle at which the ignition coil is triggered to prevent engine stalling.

[00051] At step S305, the ignition control unit 225 receives data from pulser coil 245, which gives data about the position of the crankshaft 125B and successive detection of the pip 240 gives the speed of rotation of the crankshaft 125B. At step S310, the ignition control unit 225 calculates engine speed from the data received from the pulser coil 245. The engine speed is analogous to the rotations per minute (RPM) of the crankshaft 125B. Hereinafter, the terms engine speed, engine RPM, crankshaft speed, or crankshaft RPM are interchangeably used. Further, the ICU 225 compares the calculated engine speed with a first hardware-trigger speed, at step S315. Once the ICU 225 detects that the engine speed is less than the hardware-trigger speed, at step S320, the ICU 225 enables triggering of the ignition coil 250 at a first angle of the crankshaft 125B and subsequently checks the engine speed at step S310. In one embodiment, the first angle is a base angle, which is a pre-determined angle determined by the manufacturer.

[00052] Furthermore, at step S315, upon detection of the engine speed being greater than the hardware-trigger speed, at step S325, the ICU 225 calculates and compares the engine speed with a target reference speed/first reference speed.

Upon detection of the engine speed being less than the first reference speed, the ICU 225 modifies the triggering of spark plug/ignition coil 250 at a second angle, at step S345. In a preferred embodiment, the triggering of the ignition coil 250 is advanced upon detection of engine speed to be less than the first reference speed, at step S345. In other words, the timing of triggering of the ignition coil 250 is advanced. This enables occurrence of combustion of air-fuel mixture at a position of the piston, which is advanced providing improved force to the piston increasing the engine speed.

[00053] Whereas, at step S325, upon detection of the engine speed being greater than the first reference speed, the ICU 225 delays the triggering of the ignition coil 250 which becomes the second angle. Then at step S335, the ICU 225 compares the engine speed with an exit speed, and upon detection of the engine speed being greater than the exit speed, the ICU 225 identifies the IC engine 125 has started. Further, at step S340, the ICU 225 will enable triggering of the ignition coil 250 with reference to a pre-determined look-up table or ignition table for triggering the ignition coil basing on various engine parameters including throttle position, engine speed, a load on said internal combustion engine or the load on the vehicle, an input from an oxygen sensor, or the like.

[00054] Moreover, at step S350 when the engine speed is less than the first reference speed, the ICU 225 calculates the engine speed and checks the engine speed with a threshold reference speed/second reference speed. If the calculated engine speed is less than the second reference speed, the ICU 225 further modifies the angle of triggering of the ignition coil 250 to a third angle. In a preferred embodiment, the third angle is a delayed angle or is analogous to delayed triggering of the ignition coil 250 with respect to the previous angle of trigger. The ICU 225 modifies the third angle until the engine speed is above the threshold reference speed. In a preferred embodiment, the second reference speed/threshold

is the speed below which the piston experiences speed retarding forces. At step S350, upon detection of the engine speed being greater than the second reference speed, the ICU 225 compares the engine speed with the target reference speed of step S325.

- 5 [00055] Fig 4 depicts an exemplary graph for Ignition timing and engine speed plotted against time, in accordance with an embodiment of the present subject matter. The ignition method enables raising the engine speed to a target idling RPM quickly. In one embodiment, the hardware-trigger RPM is set in the range of 700-900 RPM. The base angle for triggering the ignition coil 250 is set to
10 8-12 degrees before TDC. Upon detecting the engine speed being above the set RPM in the range of 700-900 RPM, and less than the first reference RPM set in the range of 1400-1500 RPM, the ignition timing is advanced, thereby increasing engine speed.

- [00056] The ICU 225 enables triggering of the ignition coil at a base angle,
15 initially. If the engine speed is less than the value set in the range of 1400-1500 RPM, the ignition angle is advanced to a first angle before the piston reaches TDC. In one embodiment, the maximum ignition timing or angle advance is set to 25 degrees before TDC. If the engine speed is greater than the value set in the range of 1400-1500 RPM, the ignition timing is delayed to a value set in the range of
20 13-17 degrees before TDC. Also, the second reference speed, which is the threshold reference speed, is set in the range of 1000-1200 RPM. Upon detection of the engine speed falling below the value set in the range of 1000-1200 RPM, the ICU 225 delays the triggering of the ignition coil before the piston reaches TDC.

- 25 [00057] In the depicted graph, at instances 405 and 410, the engine speed is detected to be falling below the threshold reference speed, where after the ICU 225 of the ignition system 200 delays the ignition timing or the ignition angle

thereby recovering the engine 125 from unstable combustion.

