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(71) Applicant: **EXXONMOBIL RESEARCH AND ENGINEERING COMPANY** [US/US]; 1545 Route 22 East, P.O. Box 900, Ammandale, NJ 08801-0900 (US).

(72) Inventors: **KOENIG, Leonard, R.**; 31 Island Road, Jobstown, NJ 08041 (US). **KAR, Kenneth, C.H.**; 2807 Parrish Street, Philadelphia, PA 19130 (US). **JOHNSON, Susan, W.**; 202 Lockwood Court, Annapolis, MD 21403 (US). **BERLOWITZ, Paul, J.**; 853 Camino Ranchitos, Santa Fe, NM 87505 (US).

(74) Agent: **BOONE, Anthony, G.** et al.; ExxonMobil Research and Engineering Company, 1545 Route 22 East, P.O. Box 900, Ammandale, NJ 08801-0900 (US).

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(54) Title: PROVIDING FUELS OF TARGETED FUEL GRADES

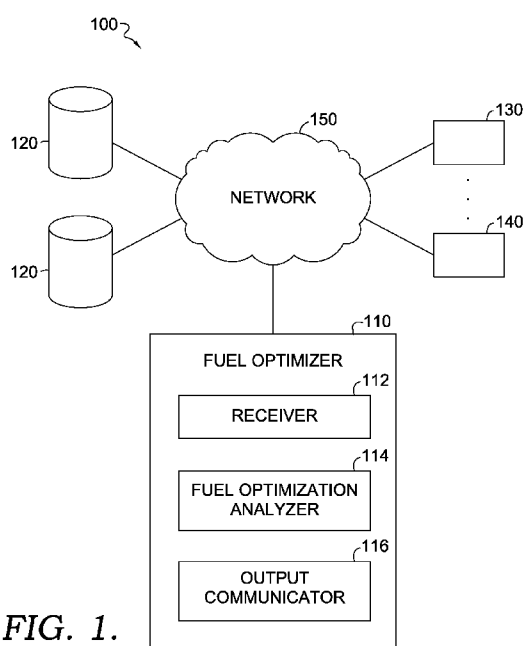


FIG. 1.

(57) Abstract: Systems and methods are provided for recommending and providing a fuel having a target property to a vehicle. The system includes a fuel optimizer, which receives data associated with the vehicle, engine conditions, and environmental conditions and utilizes this data to determine a fuel for the vehicle having a target fuel property. The recommended fuel can be blended and dispensed from a service station utilizing the available inventory.

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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PROVIDING FUELS OF TARGETED FUEL GRADES**FIELD**

[0001] This invention is directed to systems and methods for providing a tailored fuel for a vehicle.

BACKGROUND

[0002] Manufacturers of gasoline (spark ignition) engine vehicles typically recommend utilizing a fuel having a minimum Anti-Knock Index (AKI) value. In certain circumstances, a vehicle may benefit from utilizing a fuel having an AKI value different than that recommended by the manufacturer, e.g., a fuel with an AKI value above the minimum requirement. However, the limited selection of fuels available at conventional service stations may lead to a consumer paying for a fuel having a higher AKI value than the consumer's vehicle will benefit from. Further, the consumer may not be aware of the optimal AKI level for their vehicle and/or how this optimal AKI value may differ in various driving conditions. There is a need for systems and methods to recommend a fuel that is improved or optimized based on vehicle conditions and/or driving conditions and to further provide that improved or optimized fuel to the vehicle.

[0003] U.S. Patent No. 2,997,209 discloses a variable octane rating gasoline pump. The gasoline pump includes a distributor apparatus that can deliver gasoline with varying octane ratings. The distributor apparatus can mix differing amounts of two types of gasoline with different octane ratings from different tanks.

[0004] U.S. Application Publication No. 2001/0001131 discloses a system for the preparation of custom blended fuels. The system includes a bar code reader associated with the fuel station that scans a bar code on the vehicle fuel tank or the vehicle to instruct the fuel station what specific blend of fuel is required. The system can also blend multiple fuel components, e.g., gasoline and replenishable fuel components such as methanol and ethanol, at the fueling station for dispensing.

SUMMARY

[0005] At a high level, this invention is intended to leverage information from a vehicle's engine management system, current and predicted environmental conditions, as well as anticipated changes in normal drive cycles to determine the gasoline grade tailored to a consumer's preferences (maximized performance at lowest price, engine efficiency, extended range, reduced greenhouse gas emissions, etc.). The tailored fuel can be dispensed from a blending dispenser delivering a broad range of octanes bounded by the lowest and highest octane of available blending fuels.

[0006] Accordingly, in one aspect, a method being performed by one or more computing devices including at least one processor, for providing a fuel for a vehicle, is provided. The method can include collecting at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof. The method can also include analyzing the

data to determine at least one target fuel property. Further, the method can include communicating instructions to a controller to dispense a fuel comprising the target fuel property to the vehicle.

[0007] In another aspect, a computerized system for providing a fuel is provided. The system can include one or more processors, and non-transitory computer storage media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform a method. The method can include collecting at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof. The method can also include analyzing the data to determine at least one target fuel property. Additionally, the method can include communicating instructions to a controller to dispense a fuel comprising the target fuel property to the vehicle.

[0008] In yet another aspect, a method being performed by one or more computing devices including at least one processor, for providing a fuel for a vehicle is provided. The method can include receiving at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof. The method can also include analyzing the data to determine at least one target fuel property. Additionally, the method can include mixing two or more fuels having different Anti-Knock Index (AKI) values to form a fuel including the target fuel property. The method can further include dispensing the fuel including the target fuel property to the vehicle.

[0009] In another aspect, a computerized system for providing a fuel is provided. The system can include one or more processors, and non-transitory computer storage media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform a method. The method can include receiving at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof. Further, the method can include analyzing the data to determine at least one target fuel property. The method can also include mixing two or more fuels having different Anti-Knock Index (AKI) values to form a fuel including the target fuel property. Additionally, the method can include dispensing the fuel including the target fuel property to the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 shows a block diagram of an exemplary fuel optimization system.

[0011] FIG. 2 shows a flow diagram illustrating exemplary methods of determining a target fuel property and determining ignition timing changes.

[0012] FIG. 3 shows a schematic representation of a controller, dispenser, and fuel tanks for forming and dispensing a fuel blend.

[0013] FIG. 4 shows a schematic representation of a controller, flow meters and flow valves associated with fuel tanks, and a flow totalizer for providing a blended fuel to a dispenser.

[0014] FIG. 5 shows a block diagram of an exemplary computing environment suitable to implement aspects of the present invention.

[0015] FIG. 6 is a flow diagram illustrating one method for providing a fuel to a vehicle.

[0016] FIG. 7 is a flow diagram illustrating another method for providing a fuel to a vehicle.

DETAILED DESCRIPTION

Overview

[0017] In various aspects, systems and methods are provided for recommending and delivering a tailored, improved, and/or optimized fuel to a vehicle. For instance, in certain aspects, a system for optimizing fuel for a vehicle is provided, which can utilize engine-related information and/or environmental-related information to determine a tailored, improved, or optimized fuel for the vehicle. The system includes a fuel optimizer, which receives data on one or more of engine conditions and environmental conditions and utilizes this information to determine an optimal fuel for the vehicle. In aspects, the fuel recommended by the fuel optimizer can be dispensed from available inventory from a typical service station tankage configuration. For example, the recommended fuel can be delivered as a blend of two or more fuels with different AKI values available at a typical service station.

[0018] In certain aspects, the fuel recommendation can include a recommendation for the addition of one or more additives or detergents. For instance, the fuel optimizer may determine, based on received data, that there are deposits in the engine. In such an instance, the fuel optimizer may recommend that the fuel include additional detergents, which may also be blended into the fuel at the point of sale.

[0019] In certain aspects, the driver or user can specify or provide criteria for the fuel optimizer to weigh when deciding upon providing a recommended fuel. For instance, in certain aspects, a driver may plan to use a vehicle to tow a heavy trailer. In such an instance, the fuel optimizer can more heavily weigh the prospect of recommending an increased AKI fuel to provide more power for towing.

[0020] Unless otherwise specified, as used herein, AKI refers to the average of the following two measured fuel properties: Research Octane Number (RON); and the Motor Octane Number (MON). The term AKI is utilized to express the octane rating or octane level of a fuel or blended fuel. RON and MON can be determined according to ASTM D2699 and D2700, respectively.

