(19) **United States**

(12) **Patent Application Publication** (10) Pub. No.: **US 2013/0345914 A1**

Love et al. (43) **Pub. Date: Dec. 26, 2013**

(54) **VEHICLE SPEED LIMITING VIA ENGINE CONTROL COMMANDS BASED ON SENSED MACHINE STATE**

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(57) **ABSTRACT**

A machine includes a drive train with an electronically controlled transmission in communication with an electronic engine controller. The machine ground speed is limited by executing a vehicle speed limit algorithm in the electronic transmission controller in response to a sensed machine state. This algorithm generates an engine control message that is communicated to the electronic engine controller. The power output of the engine is reduced responsive to the engine control message. The machine responds by not exceeding a prescribed speed limit programmed into the electronic transmission controller. This vehicle speed limiting strategy is particularly applicable to machines without a vehicle speed limiting algorithm resident in the electronic engine controller.
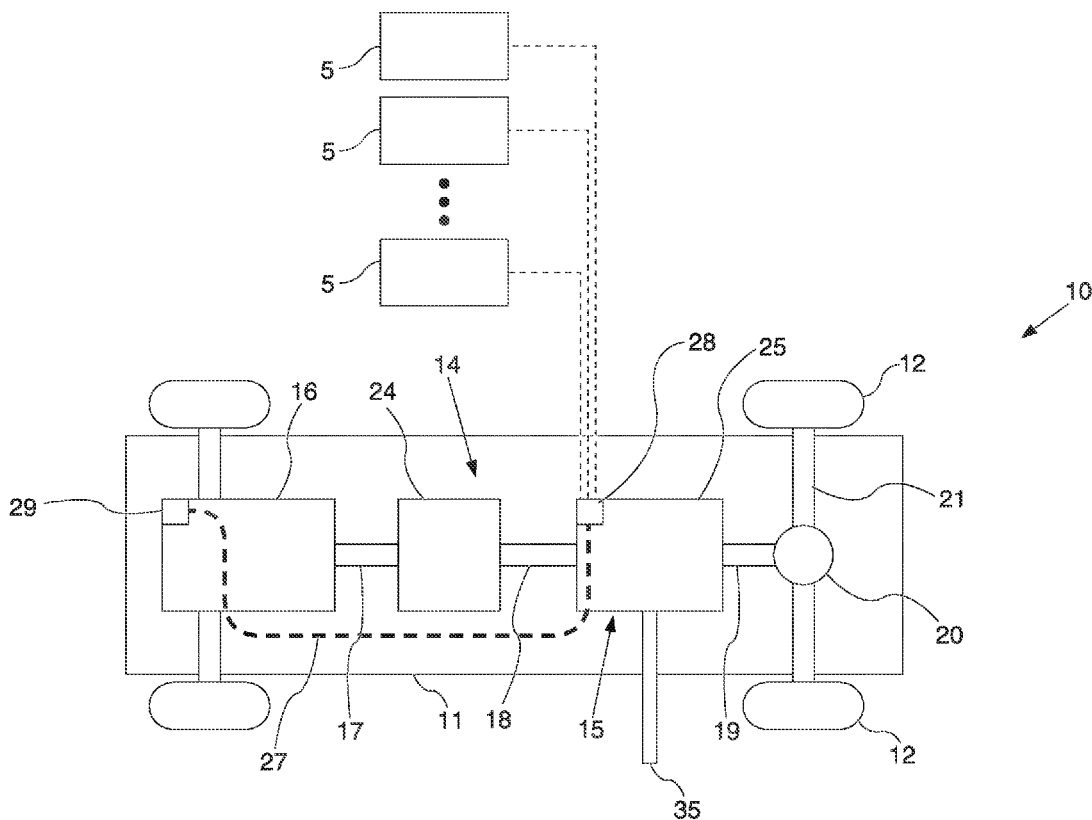
FIG. 1
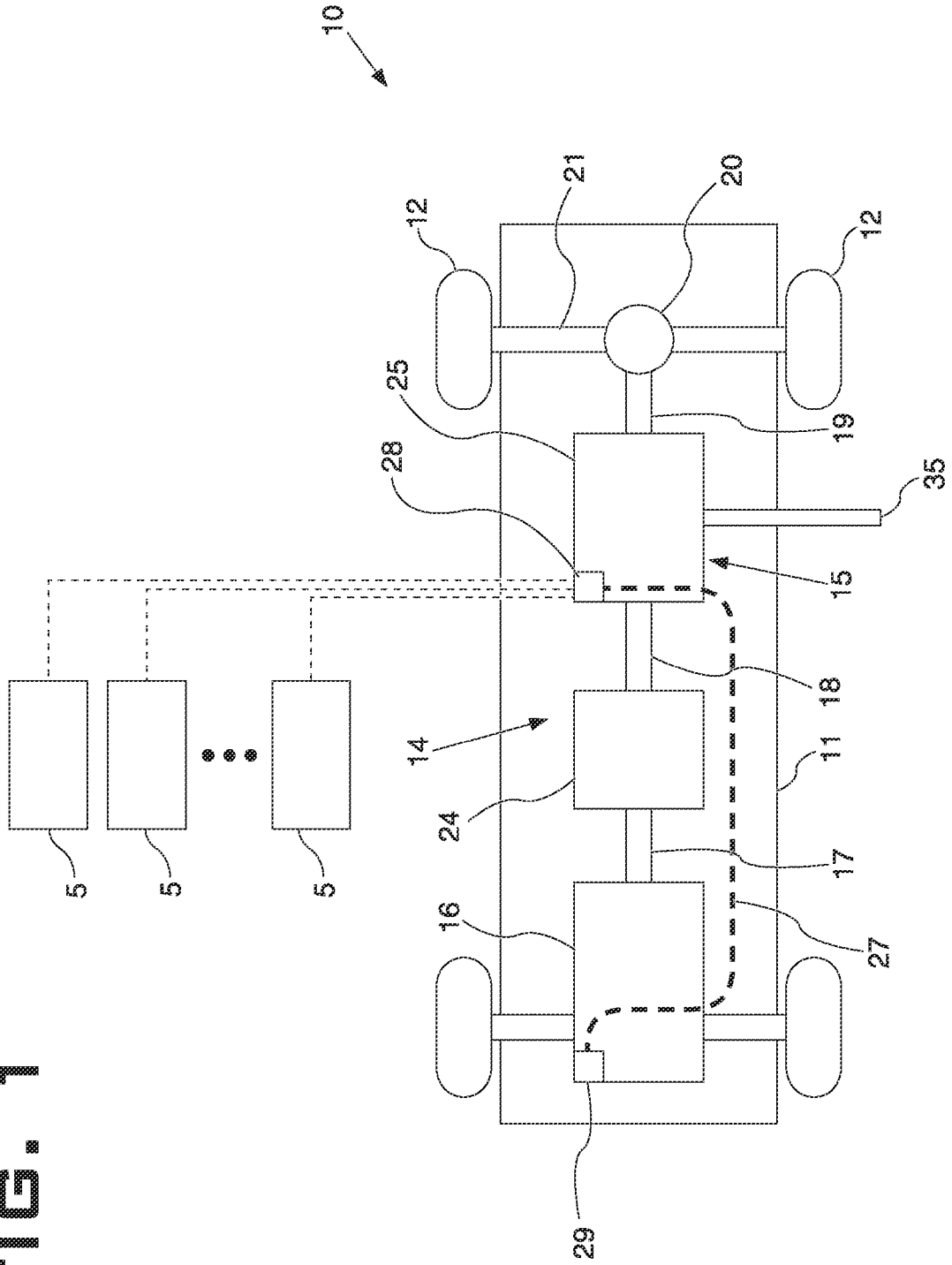
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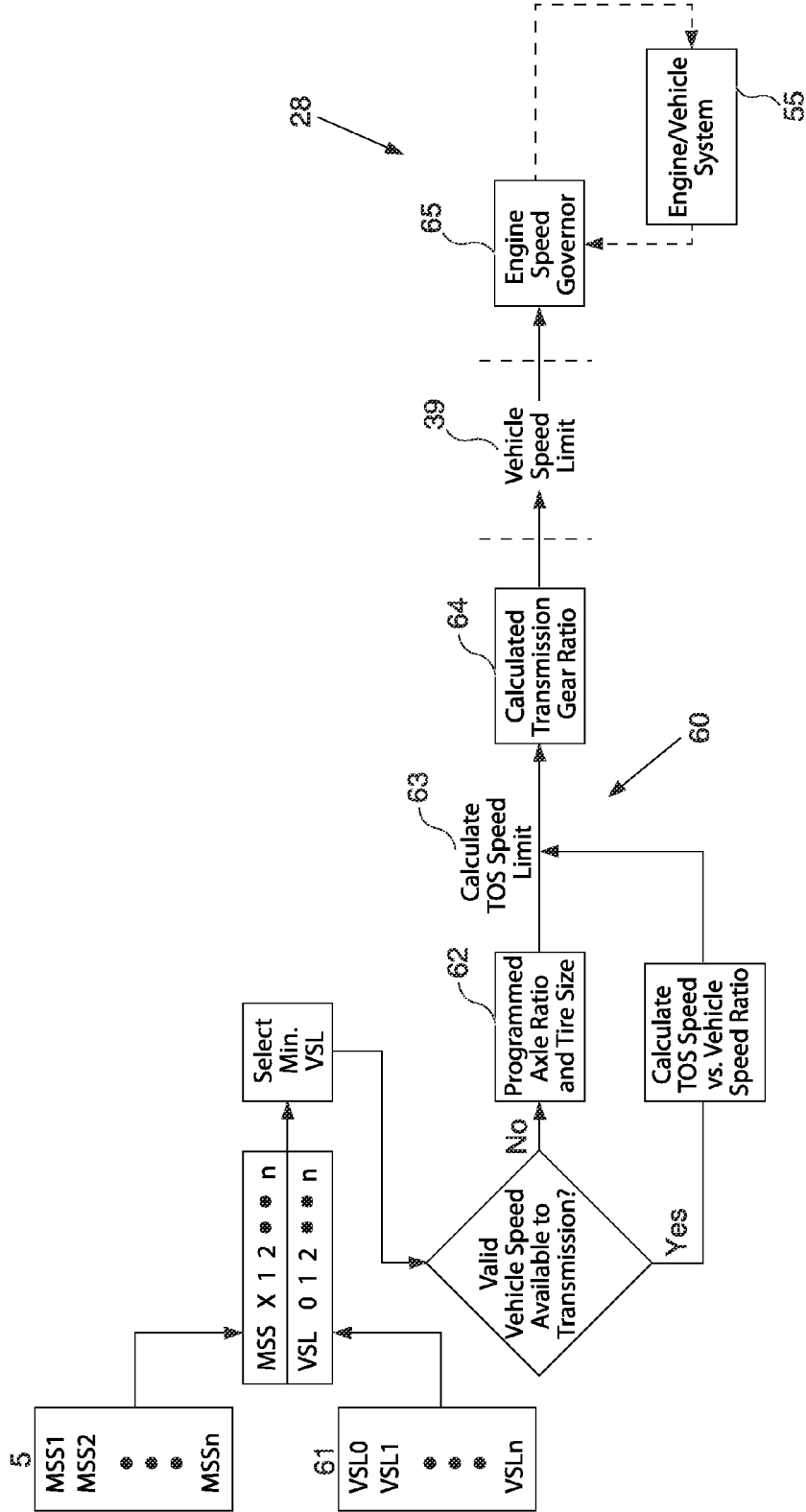
FIG. 3