[00058] In the present implementation, the delaying of the ignition timing is performed in a closed loop. Moreover, in another embodiment, the instantaneous engine speed is compared with an ignition-timing table, wherein the engine speed
5 in the ignition-timing table is averaged over few cycles. Further in an embodiment, it is possible to store the specific starting engine reference speed of the particular vehicle into the look-up table & calibrate the look-up table for each specific vehicle automatically through a controller.

[00059] Further, the present subject matter is applicable to electronic spark
10 ignition including Transistor Controlled Ignition (TCI), Capacitive Discharge Ignition (CDI), and Inductive Discharge Ignition (IDI).

[00060] It is to be understood that the aspects of the embodiments are not necessarily limited to the features described herein. Many modifications and variations of the present subject matter are possible in the light of above
15 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 ignition method for starting an internal combustion engine (125), said internal combustion engine (125) including a rotating member (125B), said method comprising the steps of:
 - 5 triggering of an ignition means (250, 255) at a first pre-determined angle of said crankshaft (125B);
 - calculating an engine speed and comparing said engine speed with a first reference speed;
 - modifying triggering of said ignition means (250, 255) at a second angle
 - 10 depending on said engine speed; and
 - checking subsequently said engine speed and modifying triggering of said ignition means (250, 255) at a third angle upon detection of said engine speed being less than a second reference speed, said second reference speed being less than said first reference speed.
- 15 2. The ignition method for starting internal combustion engine (125) as claimed in claim 1, wherein said modifying triggering of said ignition means (250, 255) at said second angle depending on said engine speed includes one of advancing of triggering of said ignition means (250, 255) with respect to a previous angle of triggering of said ignition means (250, 255) depending on said engine speed being
- 20 one of lesser.
3. The ignition method for starting the internal combustion engine (125) as claimed in claim 1, wherein said modifying triggering of said ignition means (250, 255) at said second angle, said second angle is an angle delayed with respect to a previous angle triggering of said ignition means (250, 255) when said engine
- 25 speed is greater than said first reference speed.
4. The ignition method for starting the internal combustion engine (125) as claimed in claim 1 further comprises the step of comparing said engine speed with

an exit speed, and subsequently triggering said ignition means (250, 255) basing on a pre-set table upon detecting of said engine speed being greater than said exit speed.

5 5. The ignition method for starting the internal combustion engine (125) as claimed in claim 1, wherein triggering said ignition means (250, 255) basing on one or more parameters including an engine speed, a throttle position, a load on said internal combustion engine (125), an input from an oxygen sensor, or the like.

10 6. The ignition method for starting the internal combustion engine (125) as claimed in claimed any of the preceding claims, wherein calculating said engine speed includes calculating a rotational speed of a reference member mounted to said rotating member (125B), and said reference member being provided with a pip (240), and a pulser coil (245) fixedly disposed working in conjunction with said pip (240) to provide speed of said rotating member (125B).

15 7. An ignition system (200) for an internal combustion engine (125) provided in a two-wheeled or a three-wheeled vehicle (100), said internal combustion engine (125) operating in accordance with the method of claim 1, said ignition system (200) comprising:

20 an electrical machine (125E) functionally coupled to a rotating member (125B) of said internal combustion engine (125); and

an ignition means (250, 255),

wherein

an ignition control unit (225) initially enables triggering of said ignition means (250, 255) at a first angle of said rotating member (125B), said ignition control unit (225) calculates an engine speed and compares said engine speed with a first reference speed, said ignition control unit (225) modifies triggering of said ignition means (250, 255) at a second angle depending on

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said engine speed, wherein said ignition control unit (225) subsequently checks said engine speed and modifies triggering of said ignition means (250, 255) at a third angle upon detection of said engine speed being less than a second reference speed, said second reference speed being less than said first reference speed.

8. The ignition system (200) for the internal combustion engine (125) as claimed in claim 7, wherein said third angle enables triggering of said ignition means (250, 255) at a delayed angle/ time with respect to a previous triggering angle/timing.

9. The ignition system (200) for the internal combustion engine (125) as claimed in claim 7, wherein said rotating member (125B) is a crankshaft (125B) of internal combustion engine (125), and wherein said first reference speed is an idling speed of said internal combustion engine (125), and said second reference speed is a threshold speed at which said internal combustion engine (125) tends to stall.

