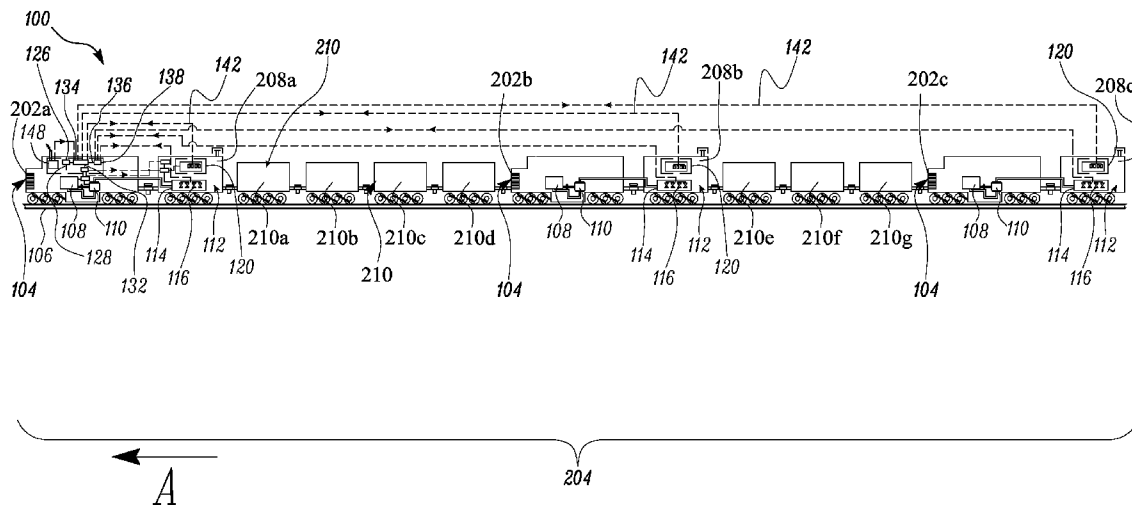




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(19) **United States**(12) **Patent Application Publication**
Kupiec et al.(10) **Pub. No.: US 2015/0149003 A1**(43) **Pub. Date: May 28, 2015**(54) **CONTROL SYSTEM FOR FUEL TENDER OF LOCOMOTIVE**(52) **U.S. Cl.**CPC **B61C 17/12** (2013.01); **B61C 17/02** (2013.01)(71) Applicant: **Electro-Motive Diesel, Inc.**, LaGrange, IL (US)(72) Inventors: **Gregory Raymond Kupiec**, Lemont, IL (US); **Dennis Melas**, Chicago, IL (US)(73) Assignee: **Electro-Motive Diesel, Inc.**, LaGrange, IL (US)(21) Appl. No.: **14/088,038**(22) Filed: **Nov. 22, 2013****Publication Classification**(51) **Int. Cl.**
B61C 17/12 (2006.01)
B61C 17/02 (2006.01)(57) **ABSTRACT**

A control system for a fuel tender of a locomotive includes an input module, a sensor module, a processor unit, and at least one actuator. The input module is configured to generate a first signal based on one or more inputs received from an operator of the locomotive. The sensor module is configured to generate a second signal based on one or more operating parameters of at least one of the locomotive and the fuel tender. The processor unit is configured to generate a first actuation signal based on at least one of the first signal and the second signal. The actuator is disposed in electrical communication with the processor unit and the fuel tender. The actuator is configured to selectively perform at least one of enabling or disabling fuel flow from the fuel tender to the locomotive based on the first actuation signal.



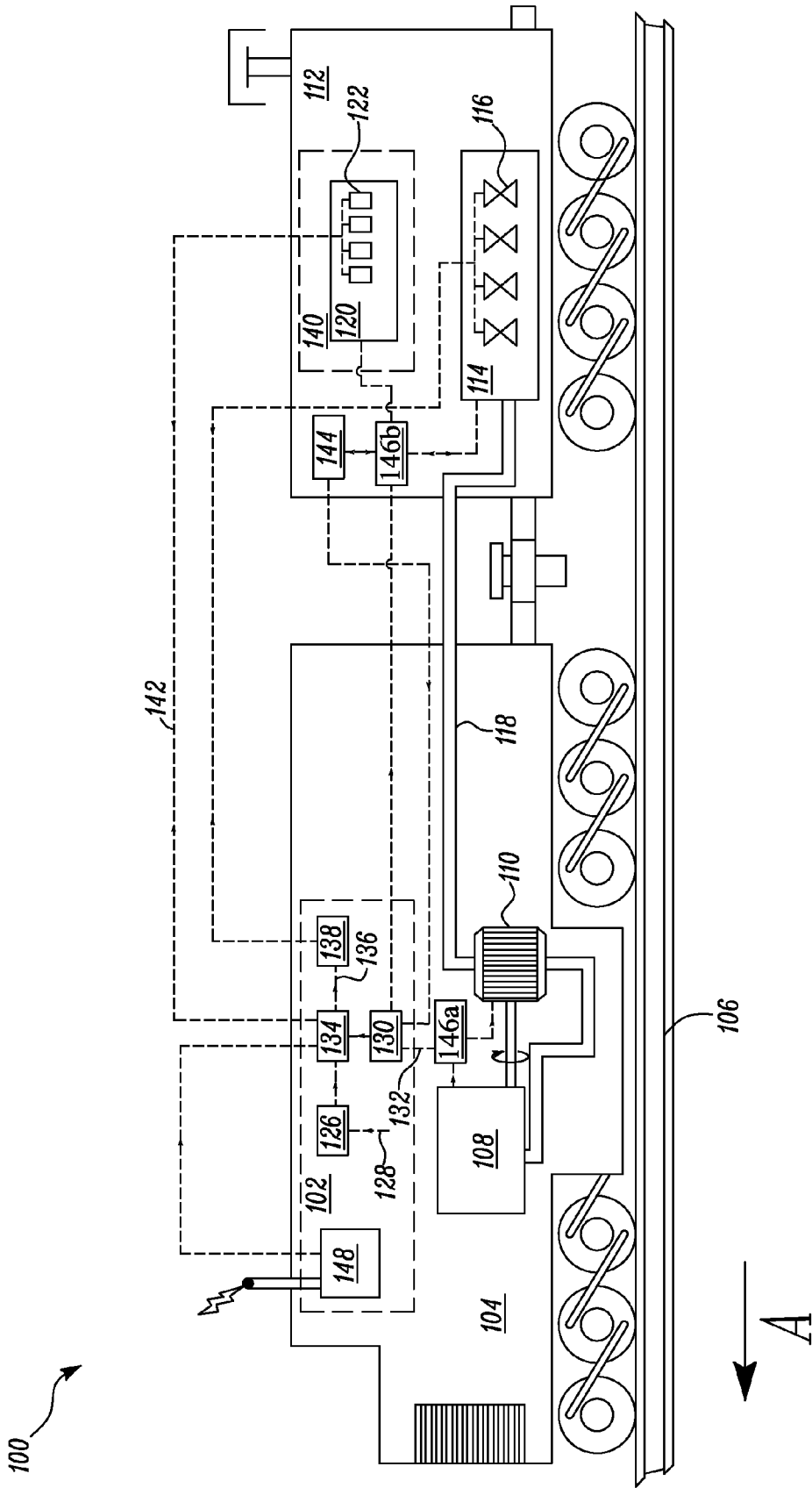
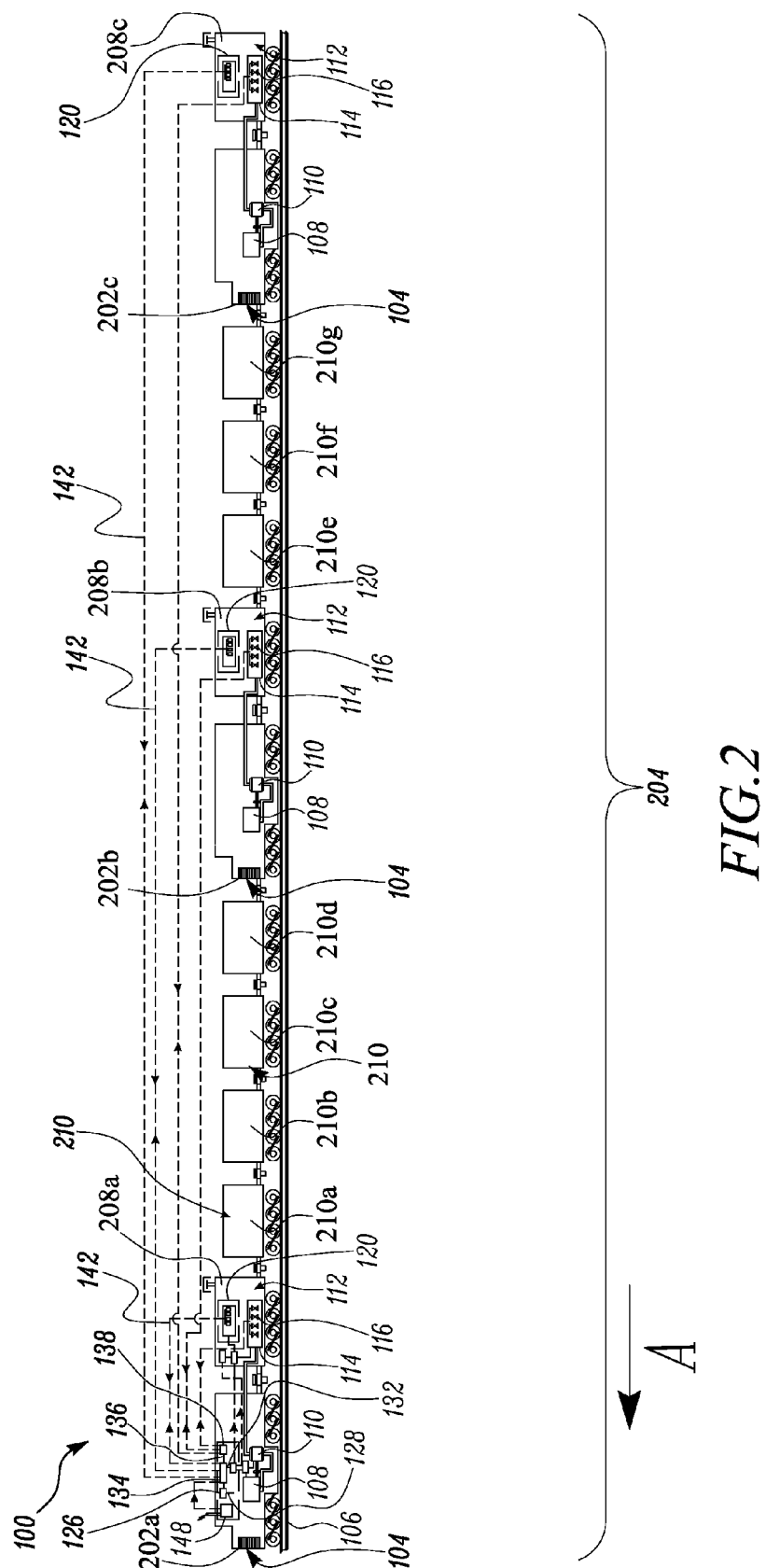