# FIG. 4

# FIG. 5

FIG. 6

10

12

5
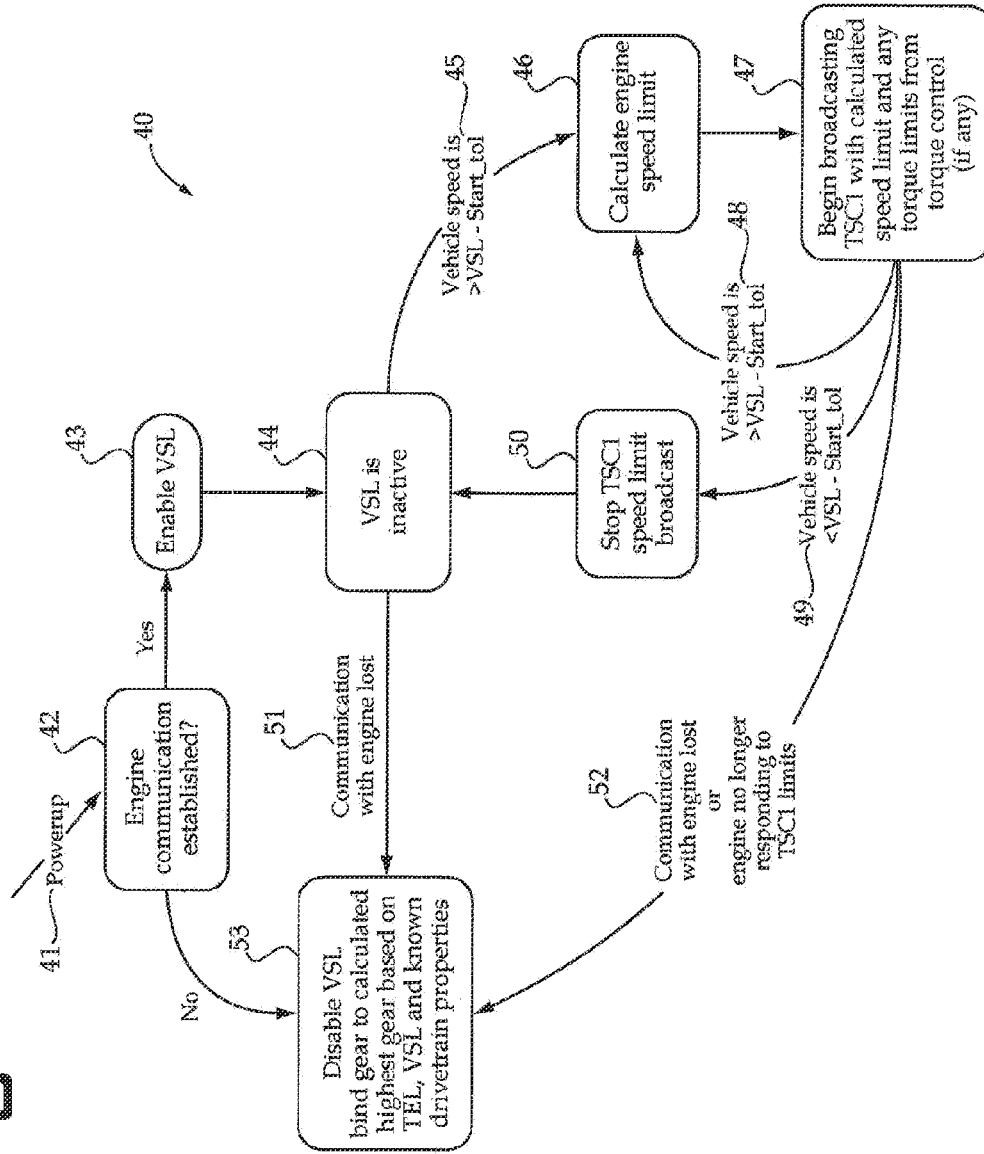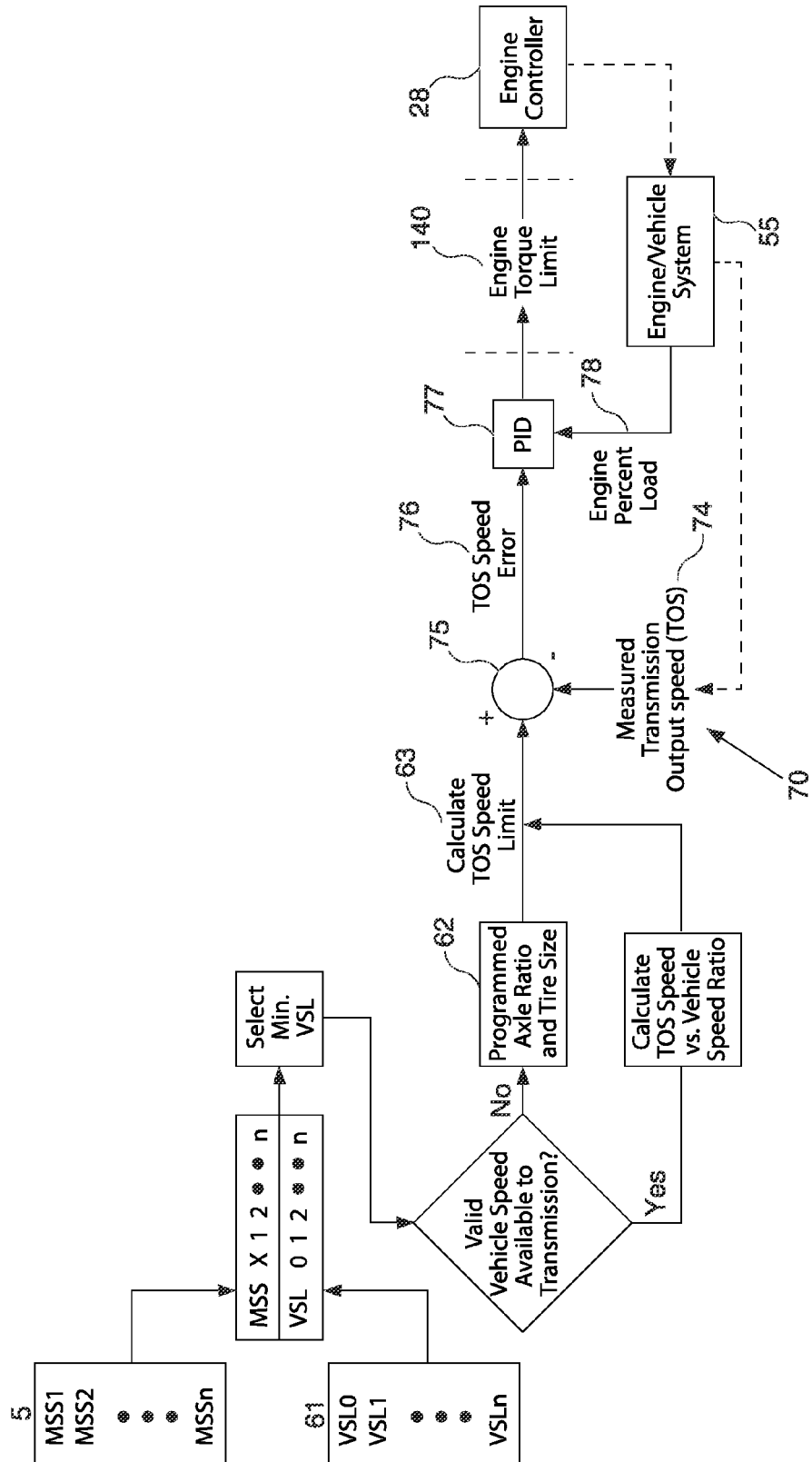