10. The ignition system (200) for the internal combustion engine (125) as claimed in claim 7, wherein said second angle enables triggering of said ignition means (250, 255) at one of advanced or delayed angle with respect to said first angle, and wherein said first angle is a base angle.

11. The ignition system (200) for the internal combustion engine (125) as claimed in claim 7, wherein said rotating member (125B) is coupled to an electric machine (125E) including at least one of a starter motor or an integrated starter generator (125E), wherein said electrical machine (125E) is driven by an auxiliary power source (230).

12. The ignition system (200) for the internal combustion engine (125) as claimed in claim 7, wherein said rotating member (125B) supports a reference

member provided with a pip (240), and a pulser coil (245) working in conjunction with said pip (240) to provide speed of said rotating member (125B).

13. The ignition system (200) for the internal combustion engine (125) as claimed in claim 7, wherein said ignition means (250, 255) includes at least one
5 spark plug (255) functionally coupled to an ignition coil (250), and said ignition coil (250) is triggered by said ignition control unit (225) at any of said angles.

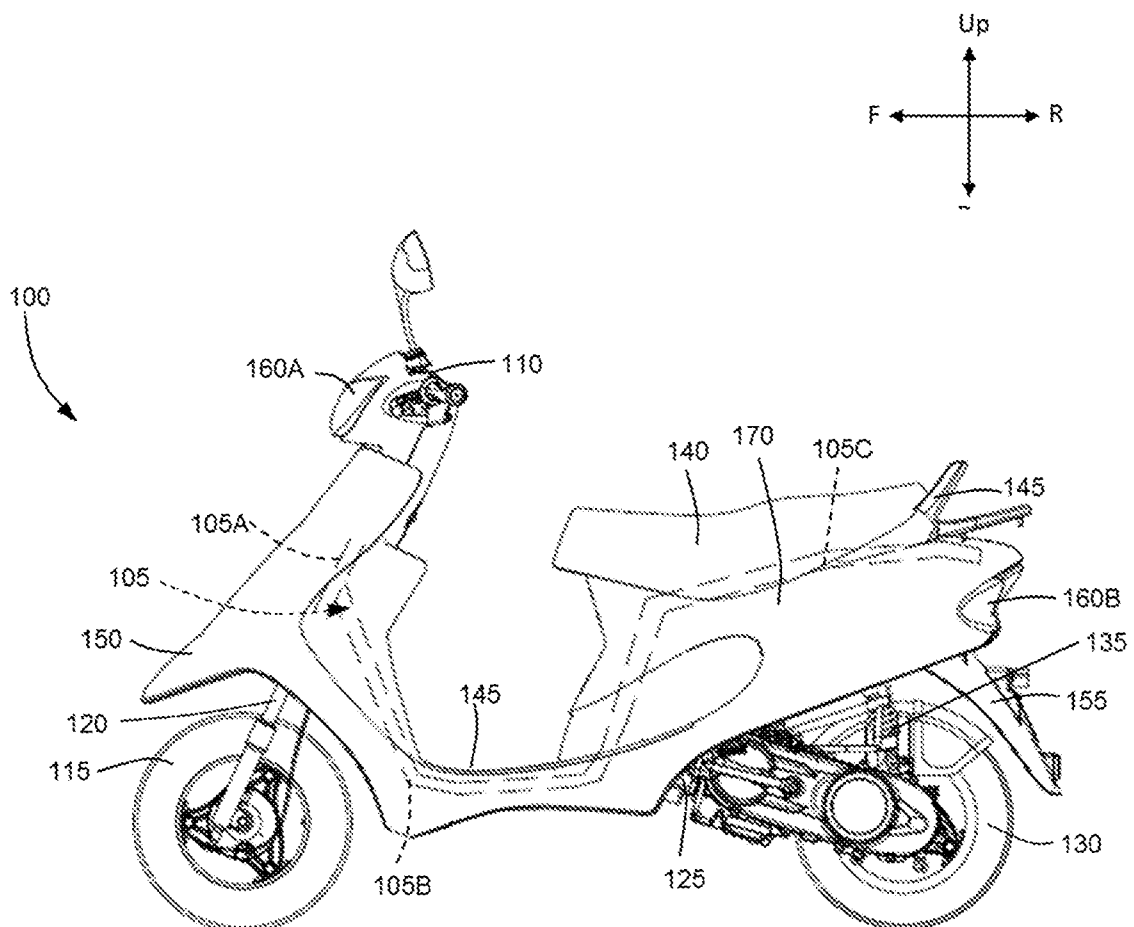


Fig. 1 (a)