Systems and Methods

[0021] FIG. 1 depicts a fuel optimization system 100 suitable for use in implementing aspects described herein. It should be understood that the fuel optimization system 100 is an example of one suitable computing system environment and is not intended to suggest any limitation as to the scope of use or functionality of aspects of the present invention. Neither should the fuel optimization system 100 of FIG. 1 be interpreted as having any dependency or requirement related to any single source module, service, or device illustrated therein.

[0022] Generally, a fuel optimization system 100 can include a fuel optimizer 110 that can take a variety of inputs related to historical vehicle performance, historical user preferences, expected vehicle operation, and/or expected user preferences and use the inputs to provide a recommendation regarding a desirable octane value (RON, MON, or AKI) to obtain during the next visit to a service station. In some instances, the recommendation can correspond to obtaining a fuel with a higher octane rating, such as a fuel with a higher AKI value. This can be due to prior vehicle performance data that indicates knocking and/or operation at conditions which could lead to knocking behavior; due to expected changes in driving habits corresponding to an increase in mountain driving or increased towing; or various other factors. Similarly, a recommendation can correspond to using a lower AKI value if past vehicle performance data indicates operation far from knocking thresholds. Optionally, the fuel optimization system can also make adjustments to engine timing in addition to and/or in place of recommending a change in the recommended fuel. Still another type of recommendation can be to maintain the octane rating (such as AKI value) of the fuel currently being used by the vehicle.

[0023] The fuel optimization system 100 may include a fuel optimizer 110, one or more data sources 120, a user device 130, and a controller 140. In aspects, the fuel optimizer 110, the one or more data sources 120, the user device 130, and the controller 140 all may be in communication with each other, through wired or wireless connections, and/or through a network 150. The network 150 may include, without limitation, one or more local area networks (LANs) and/or wide area networks (WANs). Such networking environments are commonplace in enterprise-wide computer networks, intranets, and the Internet. Accordingly, the network 150 is not further described. In aspects, the controller 140 is associated with enabling the blending and dispensing of the recommended AKI fuel to the vehicle. The controller 140 is discussed further below with reference to FIGS. 3 and 4.

[0024] In one or more aspects, the data sources 120 can include engine conditions. A non-limiting list of example engine conditions includes vehicle mileage, vehicle age, duty cycles, engine oil temperature coolant temperatures, spark plug timing as a function of speed, data from a

knock sensor, or any combination thereof. In various aspects, one or more of the engine conditions can be collected by a telematics device, such as a telematics device plugged into, or removably coupled to, an onboard diagnostic port on the vehicle (e.g., an OBD-II port). In the same or alternative aspects, other sensors associated with a vehicle and/or engine may be communicatively coupled to an onboard vehicle computing device (e.g., an OEM vehicle computer) and can be utilized to obtain and collect any or all of the above-mentioned engine conditions.

[0025] In various aspects, the data sources 120 can include data associated with environmental conditions. A non-limiting list of example environmental conditions includes outside temperature, road elevation changes (e.g., mountain driving or driving on flat terrain), terrain (e.g., off-road or highway), or a combination thereof. In certain aspects, at least a portion of the environmental conditions data can be obtained and collected based on location data of the vehicle, e.g., via a GPS system associated with the car or driver (e.g., associated with a portion of the vehicle's onboard computing device or associated with a driver's personal computing device, such as a smart phone). In the same or alternative aspects, outside temperature can also be obtained and collected by a temperature sensor associated with the vehicle, or can be obtained via weather and location information via a driver's personal computing device.

[0026] In various aspects, the data sources 120 can include data on both the engine conditions and the environmental conditions. In certain aspects, an onboard vehicle computing device can obtain and collect both the data on the engine conditions and the environmental conditions, directly or indirectly. In aspects, one or more sensors sensing one or more engine conditions and/or environmental conditions can transmit that data to the onboard vehicle computing device for collection, e.g., using a Bluetooth connection, near-field communication, WiFi communication, wireless USB communication, optical communication, such as IrDA, or a cellular network. In alternative aspects, a driver's personal computing device can receive and collect data from one or more sensors sensing one or more engine conditions and/or environmental conditions.

[0027] In various aspects, the fuel optimizer 110 can include a receiver 112, an analyzer 114, and an output communicator 116. In some aspects, one or more of the receiver 112, the analyzer 114, and the output communicator 116 may be implemented as one or more stand-alone applications. Further, various services and/or modules may be located on any number of servers. By way of example only, the fuel optimizer 110 may reside on a server, cluster of servers, a cloud-computing device or distributed computing architecture, or a computing device remote from one or more of the data sources 120, the user device 130, or the controller 140. In certain aspects, one or more services and/or modules of the fuel optimizer 110 may reside in one or more of a user device 130, such as a laptop computer, phone, and/or a tablet, or may reside in an onboard computer

associated with a vehicle. In the same or alternative aspects, one or more services and/or modules of the fuel optimizer 110 may reside in one or more servers, cluster of servers, cloud-computing devices or distributed computing architecture, or a computing device remote from the user device 130 or the onboard computer associated with a vehicle.

[0028] In various aspects, the receiver 112 of the fuel optimizer 110 receives information from the one or more data sources 120. In certain aspects, the information from the one or more data sources 120 is transmitted to and received by the receiver 112, e.g., wirelessly transmitted using a Bluetooth connection, near-field communication, WiFi communication, wireless USB communication, optical communication, such as IrDA, or a cellular network. In aspects, the user device 130 (or an onboard computing device associated with the vehicle) may transmit to the receiver data from the one or more data sources 120.

[0029] In aspects, once the fuel optimizer 110 has received the information from the one or more data sources 120, the analyzer 114 utilizes that information from the one or more data sources 120 to determine a fuel for the vehicle that has one or more target properties, such as a target AKI value or a target amount of a detergent.

[0030] In one example, the data sources 120 may indicate that the vehicle has been driving in mountainous roads putting the engine under a heavier load, which may trigger pre-knock conditions. In this example, the fuel optimization analyzer 114 may determine that an increased AKI fuel would be beneficial, e.g., a 91 AKI fuel as opposed to the 87 AKI fuel recommended by the vehicle manufacturer. This increased AKI fuel for the vehicle in this example should provide increased protection from engine knock. As a further iteration of this example, the data sources 120 may subsequently indicate that that vehicle is in flat terrain and that the engine is not under as heavy loads as it was in the mountainous terrain. Thus, the analyzer 114 may then determine that a decreased AKI fuel, e.g., an 87 AKI fuel, is sufficient for knock protection.

[0031] In another example, the data sources 120 may indicate that the vehicle is operating in increased temperatures and/or at higher rpms, which may result in a higher load on the engine. Thus, in this example, the analyzer 114 may determine that an increased AKI fuel, e.g., a 91 AKI fuel as opposed to an 87 AKI fuel, would be beneficial to ensure that combustion in the engine's cylinders does not start too early, thus providing increased protection against engine knock. Further, under these circumstances, e.g., increased temperatures, the increased AKI fuel may provide enhance engine performance, e.g., increased horsepower.

[0032] In yet another example, based on the data sources 120, such as data on the engine conditions, the analyzer 114 may indicate that there may be combustion chamber deposits in the engine. In such an example, the analyzer 114 may recommend an increased AKI fuel that also

includes additional detergents to facilitate the removal of the combustion chamber deposits. Since combustion chamber deposits can increase engine knock propensity, the increased AKI in the fuel may provide the protection against knock before the combustion chamber deposits have been cleaned.

[0033] In still other examples, the analyzer 114 may utilize other data from the data sources 120, such as air humidity, air temperature, and/or altitude to discern the propensity of pre-knock conditions and recommend a target fuel accordingly. For instance, the propensity for pre-knock conditions may be reduced when driving in areas with higher air humidity (e.g., water may impede knock), cooler temperatures, and/or higher altitudes (e.g., lower cylinder pressure may impede knock). Based on one or more of these conditions, the analyzer 114 may recommend a decreased AKI fuel (than would be recommended in lower humidity, hotter temperatures, and/or at lower altitudes).

[0034] In certain aspects, the driver or user can specify particular criteria for the analyzer 114 to weigh when deciding upon providing a recommended fuel. For instance, in certain aspects, a driver may plan to use a vehicle to tow a heavy trailer. In such an instance, the fuel 114 can more heavily weigh the prospect of recommending an increased AKI fuel to provide more power for towing. In aspects, the driver or user may provide their preferences to the fuel optimization system 100 via the user device 130.

[0035] In certain aspects, the recommended fuel may be based on providing a lower carbon intensity fuel to minimize greenhouse gas emissions. In such an aspect, the analyzer 114 may weigh a driver's preference for reduced greenhouse gas emissions, and thus, the fuel optimizer may recommend a fuel blend that includes a biofuel or ethanol, etc. that is appropriate for the current conditions of the engine and vehicle.