FIG. 1



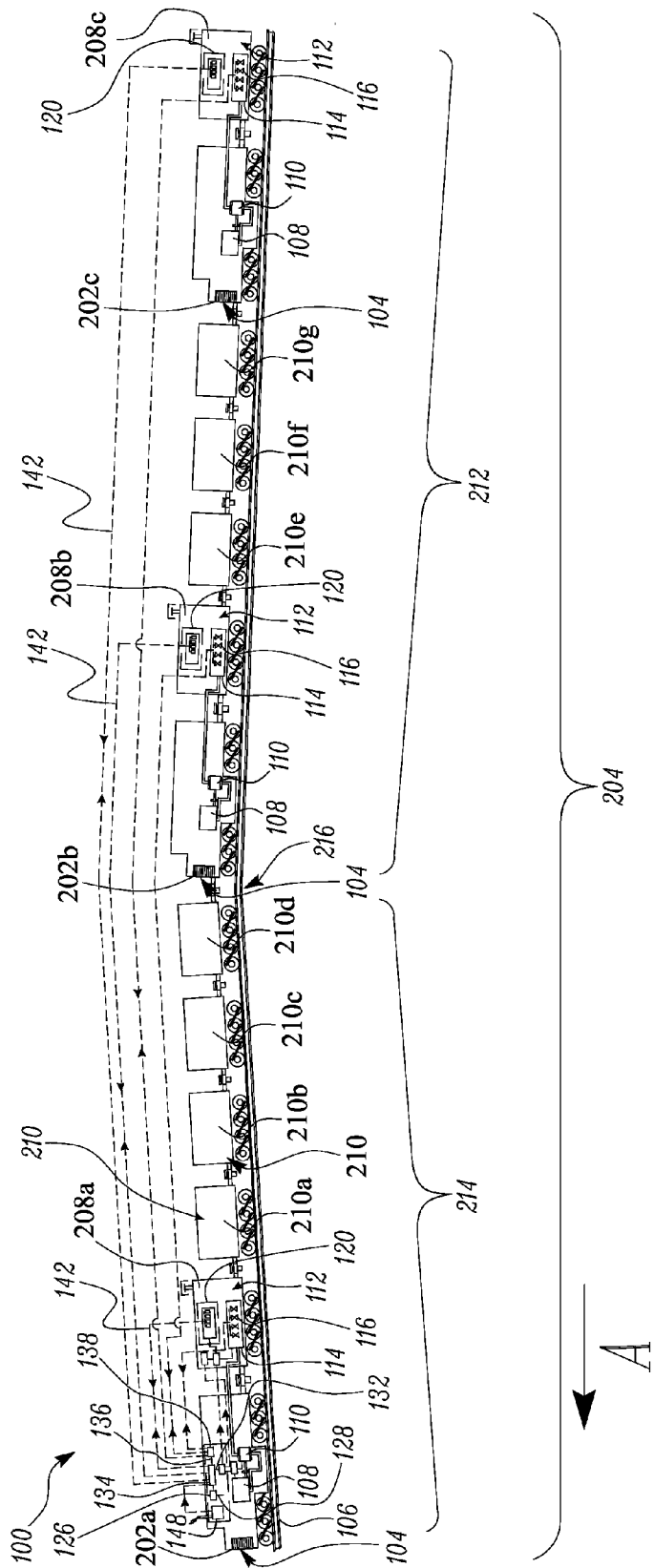


FIG. 3

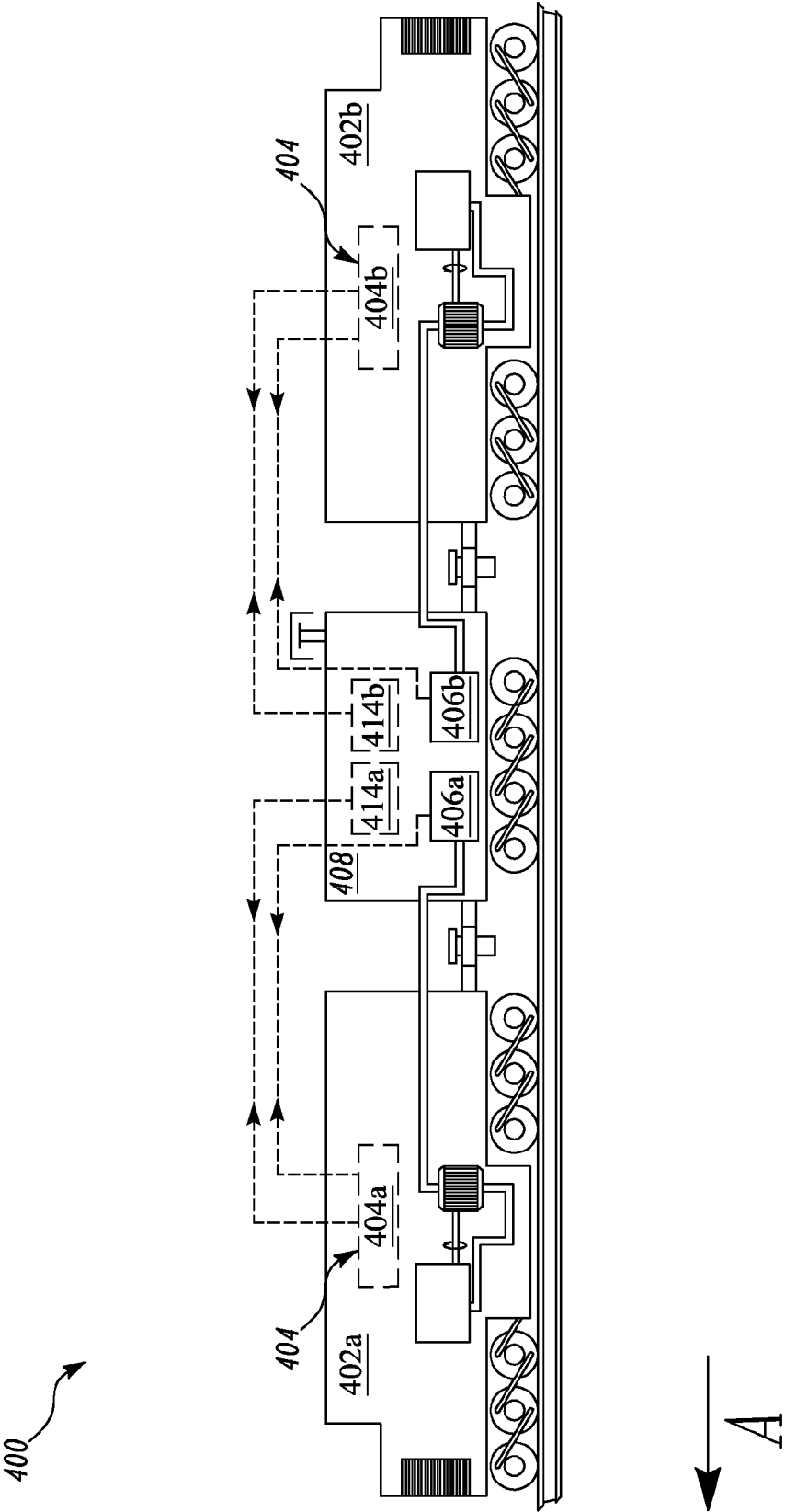


FIG.4

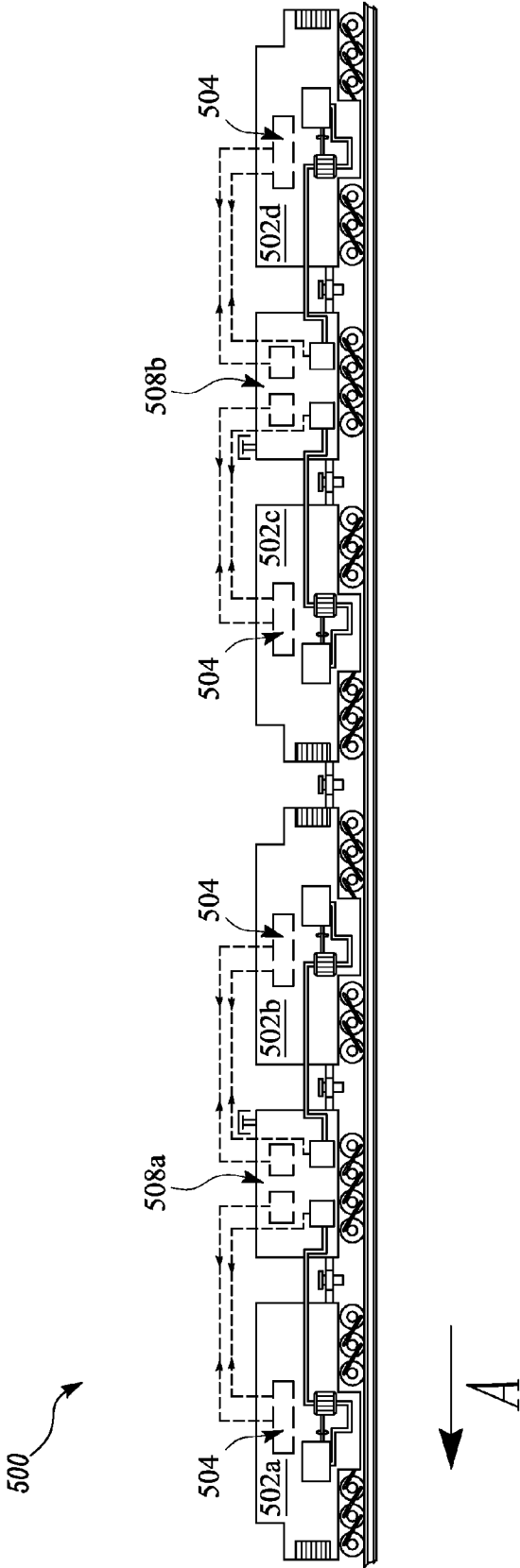


FIG.5

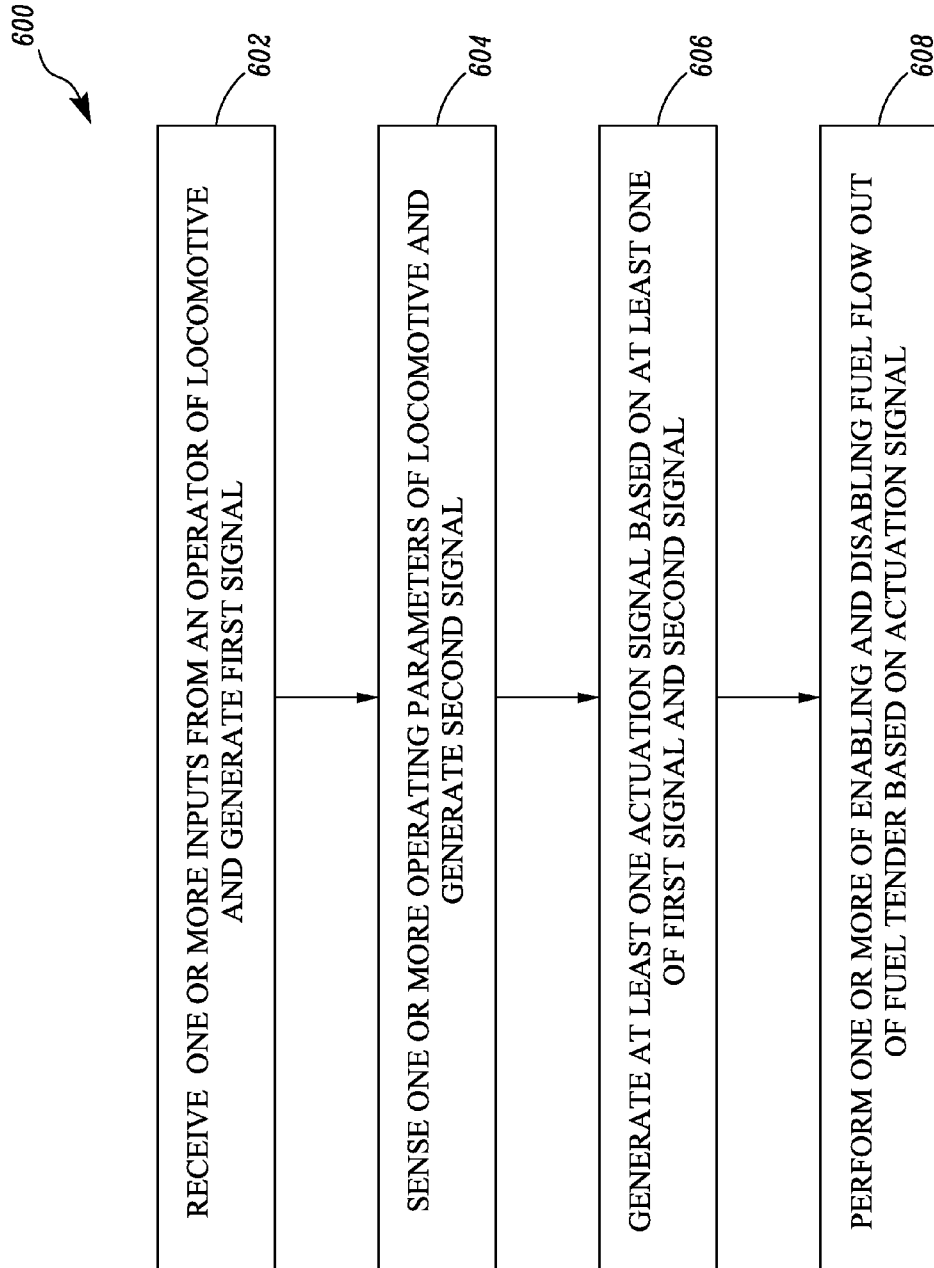


FIG. 6

CONTROL SYSTEM FOR FUEL TENDER OF LOCOMOTIVE

TECHNICAL FIELD

[0001] The present disclosure relates to a fuel tender of a locomotive, and more particularly to a control system for the fuel tender of the locomotive.