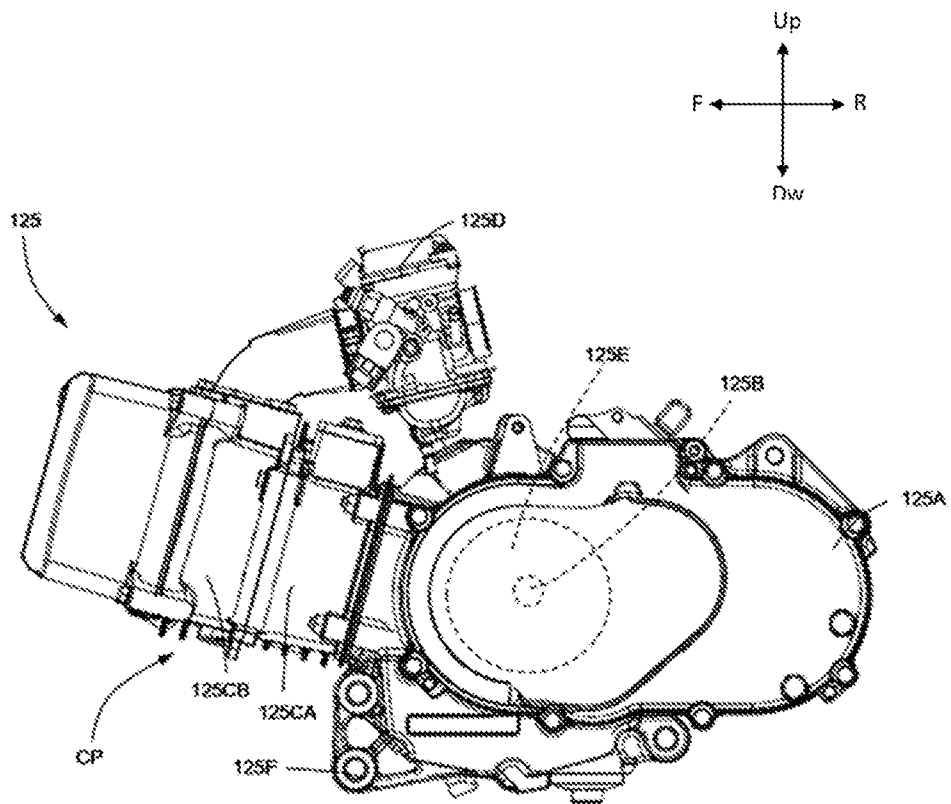


Fig. 1 (b)

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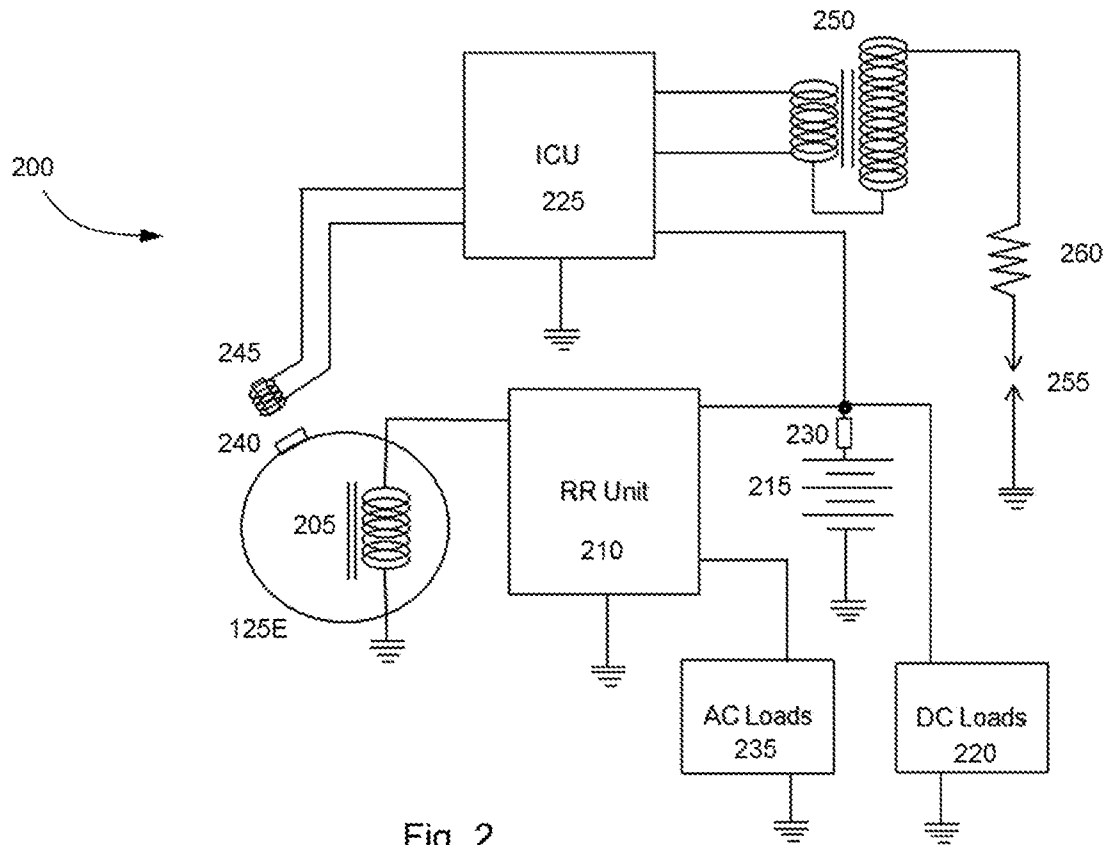