[0036] It should be understood that the above examples are only a few scenarios to demonstrate the functionality of the analyzer 114 and that any combination of other information from the data sources 120 can be utilized to analyze the appropriate AKI fuel for a vehicle.

[0037] In aspects, the output communicator 116 communicates, to the user or a service station, the recommended fuel determined by the analyzer 114. For instance, in one aspect, the output communicator 116 communicates the recommended fuel to the driver's mobile computing device, e.g., the user device 130, (or an onboard computing device associated with the vehicle). In the same or alternative aspects, the output communicator 116 may communicate the recommended fuel directly to the controller 140. In aspects, the output communicator 116 may also communicate any additional recommendations or instructions associated with the recommended AKI fuel, such as a reminder to get an oil change or to add more coolant to the engine. In aspects, the output

communicator 116 can communicate via the network 150 with the user device 130, the onboard computing device associated with the vehicle, and/or the controller 140 using any of the above-mentioned wireless communication modalities.

[0038] In various aspects the fuel optimization system 100 can also provide recommended engine parameters based on information from the data sources 120. For example, FIG. 2 depicts an example process 200 for determining a recommended AKI fuel and also recommending if the timing of the ignition of a fuel and air mixture in the cylinder (hereinafter referred to as ignition timing) should be altered. For instance, the process 200 starts at step 202 with the vehicle driving. At step 204, information on the engine conditions is collected, such as information on engine knock indicators, e.g., via a knock detector device associated with the engine, or inferred from the engine conditions discussed above with reference to the data sources 120 of FIG. 1.

[0039] At step 206, it is determined if a pre-knock condition exists. In such an aspect, this determination can be carried out, for example, by the analyzer 114 of the fuel optimizer 110 discussed above with reference to FIG. 1. For instance, the fuel optimization analyzer 114 may determine, based on the information on the engine conditions (or inferred therefrom) obtained in step 204, that there is inappropriate or suboptimal combustion in one or more of the engine cylinders. At step 208, such a determination can result in determining that an increased AKI fuel is necessary, e.g., a 91 AKI fuel as opposed to an 87 AKI fuel currently being used. At step 210, the recommended increased AKI fuel is communicated to driver, the vehicle, and/or the service station. In such a step, the recommended increased AKI fuel can be communicated to driver, the vehicle, and/or the service station utilizing the output communicator 116 discussed above with reference to FIG. 1.

[0040] In certain aspects, the fuel optimization system, e.g., the fuel optimization system 100 of FIG. 1, may also take into consideration the current level of the fuel and its AKI level already in the vehicle. In such an aspect, the AKI fuel recommendation may be adjusted to account for the averaging out the AKI level of the fuel once the fuel is dispensed into the vehicle and mixed with the current fuel therein.

[0041] It should be appreciated that the lower the AKI level of the fuel, the easier or quicker such a fuel is to ignite, and conversely, the higher the AKI level of the fuel, the slower the fuel is to ignite. In certain aspects, when switching to an increased AKI fuel, it may be advantageous to delay the ignition timing to ensure ignition of the increased AKI fuel and air mixture in the cylinder occurs at the peak pressure in the cylinder. Accordingly, in various aspects, at step 212, since an increased AKI fuel is recommended, it may also be recommended to retard or delay the spark plug

ignition to compensate for the increased AKI fuel, thereby ensuring full ignition of the fuel/air mixture and to provide the maximum torque from the engine.

[0042] In one or more aspects, the delayed spark plug timing recommendation at step 212 can be communicated to the onboard computing device associated with the vehicle, e.g., via the output communicator 116 of the fuel optimizer 110 discussed above with reference to FIG. 1. In certain aspects, the delayed spark plug timing recommendation at step 212 may include an instruction to not implement the delayed spark plug timing until the increased AKI fuel is dispensed in the vehicle.

[0043] In certain aspects, once the delayed spark plug timing is recommended at step 212 and/or implemented in the vehicle after the increased AKI fuel is provided, the process 200 returns to step 204 to collect additional information on the engine conditions.

[0044] In aspects, if at step 206, it is determined that a pre-knock condition does not exist, the process 200 may ultimately recommend that a decreased AKI fuel be utilized, if the vehicle currently is utilizing a higher AKI fuel than is necessary under the current driving conditions. However, prior to recommending a lower AKI fuel be utilized, the process 200 ensures that the ignition timing is improved optimized. At step 214 of the process 200, it is determined if the ignition timing is suitable for the potential use of a lower AKI fuel, which may ultimately be recommended since no pre-knock condition exists. If the ignition timing is not sufficiently advanced, at step 216 it is recommended that the vehicle advance the ignition timing to ensure that the ignition of the fuel/air mixture occurs at the peak pressure in the cylinder. In aspects, the output communicator 116 of the fuel optimizer 110 discussed above with reference to FIG. 1 may be utilized to communicate, to the onboard computing device associated with the vehicle, the recommendation or instruction to advance the ignition timing.

[0045] If at step 214 of the process 200 it is determined that the ignition timing is optimized, then at step 218 it is determined that a lower AKI fuel is appropriate for the current driving conditions, e.g., since no pre-knock condition exists (as determined at step 206). Accordingly, at step 210 a lower AKI fuel is recommended to for the vehicle under the current driving conditions. In various aspects, the fuel optimization analyzer 114 of the fuel optimizer 110 discussed above with reference to FIG. 1 can be utilized to determine that a lower AKI fuel is appropriate, and the output communicator 116 of the fuel optimizer 110 can be utilized to communicate such a recommendation to the driver, the vehicle, and/or the service station

[0046] As discussed above, in certain aspects, the systems and processes described herein may provide a recommendation for a fuel based on engine conditions and/or environmental conditions. Further, as discussed above, such a recommended fuel may require the blending of two or more

AKI fuels readily available at a service station. FIG. 3 depicts a schematic representation of one example process 300 for communicating the AKI fuel recommendation at a service station to receive the recommended AKI fuel. It should be understood that the process 300 of FIG. 3 is only one example of how the recommended AKI fuel is communicated to the service station and provided to the vehicle 310.

[0047] FIG. 3 depicts a vehicle 310 communicating, to a controller 140 that is associated with a service station, a recommended fuel, e.g., recommended by the fuel optimizer 110 of FIG. 1. In aspects, the controller 140 enables the blending and/or dispensing of the appropriate recommended fuel to the vehicle 310. While FIG. 3 depicts the vehicle 310 communicating with the controller 140, it should be understood that the onboard computing device associated with the vehicle 310 may communicate to the controller 140, or a driver's personal mobile computing device, e.g., the user device 130 of FIG. 1, may be utilized to communicate with the controller 140. Alternatively, in certain aspects, the output communicator 116 of the fuel optimizer 110 discussed above with reference to FIG. 1, may directly communicate with the controller 140. In another alternative aspect, the driver (or other occupant) of the vehicle 310 may manually input the recommended fuel to the controller 140, via an interface at the service station. It should be understood that the controller 140 can be present at the service station (e.g., coupled to a fuel dispenser), or can be present at a location away from the service station but in communication with the fuel optimizer 110, directly or indirectly. The controller 140 can also be associated with the onboard computing device of the vehicle, or associated with the driver's personal mobile computing device.

[0048] As discussed above, the controller 140 enables the blending and dispensing of the recommended fuel to the vehicle 310. For instance, at a high level as depicted in FIG. 3, the controller 140 enables the blending of fuels from Tank A 340 and Tank B 350, each having fuels with different AKI levels, by communicating directly or indirectly with one or more metering mechanisms, e.g., metering mechanisms 341 and 351. The metering mechanisms 341 and 351 can provide the necessary amount of each fuel from Tank A 340 and Tank B 350, which then ultimately get mixed and dispensed into the vehicle 310.

[0049] Turning now to FIG. 4, an example system 400 is depicted illustrating the blending of two different fuels. The system 400 includes a controller 140, metering mechanisms 341 and 351, a totalizer 410, and a dispenser 330. The metering mechanisms 341 and 351 depicted in FIG. 4 include metering valves 342 and 352, respectively, and flow valves 344 and 354, respectively. It should be understood that the system 400 is just one example of a system and that service stations may have a variety of tanking configurations, valves, and metering components. Additionally, while the example system 400 only depicts blending two fuels, it is contemplated that additional

traditional fuels, biofuel, or additional components, e.g., detergents, or other additives, can also be blended in with the recommended fuel.