BACKGROUND

[0002] Typically, locomotives travelling on rails from one location to another location may experience varying gradients or varying pay-loads, and consequently varying load, and speed conditions. Further, locomotives may include a puller locomotive alone, a consist containing a puller locomotive, a pusher locomotive and/or any other locomotives interspersed between cab cars or bogies of the consist.

[0003] Locomotives operable on gas, for example, compressed natural gas (CNG) may employ one or more fuel tenders having a supply of liquefied natural gas (LNG) therein. One or more systems within these fuel tenders may convert LNG to CNG and deliver CNG to the locomotives. Previously known systems disclose regulation of fuel from a fuel tender to a locomotive for example, WO publication number 2013/091109 discloses an apparatus and method for supplying gaseous fuel from a tender car to an internal combustion engine on a locomotive. The method includes storing the gaseous fuel at a cryogenic temperature in a cryogenic storage tank on the tender car. The method also includes pumping the gaseous fuel to a first pressure from the cryogenic storage tank. The method further includes vaporizing the gaseous fuel at the first pressure; and conveying the vaporized gaseous fuel to the internal combustion engine; whereby a pressure of the vaporized gaseous fuel is within a range between 310 bar and 575 bar.

SUMMARY OF THE DISCLOSURE

[0004] In one aspect, the present disclosure provides a control system for a fuel tender of a locomotive. The control system includes an input module, a sensor module, a processor unit, and at least one actuator. The input module is configured to generate a first signal based on one or more inputs received from an operator of the locomotive. The sensor module is configured to generate a second signal based on one or more operating parameters of at least one of the locomotive and the fuel tender. The processor unit is communicably coupled with the input module and the sensor module, and is configured to generate a first actuation signal based on at least one of the first signal and the second signal. The actuator is disposed in electrical communication with the processor unit and the fuel tender. The actuator is configured to selectively perform at least one of enabling or disabling fuel flow from the fuel tender to the locomotive based on the first actuation signal.

[0005] In another aspect, the present disclosure discloses a method of controlling fuel flow from a fuel tender of a locomotive. The method includes generating a first signal based on one or more inputs from an operator of the locomotive. The method further includes generating a second signal based on one or more operating parameters of at least one of the locomotive and the fuel tender. The method further includes generating a first actuation signal based on at least one of the first signal and the second signal. The method further includes

performing at least one of enabling and disabling fuel flow out of the fuel tender based on the first actuation signal.

[0006] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a side view of a locomotive system showing a schematic representation of a control system employed therein, in accordance with various exemplary embodiments of the present disclosure;

[0008] FIG. 2 is a side view of the locomotive system showing the schematic representation of the control system when employed in conjunction with multiple locomotives of the locomotive system;

[0009] FIG. 3 is a side view of the locomotive system of FIG. 2 on a rail having a gradient therein;

[0010] FIGS. 4-5 show different exemplary configurations of the locomotive system; and

[0011] FIG. 6 is a method of controlling fuel flow from a fuel tender of the locomotive.

DETAILED DESCRIPTION

[0012] In the accompanying drawings, it is to be noted that an underlined numeral/alpha-numeral is employed to represent an element over which the underlined numeral/alpha-numeral is positioned. A non-underlined numeral/alpha-numeral relates to an element identified by a line linking the non-underlined numeral/alpha-numeral to the element. When a numeral/alpha-numeral is non-underlined and accompanied by an associated arrow, the non-underlined numeral/alpha-numeral is used to identify a general element at which the arrow is pointing.

[0013] The following detailed description illustrates embodiments of the present disclosure and ways in which it can be implemented. Although the best mode of carrying out the present disclosure has been disclosed, those skilled in the art would acknowledge that other embodiments for carrying out or practicing the present disclosure are possible without deviating from the scope of the claims herein.

[0014] The present disclosure relates to a control system for a fuel tender of a locomotive. FIG. 1 shows a side view of a locomotive system 100 including a schematic representation of a control system 102 employed therein. The locomotive system 100 includes a locomotive 104 configured to run on a rail 106. The locomotive 104 may be, for example, a diesel locomotive configured to run on diesel and/or Compressed Natural Gas (CNG). In an embodiment, the locomotive 104 may include an engine 108 such as, but not limited to, a diesel engine or a gas turbine engine. The locomotive 104 may further include a pump 110 coupled to the engine 108 such that the engine 108 may be configured to drive the pump 110.

[0015] The locomotive system 100 further includes a fuel tender 112 associated with the locomotive 104. The fuel tender 112 is configured to store fuel therein. The fuel may be for example, Liquefied Natural Gas (LNG). The fuel tender 112 may further include a fuel delivery system 114 including one or more fuel delivery valves 116 therein. The fuel delivery system 114 may render the fuel tender 112 in selective fluid communication with the engine 108. The pump 110 associated with the engine 108 may be configured to pump fuel from the fuel tender 112 for delivery to the engine 108. A fluid coupling system 118 may be employed to establish a fluid

connection between the pump 110 and the fuel delivery system 114. The fluid coupling system 118 may include various components such as, but not limited to, hoses, pipes or other apparatuses commonly known in the art to accomplish a fluid connection between the pump 110 and the fuel delivery system 114.

[0016] Fuels such as LNG may typically require conversion to CNG in order to be utilized by locomotives. The fuel tender 112 may include one or more fuel conversion units 120 configured to convert LNG into CNG. In an embodiment, the fuel conversion unit 120 may include one or more heat exchangers 122 therein such that the heat exchangers 122 heat up and vaporize LNG for conversion into CNG.

[0017] In an embodiment as shown in FIG. 1, the control system 102 is associated with the locomotive 104 and the fuel tender 112. The control system 102 is communicably coupled to the fuel delivery system 114 and the fuel conversion unit 120. The control system 102 includes an input module 126, which is configured to generate a first signal 128 based on one or more inputs received from an operator of the locomotive 104. In an embodiment, the input module 126 may receive at least one of a throttle position of the locomotive 104, and a position of a reverser (not shown) of the locomotive 104.

[0018] The control system 102 further includes a sensor module 130, which is configured to generate a second signal 132 based on one or more operating parameters of at least one of the locomotive 104 and the fuel tender 112. In an embodiment, the operating parameters may include at least one of a historical operating record of the locomotive 104, and a current operating record of the locomotive 104. The historical operating record and the current operating record may be a repository of data indicating past and present operating conditions of at least one of the locomotive 104 and the fuel tender 112. The operating parameters may be used to correlate and determine performance metrics of the locomotive 104 and the fuel tender 112. The sensor module 130 may generate the second signal 132 based on the performance metrics of the locomotive 104 and the fuel tender 112.

[0019] In another embodiment, the operating parameters of the locomotive 104 may include the throttle position of the locomotive 104. The sensor module 130 may include one or more sensors (not shown) configured to sense the throttle position of the locomotive 104. Although it is disclosed herein that the throttle position of the locomotive 104 is provided as by the operator or sensed by the sensor module 130, it is to be noted that these methods are exemplary in nature and hence, non-limiting of this disclosure. A person having ordinary skill in the art will acknowledge that various methods of receiving the throttle position are known in the art such that the first signal 128 and/or the second signal 132 of the present disclosure may be generated therefrom. Therefore, in an embodiment, the operator may provide the throttle position as an input via the input module 126 and alternatively, depending on specific application requirements and other design criteria of the locomotive 104, the sensor module 130 may determine the throttle position of the locomotive 104.