Fig. 2

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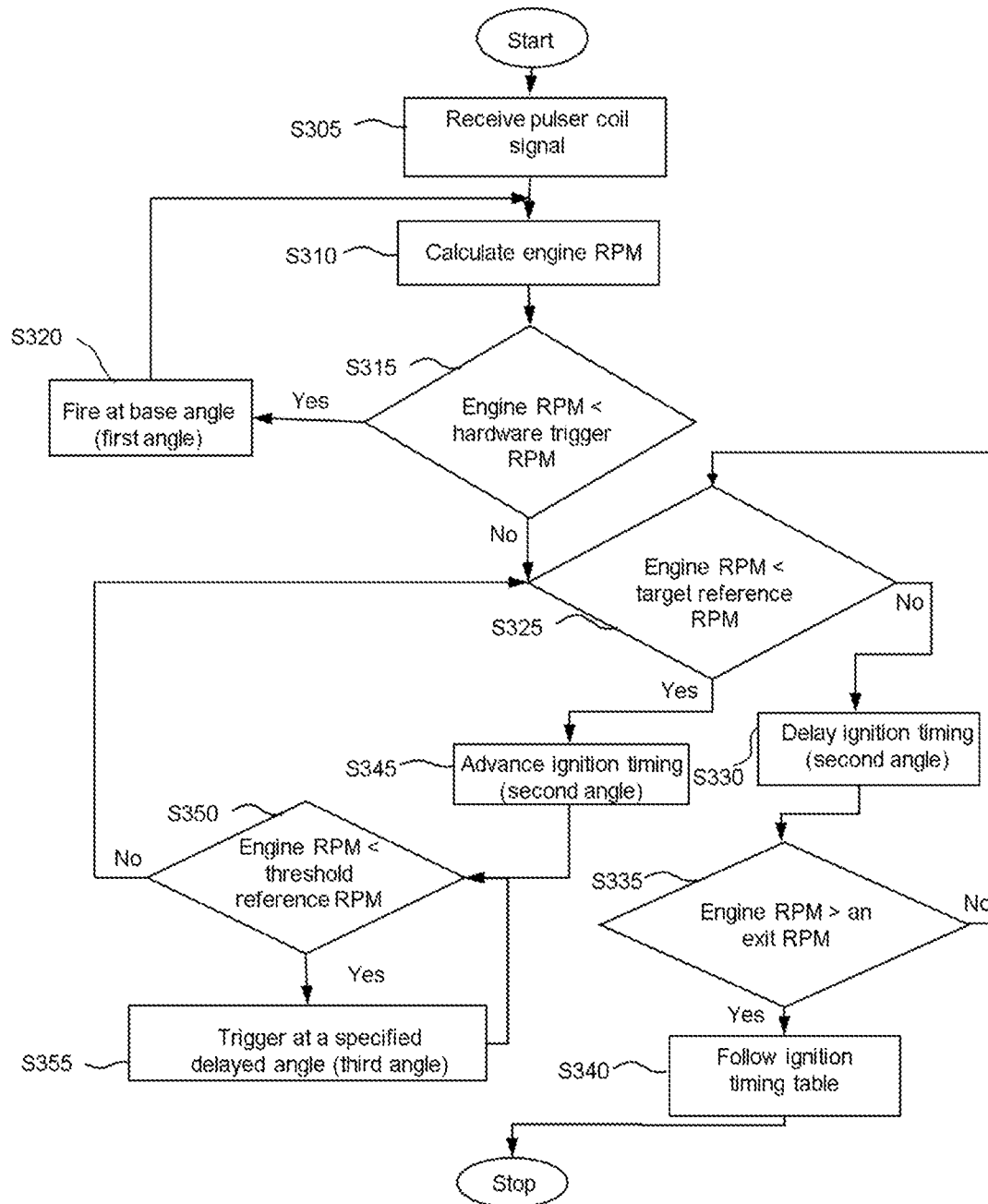