[0050] As discussed above, the controller 140 can enable the blending and dispensing of a recommended fuel to a vehicle. In operation, the controller 140 can communicate to a portion of the metering mechanisms 341 and/or 351 to initiate the blending of two or more fuels or fuel components. For instance, the controller 140 can communicate a specified required volume of a particular fuel to the flow valves 344 and/or 354. The controller 140 can communicate via a wired or wireless communication with the flow valves 344 and/or 354, such as via WiFi, Bluetooth, NFC, or cellular communication systems. The flow valves 344 and 354, along with the metering valves 342 and 352 can supply the specified volume of the respective fuels to the conduit 412, which can then be mixed in the totalizer 410 to ensure the proper blend is provided.

[0051] In one example, the controller 140 may communicate that 10 gallons of a recommended fuel having a 91 AKI value is needed. In this example, a first tank of 87 AKI fuel can be associated with the flow valve 344 and the metering valve 342, while a second tank of 93 AKI fuel can be associated with the flow valve 354 and the metering valve 352. The flow valves 344 and 354 can enable the delivery of 5 gallons of each of the 87 AKI fuel and the 93 AKI fuel to the totalizer 410 via the conduit 412. The totalizer 410 can ensure that the two fuels are properly mixed and then supply this mixed 91 AKI fuel to the dispenser 330 for dispensing to the vehicle. While not depicted in the figures, additional conduits or piping may be present to ensure that the blended fuel is provided to the appropriate dispenser at the service station.

[0052] FIG. 5 depicts one exemplary operating environment in which aspects of the present invention may be implemented is described below in order to provide a general context for various aspects of the present invention. Referring to FIG. 1, an exemplary operating environment for implementing aspects of the present invention is shown and designated generally as computing device 500. The computing device 500 is but one example of a suitable computing environment and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the invention. Neither should the computing device 500 be interpreted as having any dependency or requirement relating to any one component nor any combination of components illustrated.

[0053] Embodiments of the invention may be described in the general context of computer code or machine-useable instructions, including computer-useable or computer-executable instructions such as program modules, being executed by a computer or other machine, such as a personal data assistant or other handheld device. Generally, program modules may include routines, programs, objects, components, data structures, and the like, and/or refer to code that

performs particular tasks or implements particular abstract data types. Aspects of the invention may be practiced in a variety of system configurations, including hand-held devices, consumer electronics, general-purpose computers, more specialty computing devices, and the like. Aspects of the invention may also be practiced in distributed computing environments where tasks are performed by remote-processing devices that are linked through a communications network.

[0054] With continued reference to FIG. 5, the computing device 500 includes a bus 510 that directly or indirectly couples the following devices: a memory 512, one or more processors 514, one or more presentation components 516, one or more input/output (I/O) ports 518, one or more I/O components 520, and an illustrative power supply 522. The bus 510 represents what may be one or more busses (such as an address bus, data bus, or combination thereof). Although the various blocks of FIG. 5 are shown with lines for the sake of clarity, in reality, these blocks represent logical, not necessarily actual, components.

[0055] The computing device 500 typically includes a variety of computer-readable media. Computer-readable media may be any available media that can be accessed by the computing device 500 and includes both volatile and nonvolatile media, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules or other data. Computer-readable media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computing device 500. Combinations of any of the above are also included within the scope of computer-readable media. In some aspects, the computer-readable media can correspond to tangible computer-readable media. In some aspects, the computer-readable media can correspond to non-transitory computer-readable media.

[0056] The memory 512 includes computer-storage media in the form of volatile and/or nonvolatile memory. The memory may be removable, non-removable, or a combination thereof. Exemplary hardware devices include solid-state memory, hard drives, optical-disc drives, and the like. The computing device 500 includes one or more processors that read data from various entities such as the memory 512 or the I/O components 520. The presentation component(s) 516 present data indications to a user or other device. Exemplary presentation components include a display device, speaker, printing component, vibrating component, and the like.

[0057] The I/O ports 518 allow the computing device 500 to be logically coupled to other devices including the I/O components 520, some of which may be built in. Illustrative components include a microphone, satellite dish, scanner, printer, wireless device, and the like.

[0058] FIG. 6 depicts a flow diagram illustrating a method 600 for providing a fuel to a vehicle. At step 610, the method 600 includes collecting at least one of vehicle data and user data. The vehicle data and/or user data can be associated with engine conditions, environmental conditions, or a combination thereof. The engine conditions and environmental conditions can include any or all of the engine conditions and environmental conditions discussed above with respect to the data sources 120 of FIG. 1. In aspects, the data can be collected at a fuel optimizer receiver, such as the receiver 112 of the fuel optimizer 110 discussed above with reference to FIG. 1.

[0059] At step 620, all or a portion of the data collected at step 610 can be analyzed to determine at least one target fuel property. In aspects, the data can be analyzed by the fuel optimization analyzer 114 of the fuel optimizer 110 discussed above with reference to FIG. 1. In one aspect, the target fuel property can include a target Anti-Knock Index (AKI) value.

[0060] At step 630, instructions are communicated to a controller to dispense a fuel comprising the target fuel property to the vehicle. In various aspects, the instructions can be communicated to a controller via the output communicator 116 of the fuel optimizer 110 discussed above with reference to FIG. 1. In aspects, the controller can include any or all of the properties of the controller 140 discussed above with reference to FIG. 1.

[0061] FIG. 7 depicts a flow diagram illustrating a method 700 for providing a fuel to a vehicle. At step 710, the method 700 includes receiving at least one of vehicle data and user data. In one or more aspects, the vehicle data and/or the user data can be associated with engine conditions, environmental conditions, or a combination thereof. The engine conditions and environmental conditions can include any or all of the engine conditions and environmental conditions discussed above with respect to the data sources 120 of FIG. 1. In aspects, the data can be received at a fuel optimizer receiver, such as the receiver 112 of the fuel optimizer 110 discussed above with reference to FIG. 1.

[0062] At step 720, all or a portion of the data collected at step 710 can be analyzed to determine at least one target fuel property. In aspects, the data can be analyzed by the fuel optimization analyzer 114 of the fuel optimizer 110 discussed above with reference to FIG. 1. In one aspect, the target fuel property can include a target Anti-Knock Index (AKI) value.

[0063] At 730, two or more fuels having different Anti-Knock Index (AKI) values are mixed to form a fuel comprising the target fuel property. In various aspects, the two or more fuels can be mixed using the controller 140 and system 400 discussed above with reference to FIG. 4.

[0064] At step 740, the fuel comprising the target fuel property is dispensed to a vehicle. In one aspect, the fuel can be dispensed using the dispenser 330 discussed above with reference to FIGS. 3 and 4.

Example 1 – Performance and Drivability of Higher Octane Fuel at Varying Temperatures

[0065] Table 1 below shows an analysis of experimental data collected on a track under normal ambient temperatures (“cool”, roughly 20°C) and at extreme desert heat (“hot”, roughly 40°C) on a number of different vehicles. The performance and drivability is expressed as demonstrated horsepower in wide open throttle (WOT) acceleration. The increase in HP column in Table 1 is the calculated increase in power relative to the 87 AKI fuel demonstrated horsepower. The 87 AKI fuel and the 93 AKI fuel have matched BTU content.

Table 1

	Cool		Increase in HP	Hot		Increase in HP
	87	93		87	93	
Buick Regal	109	119	9%	93	105	13%
Ford F-150 (2004)	89	89	0%	79	86	8%
Ford F-150 (2015)	152	152	0%	152	152	0%
Ford Focus	59	62	6%	53	54	2%
Lexus GS-350	132	140	6%	125	131	5%
Toyota Camry	79	79	0%	75	75	0%
Volvo XC60	133	138	4%	112	127	13%

[0066] As can be seen in Table 1, at ambient, cool, temperatures, the Buick Regal, Ford Focus, Lexus GS-350, and the Volvo XC60 had increased horsepower using the 93 AKI fuel as opposed to the 87 AKI fuel. This increase in horsepower was enhanced at the elevated, hot, temperature. Thus, this experimental data suggests, that in several vehicle types, enhanced performance can be obtained by increasing the AKI value of a fuel. Further, this experimental data suggests that the greatest benefit is obtained when an increased AKI fuel is utilized when operating at elevated outside temperatures. This data further shows the need for being able to customize AKI values for fuels depending on vehicle type and driving habits. As shown in Table 1, the number of vehicles that benefit from increased AKI increases at the conditions corresponding to the higher driving temperature. However, some vehicles still do not show a benefit from increased AKI even at the higher driving temperature.