[0020] The control system 102 further includes a processor unit 134 communicably coupled with the input module 126 and the sensor module 130. The processor unit 134 is configured to receive the first signal 128 and the second signal 132 from the input module 126 and the sensor module 130 respectively. Further, the processor unit 134 is configured to generate a first actuation signal 136 based on at least one of the first signal 128 and the second signal 132.

[0021] The control system 102 further includes at least one actuator 138 disposed in electrical communication with the processor unit 134 and the fuel tender 112. The actuator 138 is configured to selectively perform at least one of enabling or disabling fuel flow from the fuel tender 112 to the locomotive 104 based on the first actuation signal 136. In an embodiment, enabling or disabling the fuel tender 112 by the actuator 138 includes switching "ON" or "OFF" one or more fuel delivery valves 116 of the fuel delivery system 114 associated with the fuel tender 112.

[0022] In another embodiment, the control system 102 may further include a switching module 140 associated with the fuel conversion unit 120 of the fuel tender 112. The switching module 140 may be configured to receive a second actuation signal 142 from the processor unit 134. The second actuation signal 142 enables the switching module 140 to direct the fuel conversion unit 120 to selectively perform conversion of fuel within the fuel tender 112 from a first phase to a second phase, for example, from LNG to CNG. In one embodiment, the second actuation signal 142 generated by the processor unit 134 may be an "ON" signal such that the switching module 140 switches the heat exchangers 122 of the fuel conversion unit 120 into the "ON" mode thereby enabling fuel conversion of LNG into CNG within the fuel tender 112. In another embodiment, the second actuation signal 142 generated by the processor unit 134 may be an "OFF" signal such that the switching module 140 switches the heat exchangers 122 of the fuel conversion unit 120 into an "OFF" mode thereby disabling fuel conversion of LNG into CNG within the fuel tender 112. Thus, with reference to the foregoing embodiments, enabling and disabling the fuel tender 112 by the actuator 138 may further include switching the heat exchangers 122 of the fuel conversion unit 120 from an "OFF" mode to an "ON" mode or from an "ON" mode to an "OFF" mode respectively.

[0023] In an embodiment, the operating parameters of the fuel tender 112 may include a fluid pressure in the fuel tender 112 such that the second signal 132 may be based on such current operating record of the locomotive 104. The current operating record, disclosed herein, may functionally extend to record fluid pressure in the fuel tender 112 and any fluctuations thereof. The processor unit 134 may then monitor compliance of the second signal 132 to the current fluid pressure. Further, the processor unit 134 may use the current operating record to compute or predict forward fluid pressures by way of using test data, for example, pre-calculated tables, curves, graphs, obtained from various theoretical models, statistical models, simulated models or any combinations thereof.

[0024] In order to measure the fluid pressure within the fuel tender 112, the sensor module 130 may include a pressure sensor 144 disposed within or located on the fuel tender 112. The pressure sensor 144 may be configured to measure the fluid pressure within the fuel tender 112, for example, a pressure of LNG and CNG, and provide the measured fluid pressure to the sensor module 130. Thereafter, the sensor module 130 may be configured to generate the second signal 132 based at least in part on the fluid pressure in the fuel tender 112.

[0025] In another embodiment, the operating parameters of the locomotive 104 and the fuel tender 112 may include a detected operational fault of at least one of the fuel tender 112 and the locomotive 104. The current operating record of the locomotive 104 and/or the fuel tender 112 may record the

operational faults and include the detected operational faults in a repository thereof such that the processor unit 134 may periodically assess compliance of the second signal 132 on a basis of the detected operational faults. Therefore, the second signal 132 may be based on the detected operational fault of the fuel tender 112 and/or the locomotive 104.

[0026] In order to detect operational faults with the fuel tender 112 and the locomotive 104, the sensor module 130 may further include one or more detectors 146a, 146b (two detectors shown in FIG. 1) located on the locomotive 104 and the fuel tender 112. It is to be noted that a number of detectors disclosed herein, is merely exemplary in nature and hence, non-limiting of this disclosure. Any number of detectors may be employed depending on specific requirements of an application associated with locomotives 104. For ease and convenience in differentiating between the detectors 146a, 146b disclosed herein, the two detectors 146a, 146b will be hereinafter referred to as a first detector 146a, and a second detector 146b, wherein the first detector 146a is associated with the locomotive 104 and the second detector 146b is associated with the fuel tender 112 respectively.

[0027] As shown in FIG. 1, the first detector 146a may be disposed in connection with one or more components of the locomotive 104 such as the engine 108 and/or the pump 110. Thus, the first detector 146a may be configured to detect an operational fault with the engine 108 and/or the pump 110. Similarly, the second detector 146b may be disposed in connection with the pressure sensor 144, the fuel delivery system 114, and/or the fuel conversion unit 120 of the fuel tender 112 such that the second detector 146b may be configured to detect an operational fault with the pressure sensor 144, the fuel delivery system 114, and/or the fuel conversion unit 120 of the fuel tender 112. Thus, with reference to the foregoing embodiments, the second signal 132 may be generated based on the detected operational fault of one or more of the engine 108, the pump 110, the pressure sensor 144, the fuel delivery system 114, and the fuel conversion unit 120 by the first and second detectors 146a, 146b.

[0028] In an embodiment, the control system 102 may further include a positioning module 148 disposed in communication with the processor unit 134. The positioning module 148 may be, for example, a Global Positioning System (GPS). The positioning module 148 may be configured to determine current geographic co-ordinates of the locomotive 104 and provide them to the processor unit 134. The processor unit 134 of the control system 102 may determine one or more desired operating parameters of the locomotive 104 for an oncoming rail (not shown) based on the current geographic co-ordinates of the locomotive 104.

[0029] Referring to FIG. 2, the locomotive system 100 may include multiple locomotives 104, wherein each of the locomotives 104 is associated with at least one fuel tender 112. For the purposes of clarity and understanding, reference numerals 202a, 202b, and 202c are used to denote locomotives 104 at different locations in a consist 204 of the locomotive system 100. With reference to a direction of travel "A" of the locomotive system 100, the locomotive 202a therein may be construed as a puller locomotive or a leader locomotive while the locomotive 202b and the locomotive 202c may be construed as an intermediary locomotive, and a pusher locomotive respectively. With reference to the preceding embodiment, it may be evident to a person having ordinary skill in the art that the locomotive 202a, the locomotive 202b,

and the locomotive 202c may co-operatively drive the consist 204 in the direction of travel "A".

[0030] Similarly, reference numerals 208a, 208b, and 208c are used to denote or represent fuel tenders 112 associated with the respective locomotives 202a, 202b, and 202c. In an embodiment, the locomotive system 100 may further include one or more railcars, for example cab-cars or cargo containers, interspersed along the consist 204. For the purpose of differentiation and ease in understanding the present disclosure, the railcars 210 are individually designated as 210a, 210b, 210c, 210d, 210e, 210f, and 210g. Although seven railcars 210 are illustrated in FIG. 2, it is to be noted that a number of railcars 210 in the consist 204 may differ from one locomotive system 100 to another. Further, with reference to the direction of travel "A", four railcars 210a, 210b, 210c, and 210d are shown trailing locomotive 202a while three railcars 210e, 210f, and 210g are shown trailing locomotive 202b and leading locomotive 202c. Although four railcars 210a, 210b, 210c, and 210d are shown disposed between locomotive 202a and locomotive 202b, and three railcars 210e, 210f, and 210g are shown disposed between locomotive 202b and locomotive 202c, any number of railcars may be disposed between adjacent pairs of locomotives 202a and 202b, or 202b and 202c. Hence, it is to be noted that an arrangement of railcars 210 within the consist 204 is merely exemplary in nature and hence, non-limiting of this disclosure.