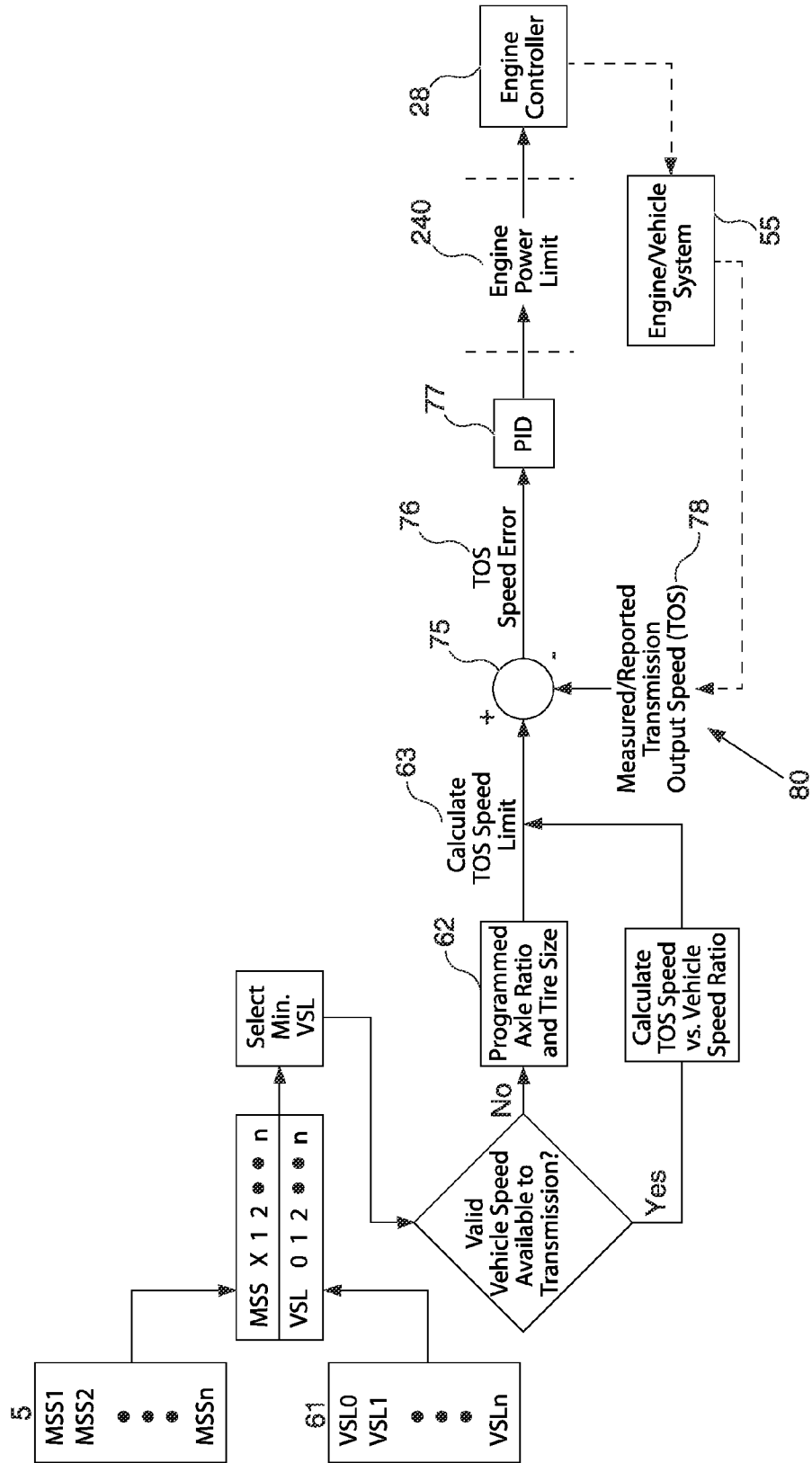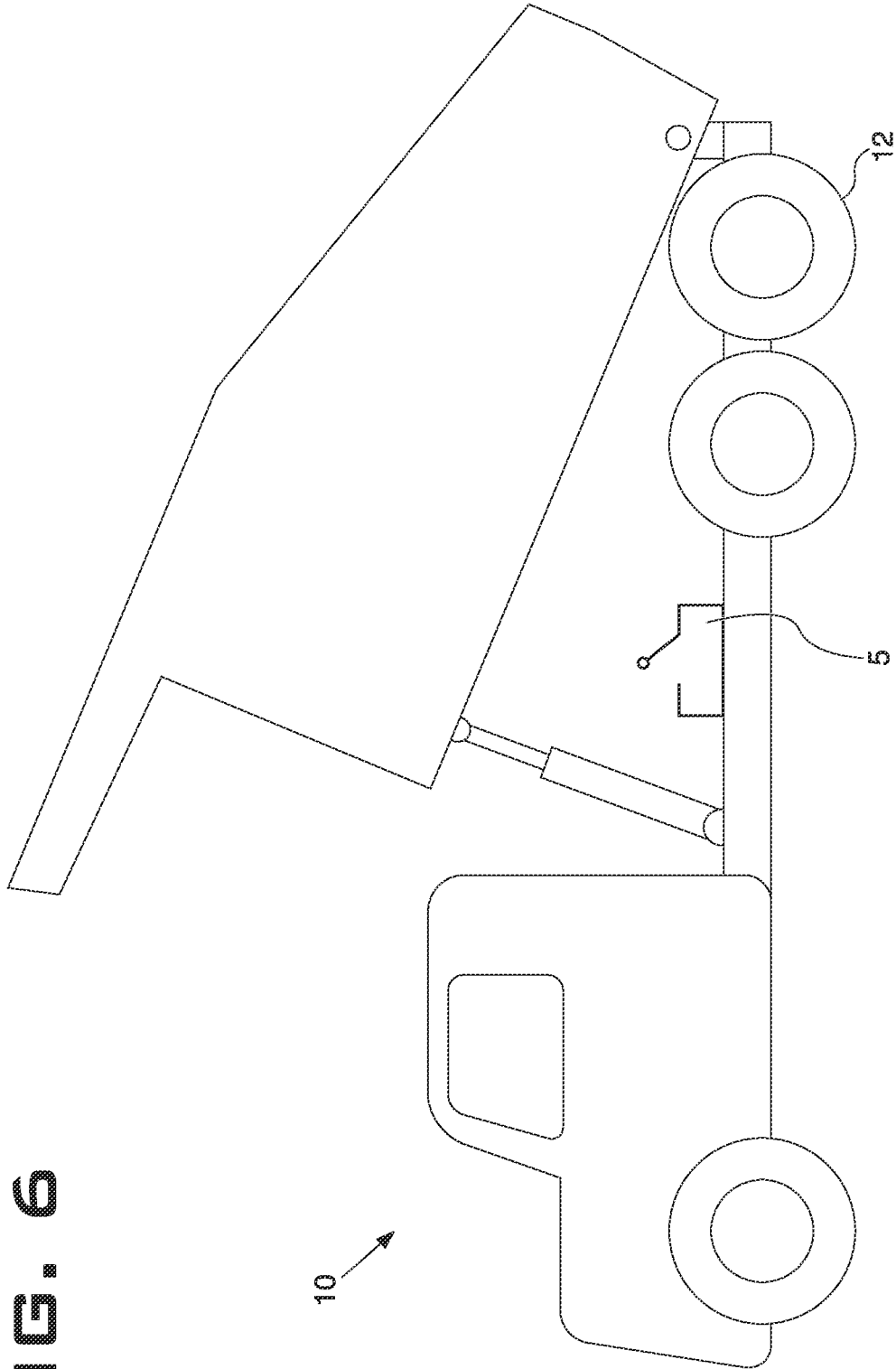
FIG. 7