Example 2 – Engine Efficiency of Higher Octane Fuel at Varying Temperatures

[0067] Table 2 below shows an analysis of experimental data collected on a track under normal ambient temperatures (“cool”) and at extreme desert heat (“hot”) on a number of different

vehicles. Energy efficiency is expressed as reduced fuel consumption from using 89 AKI fuel and 93 AKI fuel relative to 87 AKI fuel on a transient drive cycle simulator similar to the Federal Test Procedure US06 utilized to evaluate vehicle emissions during high speed, high acceleration conditions. The 87 AKI fuel, the 89 AKI fuel, and the 93 AKI fuel have matched BTU content.

Table 2

	Cool		Hot	
	89	93	89	93
Buick Regal	0.0	0.0	-	2.9
Ford F-150 (2004)	0.0	0.0	0.0	0.0
Ford F-150 (2015)	0.0	1.9	0.0	1.9
Ford Focus	0.0	0.0	2.8	2.6
Lexus GS-350	0.0	0.0	3.4	4.8
Toyota Camry	0.0	0.0	3.6	4.7
Volvo XC60	-	7.7	2.6	6.1
Average	0.0	1.4	2.1	3.3

[0068] As can be seen in Table 2, in the ambient, cool, temperatures, there is no increased engine efficiency with the 89 AKI fuel. However, with the 93 AKI fuel, the Ford F-150 (2015) and the Volvo XC60 experienced an increase in engine efficiency. Further, in the extreme, hot, temperature conditions, there was an increase in energy efficiency for the majority of the tested vehicles with both the 89 AKI fuel and the 93 AKI fuel. The 93 AKI fuel provided the greatest increase in engine efficiency. This experimental data suggests that an increased AKI fuel can benefit several vehicle types, in terms of engine efficiency, especially when operating at extreme temperature conditions.

Additional Embodiments

[0069] Embodiment 1. A method being performed by one or more computing devices including at least one processor, for providing a fuel for a vehicle, the method comprising: collecting at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof; analyzing the data to determine at least one target fuel property; and communicating instructions to a controller to dispense a fuel comprising the target fuel property to the vehicle.

[0070] Embodiment 2. The method according to embodiment 1, wherein the communicated instructions further comprise instructions to mix at least two fuels having different Anti-Knock Index (AKI) values.

[0071] Embodiment 3. The method according to any of embodiments 1 and 2, wherein the controller comprises a fuel pump at a service station.

[0072] Embodiment 4. The method according to any of embodiments 1-3, wherein at least a portion of the instructions are communicated by the vehicle, or wherein at least a portion of the instructions are communicated by a handheld device, or a combination thereof.

[0073] Embodiment 5. The method according to any of embodiments 1-4, wherein the at least one of vehicle data and user data comprises engine knock information, the engine knock information comprising one or more of spark plug timing, data from a knock detection system, in-cylinder pressure, and in-cylinder temperature.

[0074] Embodiment 6. The method according to any of embodiments 1-5, further comprising analyzing the data to determine a target ignition timing.

[0075] Embodiment 7. The method according to any of embodiments 1-6, further comprising delaying ignition by a delay time period based on the target ignition timing or advancing ignition timing by an advance time period based on the target ignition timing.

[0076] Embodiment 8. A method being performed by one or more computing devices including at least one processor, for providing a fuel for a vehicle, the method comprising: receiving at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof; analyzing the data to determine at least one target fuel property; mixing two or more fuels having different Anti-Knock Index (AKI) values to form a fuel comprising the target fuel property; and dispensing the fuel comprising the target fuel property to the vehicle.

[0077] Embodiment 9. The method according to embodiment 8, wherein the mixing the two or more fuels comprises communicating with one or more flow meters or flow valves to provide a specified flow rate of each of the two or more fuels.

[0078] Embodiment 10. The method according to any of embodiments 8 and 9, further comprising mixing one or more additives into the two or more fuels based on the determined target fuel property.

[0079] Embodiment 11. The method according to embodiment 10, wherein the one or more additives comprise one or more detergents, wherein an amount of the one or more detergents for mixing into the two or more fuels is determined based on the data associated with one or more of: car engine conditions; and environmental conditions.

[0080] Embodiment 12. The method according to any of embodiments 1-11, wherein the fuel comprising the target fuel property has an increased AKI value relative to a fuel AKI value recommended by a manufacturer of the vehicle.

[0081] Embodiment 13. The method according to any of embodiments 1-12, wherein the at least one of vehicle data and user data comprises engine conditions, the engine conditions comprising one or more of mileage, duty cycles, oil temperature, and coolant temperature.

[0082] Embodiment 14. The method according to any of embodiments 1-13, wherein the at least one of vehicle data and user data comprises environmental conditions, the environmental conditions comprising one or more of location information and outside temperature.

[0083] Embodiment 15. A system comprising one or more processors and non-transitory computer storage media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform the method according to any of embodiments 1-14.

[0084] Although the present invention has been described in terms of specific embodiments, it is not so limited. Suitable alterations/modifications for operation under specific conditions should be apparent to those skilled in the art. It is therefore intended that the following claims be interpreted as covering all such alterations/modifications as fall within the true spirit/scope of the invention.

CLAIMS:

1. A method being performed by one or more computing devices including at least one processor, for providing a fuel for a vehicle, the method comprising:
 - collecting at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof;
 - analyzing the data to determine at least one target fuel property; and
 - communicating instructions to a controller to dispense a fuel comprising the target fuel property to the vehicle.
2. The method according to claim 1, wherein the communicated instructions further comprise instructions to mix at least two fuels having different Anti-Knock Index (AKI) values.
3. The method according to any of claims 1 and 2, wherein the controller comprises a fuel pump at a service station.
4. The method according to any of claims 1-3, wherein at least a portion of the instructions are communicated by the vehicle, or wherein at least a portion of the instructions are communicated by a handheld device, or a combination thereof.
5. The method according to any of claims 1-4, wherein the at least one of vehicle data and user data comprises engine knock information, the engine knock information comprising one or more of spark plug timing, data from a knock detection system, in-cylinder pressure, and in-cylinder temperature.
6. The method according to any of claims 1-5, further comprising analyzing the data to determine a target ignition timing.
7. The method according to any of claims 1-6, further comprising delaying ignition by a delay time period based on the target ignition timing or advancing ignition timing by an advance time period based on the target ignition timing.
8. A method being performed by one or more computing devices including at least one processor, for providing a fuel for a vehicle, the method comprising:
 - receiving at least one of vehicle data and user data associated with engine conditions, environmental conditions, or a combination thereof;
 - analyzing the data to determine at least one target fuel property;
 - mixing two or more fuels having different Anti-Knock Index (AKI) values to form a fuel comprising the target fuel property; and
 - dispensing the fuel comprising the target fuel property to the vehicle.

9. The method according to claim 8, wherein the mixing the two or more fuels comprises communicating with one or more flow meters or flow valves to provide a specified flow rate of each of the two or more fuels.
10. The method according to any of claims 8 and 9, further comprising mixing one or more additives into the two or more fuels based on the determined target fuel property.
11. The method according to claim 10, wherein the one or more additives comprise one or more detergents, wherein an amount of the one or more detergents for mixing into the two or more fuels is determined based on the data associated with one or more of: car engine conditions; and environmental conditions.
12. The method according to any of claims 1-11, wherein the fuel comprising the target fuel property has an increased AKI value relative to a fuel AKI value recommended by a manufacturer of the vehicle.
13. The method according to any of claims 1-12, wherein the at least one of vehicle data and user data comprises engine conditions, the engine conditions comprising one or more of mileage, duty cycles, oil temperature, and coolant temperature.
14. The method according to any of claims 1-13, wherein the at least one of vehicle data and user data comprises environmental conditions, the environmental conditions comprising one or more of location information and outside temperature.
15. A system comprising one or more processors and non-transitory computer storage media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform the method according to any of claims 1-14.