[0031] With reference to FIG. 2, in one embodiment, the fuel tenders 208a, 208b, and 208c are selectively enabled or disabled based on a load distribution along the consist 204 of the locomotive system 100, for example, considering that the rail 106 is horizontal, the locomotives 202a, 202b, and 202c running over the horizontal rail 106 may experience different conditions of load based on the overall load distribution along the consist 204, for example, it may be assumed that each railcar has a loaded or unloaded weight X. Therefore, a total weight of railcars 210a, 210b, 210c, and 210d between locomotive 202a and 202b maybe 4x and a total weight of railcars 210e, 210f, and 210g between locomotive 202b and 202c maybe 3x, wherein weight 4x may be greater than weight 3x. Therefore, a load distribution along the consist 204 of the locomotive system 100 is uneven. However, as disclosed earlier herein, an arrangement of railcars 210 within the consist 204 is merely exemplary in nature, and hence, the load distribution along the consist 204 may change according to the arrangement of railcars 210 within the consist 204.

[0032] With continued reference to FIG. 2, it may be seen that the control system 102 of the present disclosure is communicably coupled to the fluid delivery systems 114 and the fuel conversion units 120 of the each fuel tender 208a, 208b, and 208c. Therefore, the control system 102 may be configured to determine which fuel tenders 208a, 208b, and 208c are to be enabled and disabled depending on the overall load distribution along the consist 204. Thereafter, the control system 102 may be configured to switch "ON" and switch "OFF" the fuel delivery systems 114 and/or the fuel conversion units 120 of the determined fuel tenders 208a, 208b, and 208c. For example, in the specific illustration of the locomotive system 100 of FIG. 2, the control system 102 may enable the fuel tenders 208a, 208b while simultaneously disabling the fuel tender 208c based on the uneven load distribution along the consist 204. However, other combinations of fuel tenders 208a, 208b, and 208c may be selected for enablement and disablement depending on the load distribution along the consist 204 thereof. Therefore, a single control system 102

located at the locomotive **202a** may be configured to selectively enable or disable the fuel tenders **208a**, **208b**, and **208c** associated with each of the locomotives **202a**, **202b**, and **202c**. Alternatively, each locomotive **202a**, **202b**, and **202c** and the associated fuel tender **208a**, **208b**, and **208c** may be provided with the control system **102**, wherein the individual control systems **102** may be networked using suitable communication links or cables. The individual control systems **102** may be configured to co-operatively communicate with each other and synchronously perform the functions of selectively enabling and disabling the individual fuel tenders **208a**, **208b**, and **208c**.

[0033] In an embodiment of the present disclosure, the fuel tenders **208a**, **208b**, and **208c** may be selectively enabled or disabled based on one or more desired operating parameters of the locomotive for the oncoming rail. The positioning module **148**, for example, the GPS module may provide the processor unit **134** with the second signal **132** indicative of the current geographic co-ordinates of the locomotives **202a**, **202b**, or **202c**. In one embodiment, the control system **102** may further include a memory unit (not shown) configured to store geographical data such as, but not limited to, maps, terrain data, gradient of the rail **106** at various locations in the direction of onward travel **A**. The processor unit **134** may be configured to look up the memory unit based on the current geographic co-ordinates and retrieve information pertaining to the oncoming rail. Thereafter, the processor unit **134** may generate the first and/or second actuation signals **136**, **142** based on the current geographic co-ordinates such that each of the fuel tenders **208a**, **208b**, and **208c** is selectively enabled or disabled based on the desired operating parameters of the locomotive **104** for the oncoming rail. Therefore, it may be possible to achieve desired operating parameters such as, but not limited to, power, or speed at each of the locomotives **202a**, **202b**, and **202c** for the oncoming rail.

[0034] The control system **102** of the present disclosure may be configured to enable or disable each fuel tender **208a**, **208b**, and **208c** of the locomotive system **100** individually. Further, the control system **102**, disclosed herein, may be further configured to switch “ON” and switch “OFF” the fuel delivery system **114** and the fuel conversion unit **120** of each fuel tender **208a**, **208b**, and **208c** individually. Therefore, control of the fuel delivery system **114** and the fuel conversion unit **120** of each fuel tender **208a**, **208b**, and **208c** may be executed independent of each other.

[0035] As shown in FIG. 3, the rail **106** may have a gradient therein, for example, an upwardly sloping section **212**, and a downwardly sloping section **214** disposed thereafter. Further, the upwardly sloping section **212**, and the downwardly sloping section **214** together define a pinnacle **216** therebetween. With reference to the direction of travel “A”, the locomotive **202a** traverses the upwardly sloping section **212** before the locomotives **202b** and **202c**. Therefore, the locomotive **202a** is shown in a position after the pinnacle **216**. At this position, the locomotive **202a** experiences free rolling motion due to its weight and the weight $4\times$ of the railcars **210a**, **210b**, **210c**, and **210d**. However, the locomotives **202b** and **202c** may experience a need for power from their respective engines **108** due to the weight of the locomotives **202b** and **202c** and also the weight $3\times$ of the railcars **210e**, **210f**, and **210g**. Therefore, the control system **102** may selectively disable the fuel tender **208a** i.e. switch “OFF” the fuel delivery system **114** and/or the fuel conversion unit **120** associated with the fuel tender **208a** and enable the fuel tenders **208b**, and **208c** i.e. switch

“ON” the fuel delivery systems **114** and/or the fuel conversion units **120** associated with the fuel tenders **208b** and **208c**.

[0036] Although load distribution along the consist **204** and gradients in the rail **106** are disclosed herein as factors affecting the selective enabling or disabling of the fuel tenders **208a**, **208b**, and **208c**, it is to be noted that the selectively enabling or disabling of the fuel tenders **208a**, **208b**, and **208c** may be based on various other factors and operating conditions of the locomotive system **100**. Hence, load distribution along the consist **204** and gradients in the rail **106** must be construed as illustrative embodiments of the present disclosure and taken in an explanatory sense rather than limitations to the present disclosure.

[0037] FIGS. 4-5 show different exemplary configurations of the locomotive system **400**, **500**. In the exemplary configuration of FIG. 4, a single fuel tender **408** is shown disposed between a pair of locomotives **402a**, **402b**. The fuel tender **408** may be configured to supply fuel to the pair of locomotives **402a**, **402b**. The fuel tender **408** may include separate fuel delivery systems **414a**, **414b** therein, corresponding to the locomotives **402a**, **402b**. A single control system **404** may be located on one of the locomotives **402a**, **402b** and coupled to the fuel tender **408**. Alternatively, two control systems **404a**, **404b** may be employed on the locomotives **402a**, **402b**, wherein control system **404a** is associated with locomotive **402a**, while control system **404b** is associated with locomotive **402b**.

[0038] Additionally, with regards to accomplishing fuel conversion, it may be contemplated to include separate fuel conversion units **406a**, **406b** in the fuel tender **408** such that the separate fuel conversion units **406a**, **406b** correspond to the individual locomotives **402a**, **402b**. Accordingly, each fuel conversion unit **406a**, **406b** may be configured to convert a phase of the fuel depending on specific requirements of the corresponding locomotives **402a**, **402b**.

[0039] In the exemplary configuration of FIG. 5, the locomotive system **500** may employ four locomotives **502a**, **502b**, **502c**, **502d**. Further, the locomotive system **500** may further include a pair of fuel tenders **508a**, **508b**. The fuel tender **508a** may be configured to supply fuel to the locomotives **502a**, **502b** while the fuel tender **508b** may be configured to supply fuel to the locomotives **502c**, **502d**. One may observe that the locomotive system **500** may be construed as an arrangement of multiple locomotive systems **400** of FIG. 4 i.e. multiple locomotives systems **400** may be daisy-chained to each other to form the locomotive system **500**. In this case, it may be possible to employ a single control system **504** located on any one of the locomotives **502a**, **502b**, **502c**, **502d** or alternatively multiple control systems **504a**, **504b**, **504c**, **504d** corresponding to the locomotives **502a**, **502b**, **502c**, **502d**. Therefore, one having ordinary skill in the art will appreciate that various numbers, configurations, permutations and/or combinations of arrangement may be possible when employing the control system, the fuel delivery system, and the fuel conversion unit of the present disclosure such that the fuel tenders are configured to individually and/or collectively cater to the fuel requirements of the locomotives.