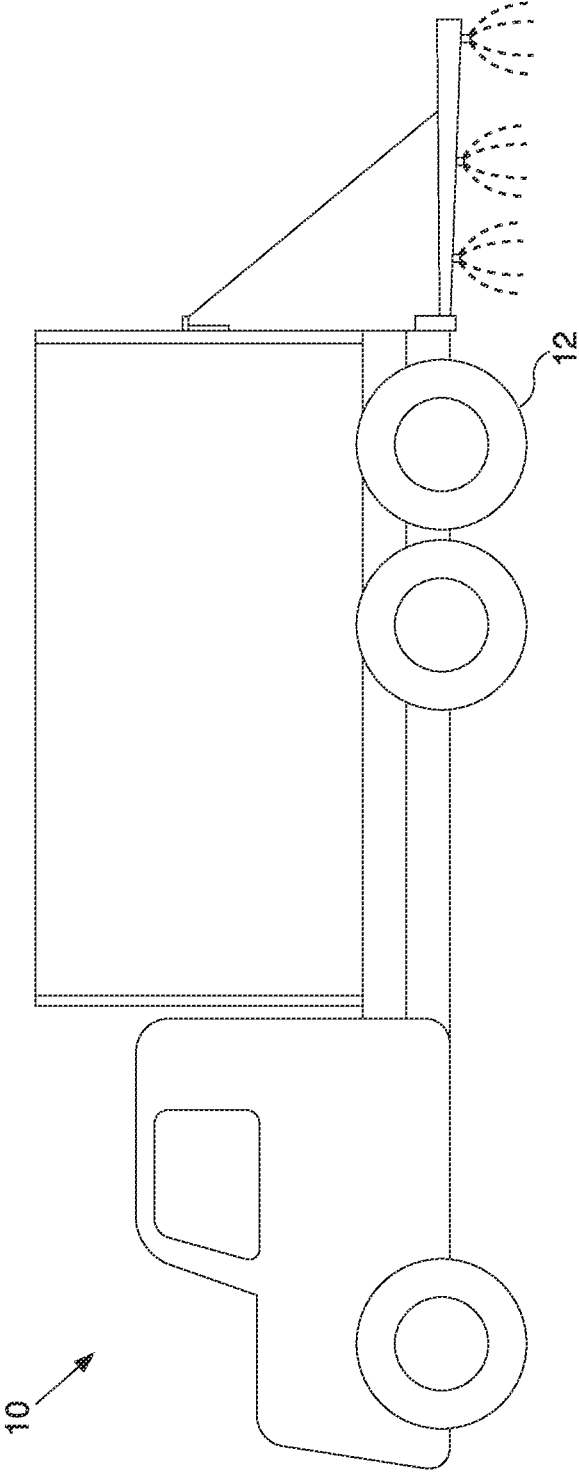
# VEHICLE SPEED LIMITING VIA ENGINE CONTROL COMMANDS BASED ON SENSED MACHINE STATE