Fig. 3

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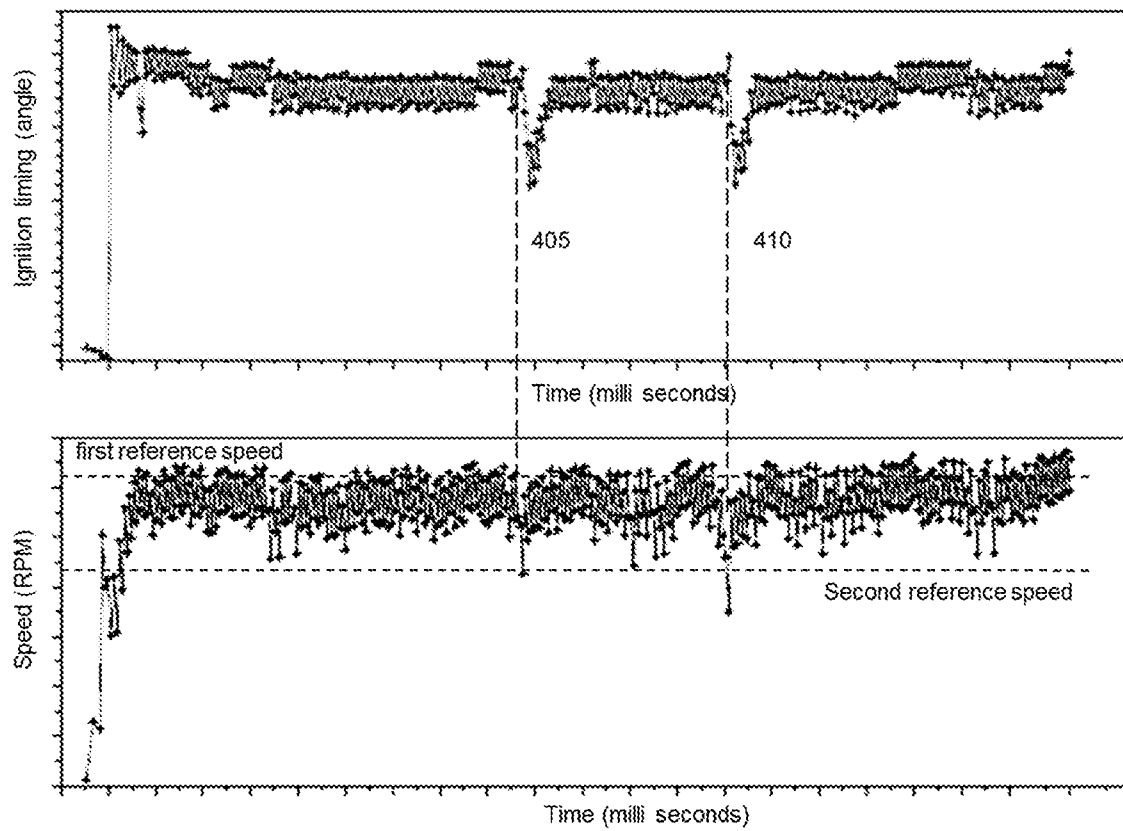


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2018/051378

A. CLASSIFICATION OF SUBJECT MATTER
F02P5/04 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)

F02P

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, TotalPatent One

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US7753028 B2 (TOYOTA JIDOSHA KABUSHIKI KAISHA; 13 Jul 2010) Abstract; Column 2: Lines 27-42, 53 to Column 3: Line 6; Column 5: Lines 31-41, 44-47; Column 6: Lines 17-23; Column 8: Lines 35-54; Column 9: Lines 8-21; Claims 8, 9 and 16; Fig. 1.	1-13

☐ 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

28-05-2018

Date of mailing of the international search report

28-05-2018

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2018/051378

Citation	Pub.Date	Family	Pub.Date
US 7753028 B2	13-07-2010	DE 102009003418 A1	15-10-2009
		JP 2009185774 A	20-08-2009