[0040] It is to be noted that the terms “first signal” and “second signal”, as disclosed herein, are used merely to aid the reader’s understanding of the present disclosure. Although the first signal **128** and the second signal **132** represent a single operator input or a single operating parameter at a given instant of time, it is further contemplated that the first signal **128** and the second signal **132** may collectively

represent a group of operator inputs and a group of operating parameters. Therefore, a scope of the terms “first signal” and “second signal” should not be construed as being limited to any specific number of operator inputs or operating parameters at a given instant of time. Rather, the scope of the terms “first signal” and “second signal” may extend to include several unique pieces of information to assist the control system in performing the functions as laid out in the present disclosure.

[0041] It may be further noted that numerous commercially available microprocessors can be configured to perform the functions of the control system 102 disclosed herein. It may be appreciated that the control system 102 could readily be embodied in a general machine microprocessor capable of controlling numerous processing and actuation functions. The control system 102 may include Random Access Memory (RAM), Read Only Memory (ROM), secondary storage devices, and other components for running an application. Various other circuits may be associated with the control system 102 such as power supply circuitry, signal conditioning circuitry, solenoid driver circuitry, and other types of circuitry. Various routines, algorithms, and/or programs can be programmed within the control system 102 for execution thereof.

INDUSTRIAL APPLICABILITY

[0042] FIG. 6 shows a method 600 of controlling fuel flow from the fuel tender 112 of the locomotive 104. At step 602, the control system 102 generates the first signal 128 based on the one or more inputs from the operator of the locomotive 104. In an embodiment, the control system 102 may receive at least one of the throttle position, and the position of the reverser associated with the locomotive 104.

[0043] At step 604, the control system 102 generates the second signal 132 based on the one or more operating parameters of at least one of the locomotive 104 and the fuel tender 112. In an embodiment, the operating parameters of the locomotive 104 may include one or more of the historical operating record, and the current operating record of the locomotive 104. In another embodiment, the operating parameters of the locomotive 104 may include the throttle position of the locomotive 104.

[0044] In an embodiment, the operating parameters of the locomotive 104 and the fuel tender 112 may include a fluid pressure in the fuel tender 112 such that the second signal 132 generated by the sensor module 130 may be based at least in part on the fluid pressure in the fuel tender 112. The control system 102 may enable or disable the fuel tender 112 based on the fluid pressure measured by the pressure sensor 144. For example, if the measured fluid pressure of LNG and CNG in the fuel tender 112 exceeds a maximum rated pressure of the fuel tender 112, the control system 102 may generate the first and second actuation signals 136, 142 configured for switching “OFF” the fuel delivery system 114 and/or the fuel conversion unit 120. In another example, when the measured fluid pressure of LNG and CNG in the fuel tender 112 exceeds a maximum rated pressure of the fuel tender 112, the control system 102 may generate the first actuation signal 136 for switching “ON” the fuel delivery system 114 while also generating the second actuation signal 142 for switching “OFF” the fuel conversion unit 120. As disclosed earlier herein, the fuel conversion unit 120 and the fuel delivery system 114

disclosed herein may be independently controlled by the control system 102 via the first actuation signal 136 and the second actuation signal 142.

[0045] In an embodiment, the control system 102 may be configured to generate the second signal 132 indicative of the operational fault of the locomotive 104 or of the fuel tender 112. For example, if the engine 108, the pump 110, or any component thereof fails to operate in a state other than that is intended, the detector 146a associated with the engine 108 or the pump 110 may generate the second signal 132 based on the detected operational fault. Thereafter, the control system 102 may enable or disable the fuel tender 112 i.e. switch “OFF” or “ON” the fuel delivery system 114 and the fuel conversion unit 120. In another embodiment, the control system 102 may be configured to receive the current geographic co-ordinates of the locomotive 104 and determine one or more desired operating parameters of the locomotive 104 for the oncoming rail based on the current geographic co-ordinates of the locomotive 104. Further, the control system 102 may enable or disable the fuel tender 112 i.e. switch “OFF” or “ON” the fuel delivery system 114 and the fuel conversion unit 120 based on the desired operating parameters of the locomotive 104 for the oncoming rail.

[0046] At step 606, the control system 102 may be configured to generate the first actuation signal 136 based on at least one of the first signal 128 and the second signal 132. The processor unit 134 receives the first signal 128 from the operator and the second signal 132 from the sensor module 130 and/or the positioning module 148 such that the processor unit 134 is configured to generate the first actuation signal 136 based on at least one of the first signal 128 and the second signal 132.

[0047] At step 608, the method 400 further includes performing one or more of enabling and disabling fuel flow out of the fuel tender 112 based on the first actuation signal 136. The actuator 138 of the control system 102 is configured to receive the first actuation signal 136 from the processor unit 134 and selectively switch “ON” or switch “OFF” the fuel delivery system 114 of the fuel tender 112. In an embodiment, the actuator 138 may be additionally configured to receive the second actuation signal 142 from the processor unit 134 and may configure the fuel conversion unit 120 to perform conversion of fuel within the fuel tender 112 from the first phase to the second phase based on the second actuation signal 142, for example, the fuel conversion unit 120 may be configured to covert LNG to CNG. Therefore, the fuel conversion unit 120 may be selectively switched “ON” or switched “OFF” by the processor unit 134 and the actuator 138 of the control system 102.

[0048] Although the present disclosure discloses one actuator 138 for switching of the fuel delivery system 114 and fuel conversion unit 120 into the “ON” or “OFF” state, it is to be noted that a number of actuators 138 used is merely exemplary in nature and hence, non-limiting of this disclosure. Any number of actuators 138 may be communicably connected to the processor unit 134 and may be configured to receive the first and/or the second actuation signals 136, 142 therefrom such that the actuators 138 are configured to switch “ON” or switch “OFF” the fuel delivery system 114 and the fuel conversion unit 120.

[0049] In an embodiment of the present disclosure, the method 400 disclosed herein may be applicable to multiple locomotives 202a, 202b, and 202c wherein the locomotive 202a, 202b, and 202c are associated with the respective fuel

tenders **208a**, **208b**, and **208c**. With reference to the preceding embodiment, the method further includes selectively enabling or disabling the fuel tender **208a**, **208b**, and **208c** associated with each locomotive **202a**, **202b**, and **202c**. The method further includes selectively enabling or disabling the fuel tender **208a**, **208b**, and **208c** associated with each locomotive **202a**, **202b**, and **202c** based on at least one of the load distribution between the locomotives **202a**, **202b**, and **202c**, and one or more desired operating parameters of the locomotives **202a**, **202b**, and **202c** for the oncoming rail.

[0050] In an exemplary embodiment, an oncoming rail may demand that the locomotive system **100** of FIG. 3 operate at an overall throttle speed “2”. However, the control system **102** of the present disclosure may take into account many factors such as the historical and/or current operating record of the locomotive **104**, and detected operational faults of the locomotive **104** and the fuel tender **112**, if any, and may thereafter determine the desired operating parameters of each locomotive **104** in the locomotive system **100**, for example, the control system **102** may determine that each of the locomotives **202a** and **202c** should operate at a throttle position “3” while the locomotive **202b** should operate at a throttle position “0”. Therefore, for the horizontally oriented rail **106** of FIG. 2 and the known load distribution along the consist **204** of the locomotive system **100**; the overall throttle speed “2” may be achieved from an average of the throttle positions “3”, “0”, and “3” at the respective locomotives **202a**, **202b**, and **202c**.

[0051] With reference to the foregoing embodiments, it may be further contemplated that the control system **102** is programmed with various decision-making logics such as algorithms of priorities, hierarchies such that the control system **102** generates the first and second actuation signals **136**, **142** with pre-set time-delays to different parameters disclosed herein. For example, it may be envisioned that an operational fault in the locomotive **104** or the fuel tender **112** may be cause for concern and hence, the control system **102** may be pre-programmed to give priority i.e. offer minimal or no time-delay while generating the actuation signals **136**, **142** upon detection of an operational fault. However, the control system **102** may offer a pre-set time delay while generating the actuation signals **136**, **142** in response to the current geographic location from the positioning module **148**.