## TECHNICAL FIELD

[0001] The present disclosure relates generally to limiting ground speed of machines equipped with an electronically controlled drive train, and more particularly, to a vehicle speed limit algorithm executed in an electronic transmission controller to issue engine control messages to limit machine speed based on a sensed machine state.

## BACKGROUND

[0002] Vehicle speed limiting for most on-highway truck applications is typically done through a vehicle speed limiting strategy resident in the electronic engine controller. Off highway machines, such as trucks operated in shipping facilities, port facilities or large factory/warehouse operations, may not be on-highway legal, and are therefore not required to meet on-highway emissions regulations. In addition, these trucks often use less expensive so called "industrial engines" that do not have built in vehicle speed limiting strategies. Nevertheless, there still may exist vehicle speed limit regulations for off-highway machines in many jurisdictions. It may also be desirable to limit vehicle speed in response to an operating state of the vehicle. For instance, an off-highway machine speed may have a speed limit of 25 miles per hour, or a limit of 5 miles per hour while a certain vehicle system is operating. In addition, some on-highway machines have an engine, transmission, and chassis from different manufacturers. This makes it difficult for the engine software to execute vehicle speed limiting strategies. In these types of machines, vehicle speed limiting has typically been accomplished by gear binding the transmission, or not allowing shifts above a certain gear, and relying upon the top engine limit speed governor on the engine to effectively limit wheel speed in the highest gear. This strategy for limiting speed is often received with frustration by many operators and also includes several other drawbacks. For instance, vehicle speed limiting through gear binding necessarily reduces efficiency and increases fuel consumption, may increase engine wear and even increase noise due to the increased engine RPM.

[0003] The present disclosure is directed to one or more of the problems set forth above.

## SUMMARY OF THE DISCLOSURE

[0004] In one aspect, a method of limiting ground speed of a machine includes propelling the machine at a speed by transmitting engine power to a ground engaging member of the machine via a drive train that includes a transmission. At least one machine state is sensed by an electronic transmission controller. A vehicle speed limit is selected in the electronic transmission controller in response to the at least one machine state. A vehicle speed limit algorithm is executed in an electronic transmission controller to determine an engine control message. The engine control message is communicated to an electronic engine controller via a communication link. The machine speed is limited by executing an engine control algorithm in an electronic engine controller in response to the engine control message.

[0005] In another aspect, a transmission includes an electronic transmission controller attached to a housing. The electronic transmission controller includes a means for establish-

ing a communication link with an electronic engine controller. The electronic transmission controller is configured to sense at least one machine state, select a vehicle speed in response to the at least one machine state, and execute a vehicle speed limit algorithm to generate an engine control message.

[0006] In still another aspect, a machine includes a plurality of ground engaging members attached to a chassis. A drive train that includes an engine coupled to the ground engaging members is attached to the chassis. The drive train includes a transmission with the electronic transmission controller. The electronic transmission controller is configured to sense at least one machine state, select a vehicle speed in response to the at least one machine state, and execute a vehicle speed limit algorithm to generate an engine control message. The machine also includes a means for communicating between the electronic transmission controller and the electronic engine controller. Finally, the machine includes means for reducing a power output of the engine responsive to a communication of the engine control message to the electronic engine controller.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic illustration of a machine according to the present disclosure;

[0008] FIG. 2 is a diagrammatic illustration of a vehicle speed limiting strategy according to one embodiment of the present disclosure;

[0009] FIG. 3 is a flow diagram of a vehicle speed limit algorithm according to the present disclosure;

[0010] FIG. 4 is a diagrammatic illustration of a vehicle speed limiting strategy according to another embodiment of the present disclosure; and

[0011] FIG. 5 is a diagrammatic illustration of a vehicle speed limit strategy according to still another embodiment of the present disclosure.