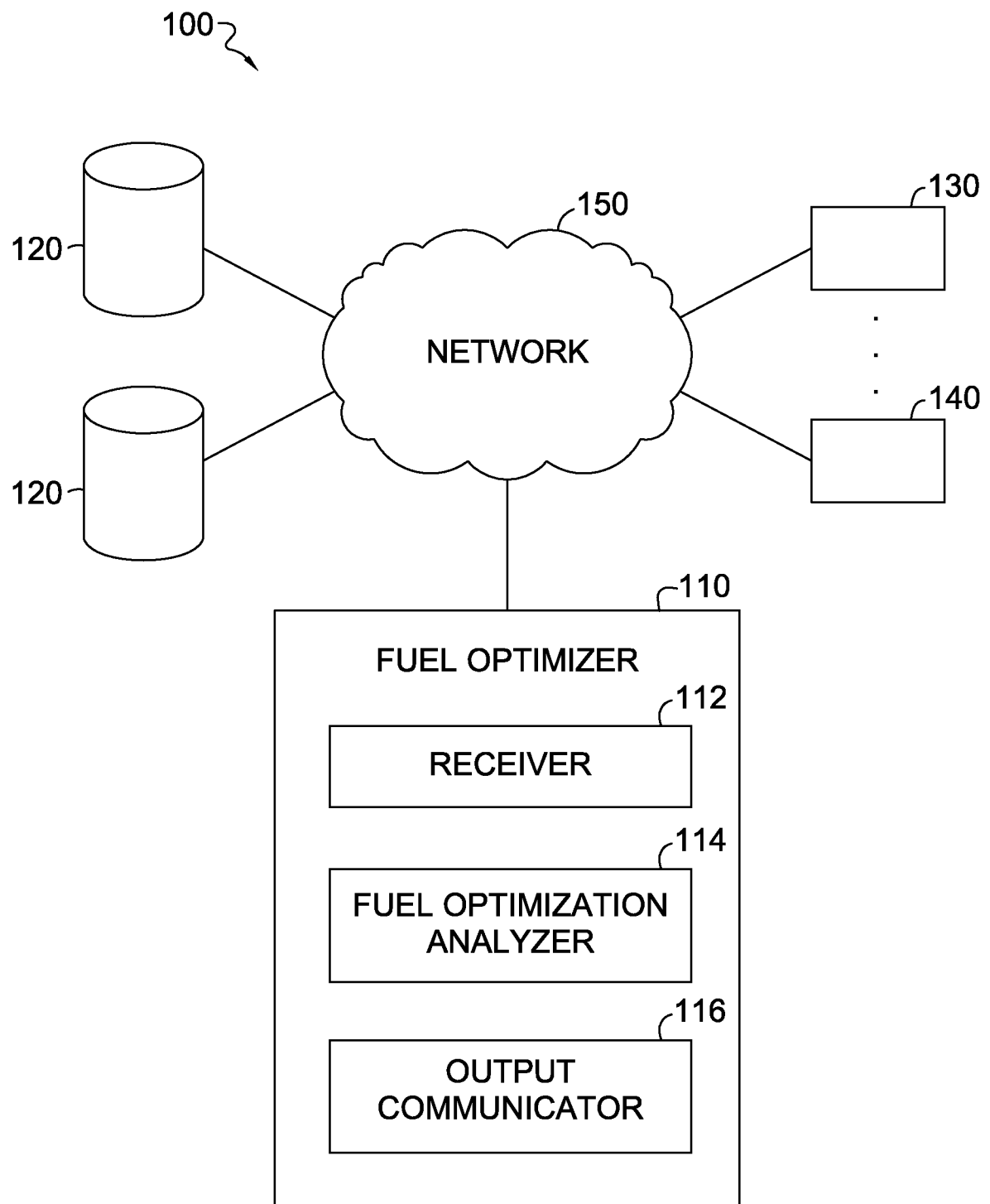


FIG. 1.

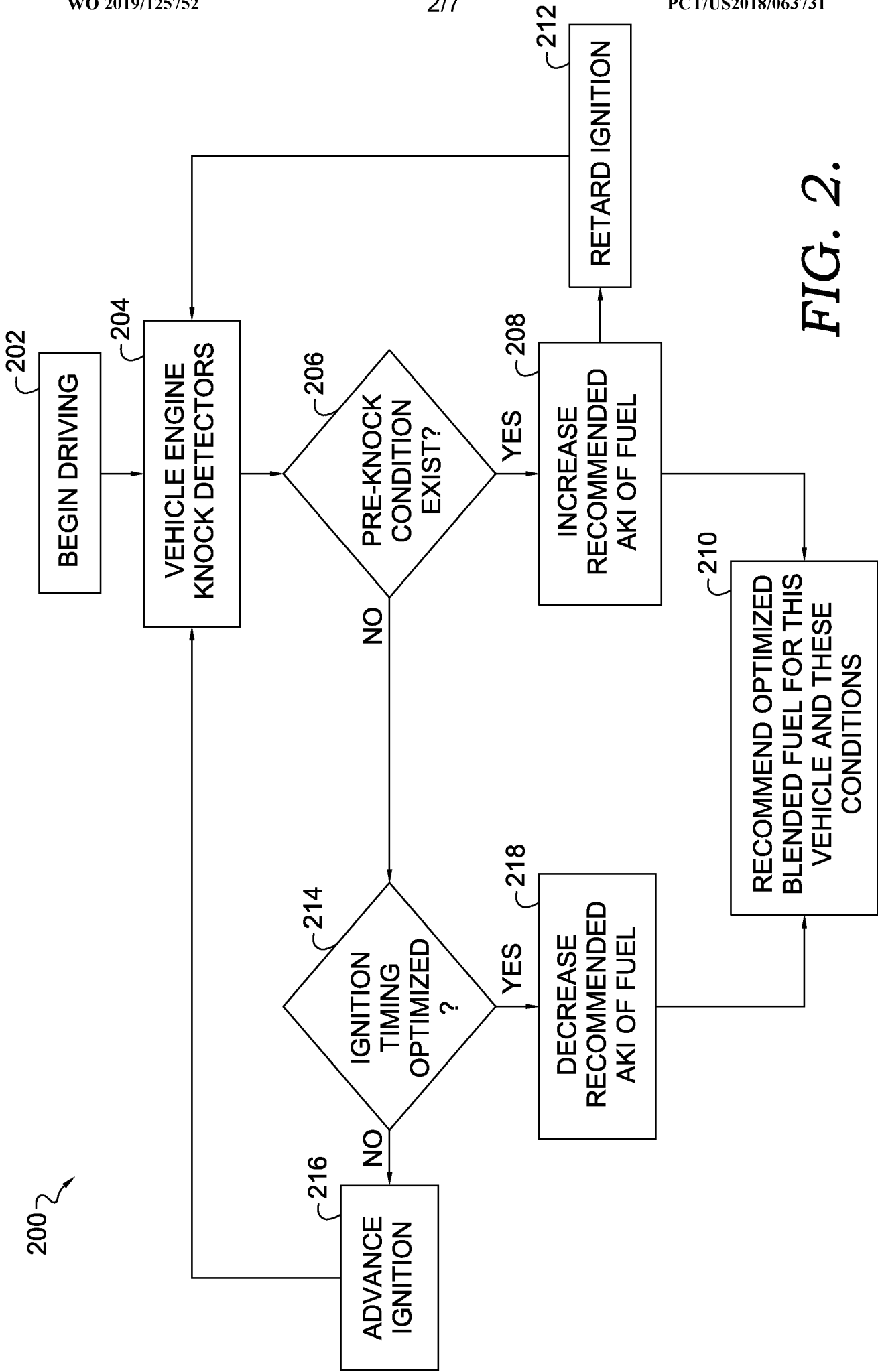


FIG. 2.