[0052] Further, the control system **102** may be additionally programmed with decision making in conflict of signals such as when one or more parameters are represented through the first and second signals **128**, **132**, for example, detection of an operational fault and an anticipated rail condition. In such scenarios, the control system **102** may give priority i.e. offer minimal or no time-delay while generating the actuation signals **136**, **142** based upon detection of the operational fault as compared to generating the actuation signals **136**, **142** based upon the anticipated rail condition. Therefore, a person having ordinary skill in the art will acknowledge that the control system **102** may be configured to execute various types and combinations of algorithms, programs, and logics to execute responses appropriately desired for the contemplated situations. Therefore, any suitable algorithm, program, and logic may be used to execute the steps and methods disclosed herein without deviating from the scope of this disclosure.

[0053] The control system **102** of the present disclosure may improve fuel utilization in the locomotive system **100**. When fuel supply is selectively needed by one or more locomotives **202a**, **202b**, and **202c**, the control system **102** may

determine the desired operating parameters of the locomotive system **100** such that the fuel from the respective fuel tenders **208a**, **208b**, and **208c** is appropriately distributed to the selected locomotives **202a**, **202b**, and **202c** based on the pre-set programs, logic, and parameters of the processor unit **134**. Therefore, the control system **102** of the present disclosure may improve fuel utilization by the locomotive system **100**.

[0054] The control system **102** of the present disclosure may prolong a service life of various components located within the fuel tender **112**. For example, the control system **102** may switch “OFF” the fuel delivery system **114** and the fuel conversion unit **120** of the fuel tender **112** when fuel supply is not needed by the locomotive **104** based on the oncoming railroad, or if the second signal **132** is based on the detected operational fault of the locomotive **104** or the fuel tender **112**.

[0055] Previously known systems typically accomplished conversion of fuel within the fuel tender **112** from the first phase to the second phase, for example, LNG to CNG. Thereafter, the fuel tender **112** would store CNG and any unconverted LNG therein. However, as the conversion process may involve heating LNG to vaporize into CNG, the fluid pressure within the tank may increase. In the event that the locomotive **104** would not need any converted fuel for an oncoming rail i.e. CNG, and/or if fluid pressure in the fuel tender **112** exceeded the maximum rated pressure of the fuel tender **112**, the converted fuel i.e. CNG would be vented out of the fuel tender **112** and into the atmosphere. This may lead to waste of effort in converting the fuel from one phase to another while also entailing wastage of the vented fuel. Further, fuel vented into the atmosphere may cause pollution and may pose other environmental concerns.

[0056] With implementation of the control system **102** disclosed herein, the locomotive system **100** may be able to offset effort and costs associated with conversion and supply of fuel into the locomotive **104**. The control system **102** may switch the fuel delivery systems **114** and the fuel conversion units **120** of the fuel tenders **208a**, **208b**, and **208c** “ON” or “OFF” based on the first actuation signal **136** and the second actuation signal **142**. The first actuation signal **136** and the second actuation signal **142** may be based on various factors such as, but not limited to, oncoming rail conditions, operational faults of the locomotives **202a**, **202b**, and **202c** or fuel tenders **208a**, **208b**, and **208c**, and historical and/or current operating record of the locomotives **202a**, **202b**, and **202c**. Further, the fuel delivery system **114** and the fuel conversion unit **120** of each fuel tender **208a**, **208b**, and **208c** may be switched “ON” and “OFF” independently of each other i.e. the fuel delivery system **114** may be switched “ON” while the fuel conversion unit **120** may be switched “OFF”.

[0057] The control system **102** may be configured to prevent wastage of fuel occurring with use of previously known systems. Therefore, use of the control system **102** disclosed herein may prevent pollution and other environmental concerns associated with venting of CNG into the atmosphere. Further, implementation of the control system **102** disclosed herein may improve an overall efficiency and performance of the locomotive system **100** thus improving profitability and reducing exorbitant costs associated with operation of the fuel tenders **112**.

[0058] While aspects of the present disclosure have been particularly shown and described with reference to the embodiments above, it will be understood by those skilled in

the art that various additional embodiments may be contemplated by the modification of the disclosed machines, systems and methods without departing from the spirit and scope of what is disclosed. Such embodiments should be understood to fall within the scope of the present disclosure as determined based upon the claims and any equivalents thereof.

We claim:

1. A control system for a fuel tender of a locomotive, the control system comprising:

an input module configured to generate a first signal based on one or more inputs received from an operator of the locomotive;

a sensor module configured to generate a second signal based on one or more operating parameters of at least one of the locomotive and the fuel tender;

a processor unit communicably coupled with the input module and the sensor module, the processor unit configured to generate a first actuation signal based on at least one of the first signal and the second signal; and at least one actuator disposed in electrical communication with the processor unit and the fuel tender, the actuator configured to selectively perform at least one of enabling or disabling fuel flow from the fuel tender to the locomotive based on the first actuation signal.

2. The control system of claim 1 further comprising a switching module associated with a fuel conversion unit of the fuel tender, the switching module configured to receive a second actuation signal from the processor unit such that the switching module directs the fuel conversion unit to selectively perform conversion of fuel from a first phase to a second phase within the fuel tender.

3. The control system of claim 1, wherein the operating parameters of the locomotive include one or more of:
a historical operating record of the locomotive; and
a current operating record of the locomotive.

4. The control system of claim 1 further comprising a positioning module configured to determine current geographic co-ordinates of the locomotive, wherein the control system is further configured to determine one or more desired operating parameters of the locomotive for an oncoming rail based on the current geographic co-ordinates of the locomotive.

5. The control system of claim 1, wherein the one or more operating parameters of the locomotive include at least a throttle position of the locomotive.

6. The control system of claim 1, wherein the one or more operating parameters include at least one of a fluid pressure in the fuel tender, and a detected operational fault of at least one of the fuel tender and the locomotive.

7. The control system of claim 1, wherein the one or more inputs received by the input module includes at least one of a throttle position of the locomotive, and a position of a reverser of the locomotive.

8. The control system of claim 1, wherein the locomotive includes a plurality of locomotives, and wherein each of the plurality of the locomotives is associated with at least one fuel tender.

9. The control system of claim 8, wherein the control system is further configured to selectively enable or disable the fuel tender associated with each of the plurality of locomotives.

10. The control system of claim 9, wherein the fuel tender is selectively enabled or disabled based on at least one of a load distribution between the plurality of locomotives, and one or more desired operating parameters of the locomotive for an oncoming rail.

11. A method of controlling fuel flow from a fuel tender of a locomotive, the method comprising:

generating a first signal based on one or more inputs from an operator of the locomotive;

generating a second signal based on one or more operating parameters of at least one of the locomotive and the fuel tender;

generating a first actuation signal based on at least one of the first signal and the second signal; and

performing at least one of enabling and disabling fuel flow out of the fuel tender based on the first actuation signal.

12. The method of claim 13 further comprising generating a second actuation signal and selectively performing conversion of fuel from a first phase to a second phase within the fuel tender based on the second actuation signal.

13. The method of claim 13, wherein the operating parameters of the locomotive include one or more of:

a historical operating record of the locomotive; and

a current operating record of the locomotive.

14. The method of claim 13 further comprising receiving current geographic co-ordinates of the locomotive to determine one or more desired operating parameters of the locomotive for an oncoming rail.

15. The method of claim 13, wherein the one or more operating parameters of the locomotive include at least a throttle position of the locomotive.

16. The method of claim 13, wherein the operating parameters of at least one of the locomotive and the fuel tender include one or more of a fluid pressure in the fuel tender, and a detected operational fault of at least one of the fuel tender and the locomotive; and wherein the second signal is based at least in part on one or more of the fluid pressure in the fuel tender, and the detected operational fault of at least one of the fuel tender and the locomotive.

17. The method of claim 13, wherein the one or more inputs received by the input module includes at least one of a throttle position of the locomotive, and a position of a reverser of the locomotive.

18. The method of claim 13, wherein the locomotive includes a plurality of locomotives, and wherein each of the plurality of the locomotives is associated with at least one fuel tender.

19. The method of claim 18, wherein the method further includes selectively enabling or disabling the fuel tender associated with each of the plurality of locomotives.

20. The method of claim 19 further including selectively enabling or disabling the fuel tender associated with each of the plurality of locomotives based on at least one of a load distribution between the plurality of locomotives, and one or more desired operating parameters of the locomotive for an oncoming rail.

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