[0012] FIGS. 6a and 6b are illustrations of vehicles suitable for use with the vehicle speed limiting strategy according to the present disclosure.

## DETAILED DESCRIPTION

[0013] Referring now to FIG. 1, a machine 10, which may be a vehicle such as an off-highway truck, includes a chassis 11 with an attached electronically controlled drive train 14. The chassis 11 is supported on a plurality of ground engaging members 12, such as tires or tracks. The electronically controlled drive train 14 includes an electronically controlled engine 16 coupled to the ground engaging members 12 via an electronically controlled transmission 15. The power from engine 16 is transmitted to ground engaging members 12 via an engine output shaft 17, a transmission input shaft 18, a transmission output shaft 19, a differential 20 and an axle 21. Optionally, the power from engine 16 may be transmitted through the electronically controlled transmission 15 to a power take off (PTO) 35. Although not necessary, electronically controlled drive train 14 may also include a torque converter 24, which may be placed selectively in a locked condition that results in engine output shaft 17 having the same rotational speed as transmission input shaft 18. When optional torque converter 24 is in an unlocked condition, the speed of shafts 17 and 18 may be different. The electronically controlled transmission 15 includes a housing 25 with an attached electronic transmission controller 28. The engine 16

includes an electronic engine controller **29** that communicates with electronic transmission controller **28** via communication link **27**. Communication link **27** may be a proprietary communication link or may be a portion of a standardized communication link, such as J1939 data bus communication network standardized according to the Society of Automotive Engineers (SAE). The electronic transmission controller **28** and the electronic engine controller **29** exchange messages according to a proprietary protocol or according to standard messages formulated according to the J1939 network communication standards known in the art, or via both.

[0014] The present disclosure contemplates several vehicle speed limiting strategies that may be implemented using public engine control message protocols or proprietary engine control messages. For instance, the present disclosure contemplates a vehicle speed limiting strategy as shown in FIG. **2** where the TSC1 speed limit command is utilized as a strategy for limiting vehicle speed. Those skilled in the art recognize that the TSC1 engine control message is standardized with regard to content and order. FIG. **3** shows the usage of the same TSC1 engine control message except utilizing the vehicle speed limit strategy according to another embodiment utilizing the torque limit command field of the TSC1 message. Finally, FIG. **5** shows an additional vehicle speed limit strategy that utilizes a proprietary power limit message sent to the engine from the electronic transmission controller as a means by which the vehicle speed is limited. Other more cumbersome strategies could be utilized, such as inserting some other engine control message, such as an artificially low smoke limit value, that causes the engine to reduce fuel, reduce power output and hence limit the vehicle speed. Thus, other strategies that might occur to one with ordinary skill in the art fall within the intended scope of the present disclosure.

[0015] In any of the strategies, it will likely be necessary to enter into the software what vehicle speed limits are desired. This feature is shown in FIGS. **2**, **4** and **5** as Item **61** where a device, such as a service tool, is in communication with the electronic transmission controller **28** of FIG. **1** and the vehicle speed limits are stored in memory available to the electronic transmission controller **28**. The vehicle speed limits may be due to jurisdiction requirements, owner preference, or how the machine is functioning at a certain time. Any number of vehicle speed limits **61** are possible, limited only by the software and memory of the electronic transmission controller **28**. These vehicle speed limits **61** will be referred to as VSL0, VSL1, VSL2, etc. up to VSLn. VSL0 is considered the default vehicle speed limit.

[0016] In addition, there is at least one machine state sensor that is in electrical communication with the electronic transmission controller **28**. The machine state sensor **5** could be a switch, a temperature sensor, a speed sensor, or other component that is known in the art. The machine state sensor **5** may communicate with the electronic transmission controller **28** via a voltage signal, a current signal, or a message over a communication link. Any number of machine state sensors **5** is possible, limited only by input/output and the software and memory of the electronic transmission controller **28**. These machine state sensors **5** will be referred to as MSS1, MSS2, etc. up to MSSn.

[0017] For example, consider a dump truck having a dump body **30**. An input from an operator is used to raise or tilt the dump body **30** using known methods. A machine state sensor **5**, such as a switch, could be configured to indicate when the dump body **30** is not in the lowered position. Other sensors, such as linear position sensors or a rotary sensor could be used to indicate other positions of the dump body **30** between raised and lowered.

[0018] Another example would be a truck mounted with a power take off (PTO) **35**. The PTO **35** could be powered by the engine using a known method. For example, the PTO **35** could be driven by the transmission **15**. The PTO **35** could be engaged by a switch or other command. The electronic transmission controller **28** could then detect the message on the control network corresponding to an active signal for MSS1.

[0019] The electronic transmission controller **28** uses the inputs from the machine state sensors **5** to determine which vehicle speed limit will be active. For instance, an active input from MSS1 will result in activation of VSL1. An active input from MSS2 will result in activation of VSL2, etc. No active inputs from any machine state sensors **5** will result in activation of VSL0, the default vehicle speed limit **61**.