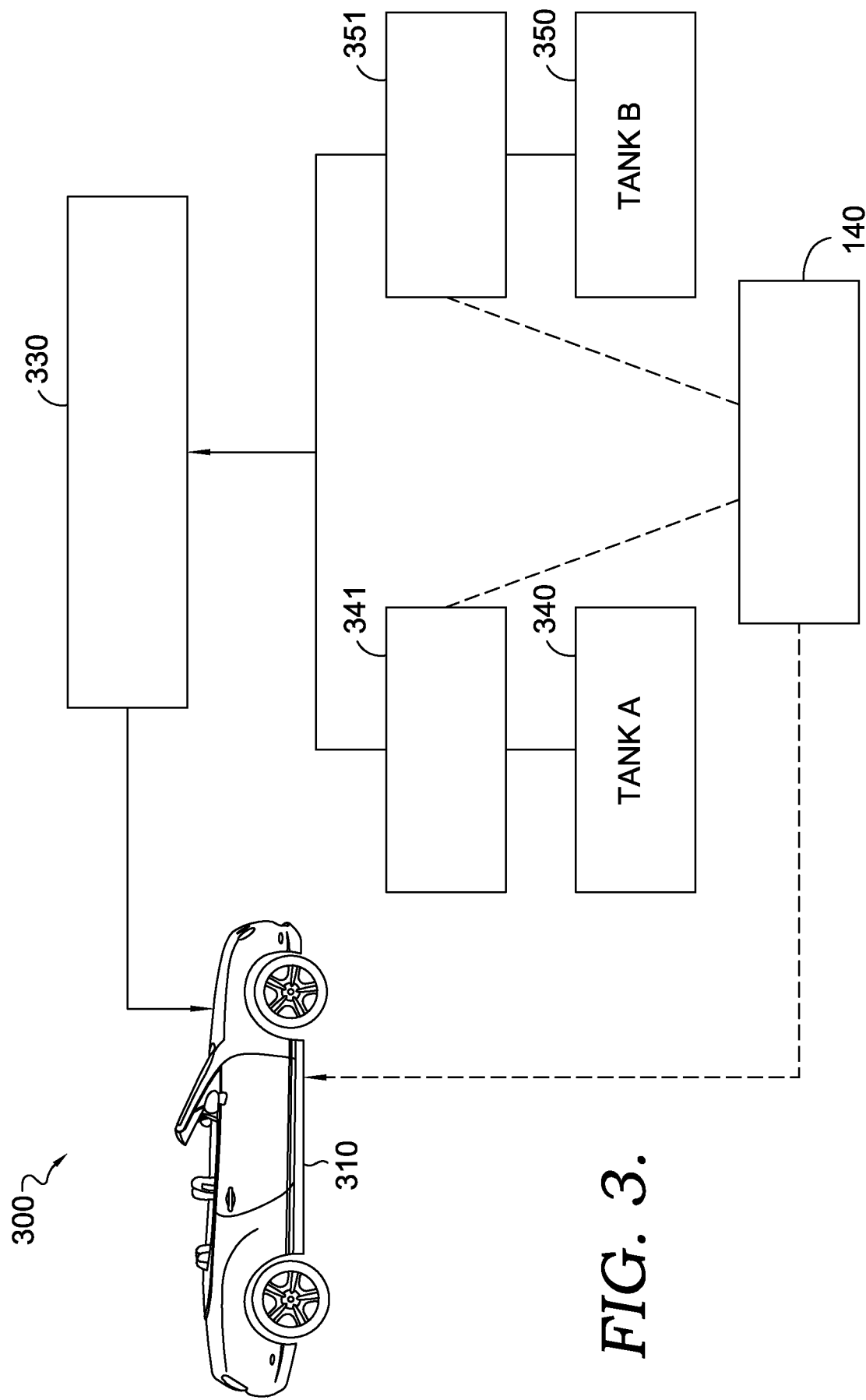


FIG. 3.

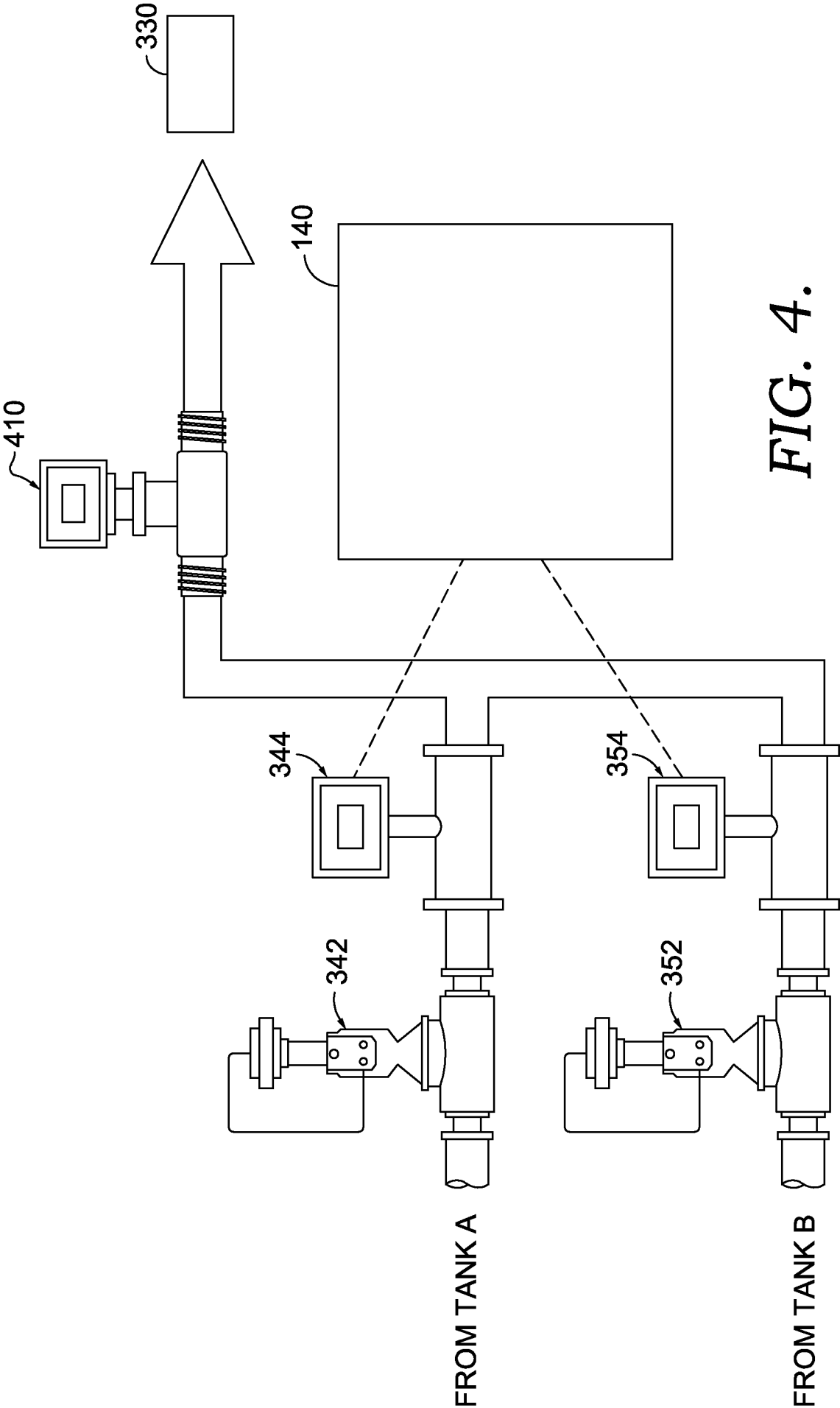
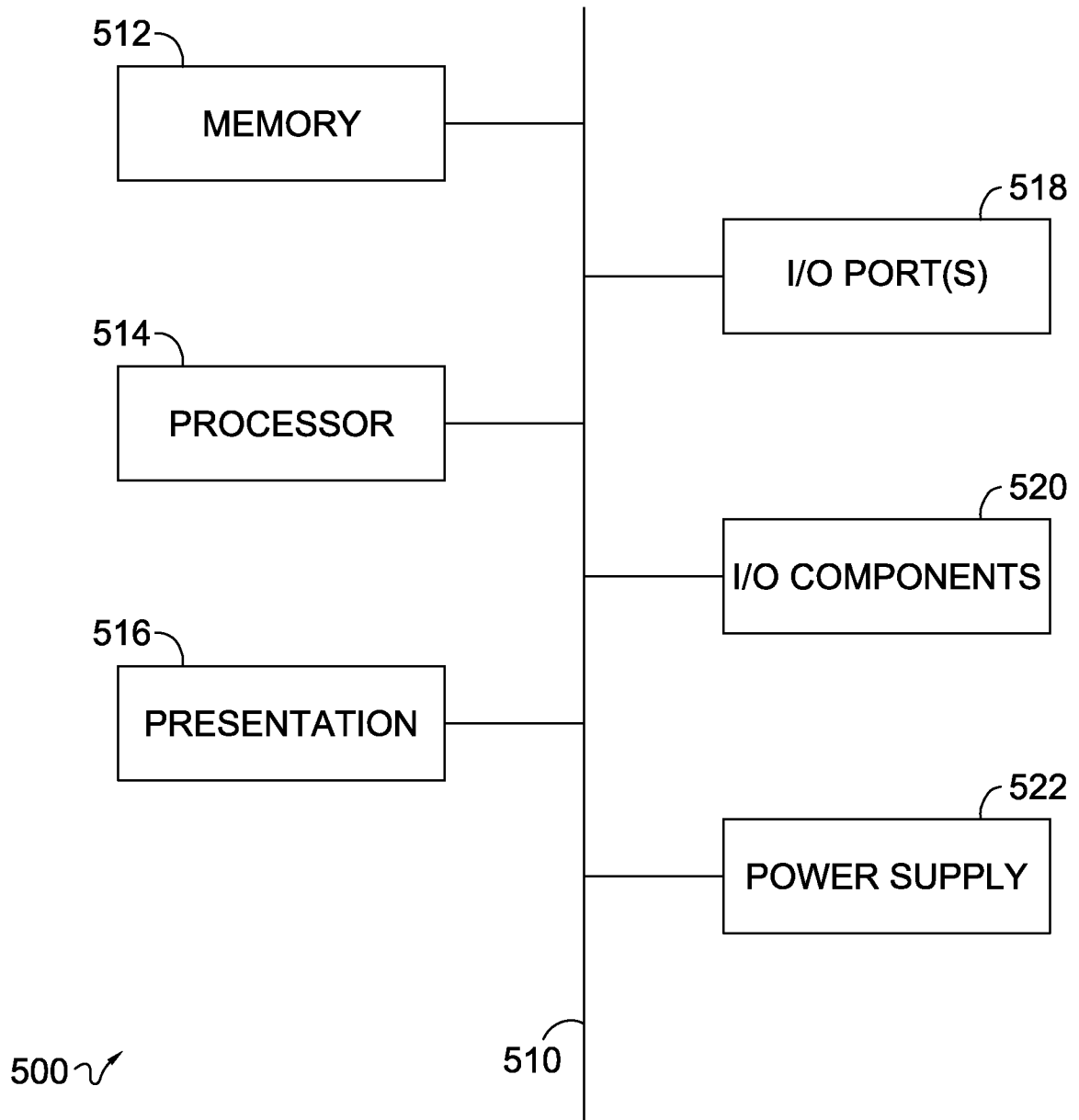
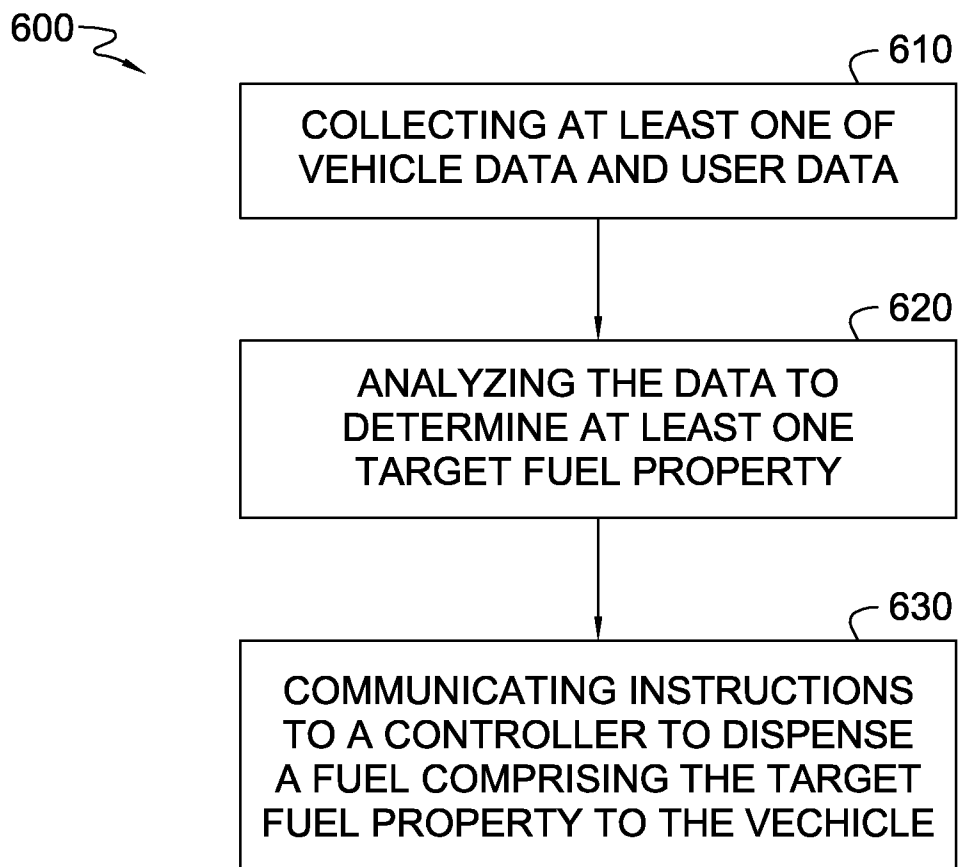
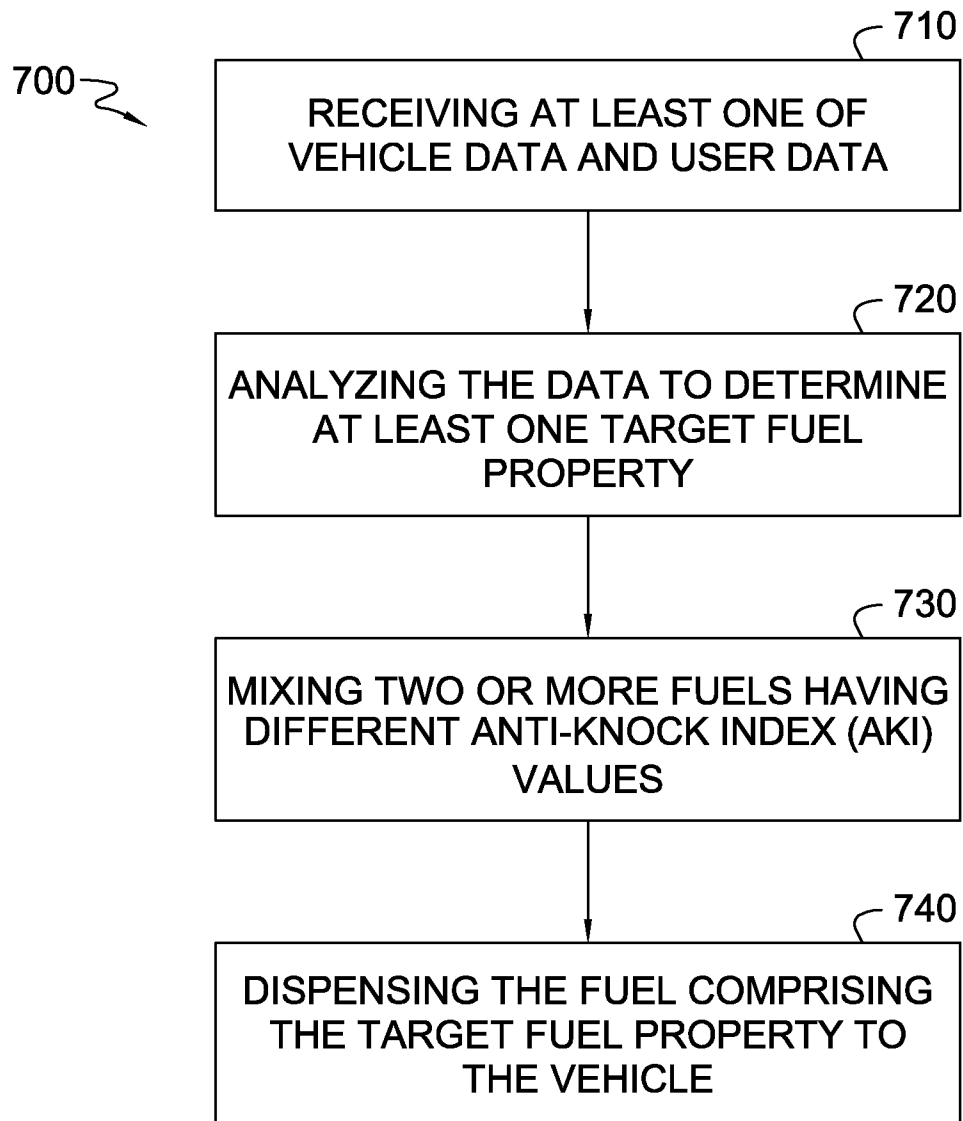


FIG. 4.

**FIG. 5.**

*FIG. 6.*

*FIG. 7.*

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/063731

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02D41/00 F02D35/02 F02D19/12 F02D19/08 B67D7/74
ADD. F02P5/15

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)
F02D F02P B67D

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	paragraphs [0004] - [0008], [0026] - [0031], [0048] - [0078]; figures 1,6 -----	2,8-11
Y	US 6 112 134 A (TERRANOVA STEVEN N [US] ET AL) 29 August 2000 (2000-08-29) column 2, line 5 - column 2, line 21; figures 1,2 column 4, line 30 - column 7, line 4 -----	2,8-11
Y	US 6 032 703 A (BAKER RICHARD EUGENE [US] ET AL) 7 March 2000 (2000-03-07) column 1, line 52 - column 3, line 15; figures 1,2 ----- -/--	2,8-11



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

6 March 2019

Date of mailing of the international search report

14/03/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Deseau, Richard

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2018/063731

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No

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