[0020] Next, there may also be data entered into the electronic transmission controller **28** relating the ratio of transmission shaft output speed to vehicle speed. This is shown as Item **62** in FIGS. **2**, **4**, and **5**. This item of data may be entered as a single number or maybe include two or more data entries and stored in memory to the electronic transmission controller **28**. For instance a first entry might relate the ratio of axle speed to transmission output speed, and a second variable might relate to tire size. The vehicle speed limit and the relationship between the transmission output shaft speed and the vehicle speed is then translated by the electronic transmission controller **28** into a transmission output speed limit **63** that is also stored in memory available to the electronic transmission controller **28**. Those skilled in the art will appreciate that Item **61** and **62** could possibly be eliminated by direct entry and storage of a transmission output speed limit **63** without departing from the intended scope of the present disclosure. In order to generate an engine control message for limiting speed, the transmission output speed limit **63** is translated via a calculated transmission gear ratio **64** into an engine speed limit **39**. That engine speed limit **39** is inserted into the speed limit command field of the standard TSC1 engine control message generated and sent from the electronic transmission controller **28** to the electronic engine controller **29** via communication line **27** according to the standard J1939 communication protocol. The engine then receives that TSC1 control message, and via operation of its engine control algorithm limits the engine speed. As a consequence, vehicle dynamics shown at Item **55** results the vehicle's ground speed being limited. The feature of the engine control algorithm that utilizes the engine speed limit **39** may be the engine speed governor algorithm **65**.

[0021] Referring now to FIG. **3**, an example of the vehicle speed limit algorithm according to the present disclosure is illustrated in the context of the engine speed limit strategy **60** disclosed in relation to FIG. **2**. At step **41**, the machine **10** is powered up which also wakes up and powers up electronic transmission controller **28** and electronic engine controller **29**. At communication diagnostic step **42**, the vehicle speed limit algorithm **40** determines whether proper communication is established between the electronic transmission controller **28** and the electronic engine controller **29** via communication link **27**. If there is a failure, the vehicle speed limit algorithm **40** transfers to step **53** where the vehicle speed limit algorithm is disabled and a secondary gear binding strategy for limiting vehicle speed is enabled. If the communication diagnostic step **42** provides a positive result, the vehicle speed

limit strategy according to the present disclosure is enabled. After being enabled, the vehicle's speed limit strategy is placed in an inactive status at step **44**. If while inactive, communication with the engine is lost via step **51**, the standard gear binding strategy to limit vehicle ground speed is engaged at step **43**. Periodically, such as at the clock speed of the processor associated with electronic transmission controller **28**, the vehicle speed limit algorithm **40** determines whether the vehicle ground speed is greater than the vehicle speed limit **61** minus some tolerance. For instance, the tolerance might be set so that the vehicle speed limit strategy initiates commands several miles per hour below the actual prescribed vehicle speed limit so that the vehicle speed limit is not exceeded before the algorithm and machine dynamics have time to respond. If the vehicle speed is within the tolerance of the vehicle speed limit, vehicle speed limit algorithm **40** calculates an engine speed limit as discussed earlier. This engine speed limit is then inserted into the public TSC1 engine control message and communicated at step **47** to the electronic engine controller **29**. In the event that communication with the electronic engine controller **29** is lost or that the engine is perceived as not responding to the TSC1 engine speed control message, the vehicle speed limit algorithm **40** may again revert to gear binding at step **53** in order to limit vehicle speed. At step **48**, the vehicle speed limit algorithm **40** determines whether the vehicle ground speed is within a stop tolerance of the vehicle speed limit. If not, step **46** and **47** will repeat and the engine speed limit will be recalculated, and broadcast engine speed limit via the J1939 data link as a TSC1 engine speed limit command. If so at step **49**, the algorithm will advance to step **50** where the TSC1 engine control broadcast will be stopped. However, the electronic transmission controller **28** may also be programmed such that vehicle speed limiting commands, such as via the TSC1 engine control message, will be implemented in a fashion so as not to interfere with other TSC1 limit commands necessary for transmission protection (e.g torque limiting) or for other known vehicle systems, such as an anti-lock brake system.

[0022] Referring now to FIG. **4**, the alternative strategy of limiting vehicle speed via the torque limit command portion of the TSC1 engine control message is illustrated. Steps **61** and **62** are identical to that discussed earlier in arriving at the transmission output speed limit **63**. The measured transmission output speed **74**, which is acquired via a sensor in a known manner, is subtracted from the transmission output speed limit **63** at summer **75** to arrive at a transmission output speed error **76**. This value is then supplied in a standard manner to a PID controller **77** that receives the engine percent load **78** to arrive at an engine torque limit **140**. That engine torque limit is then added to the appropriate field in the TSC1 engine control message and communicated to the electronic engine controller **29**. The electronic engine controller responds by executing its engine control algorithm as per the engine torque limit, which results in a limiting of vehicle ground speed due to vehicle mass properties and dynamics at step **55**.

[0023] The TSC1 torque limit strategy **70** shown in FIG. **4** could possibly be combined with the engine speed limit strategy discussed in relation to FIG. **2**. In such a case, the electronic transmission controller might carry software for both strategies and may include additional logic for determining which strategy to use during certain situations. For instance, if the machine is equipped with a torque converter **24** as shown in FIG. **1**, the strategy might prefer to use the engine

speed limit strategy if the torque converter is in a locked condition, but reverts to the torque limiting strategy **70** of FIG. **4** in the event that the electronic transmission controller **28** determines that the torque converter **24** is in an unlocked condition. In another example, the algorithm **40** may opt for vehicle speed limiting via torque limiting if a shift is detected.

[0024] Referring now to FIG. **5**, an engine power limit control strategy **80** is illustrated. This strategy might be implemented using a proprietary power limit message sent to the electronic engine controller **29** from the electronic transmission controller **28**, or rely on some future standardized message not yet in existence. In any event, those skilled in the art will appreciate that the engine speed limit strategy **60** of FIG. **2** and the engine torque limit strategy **70** of FIG. **4** are essentially attempting to limit engine power output in order to limit vehicle speed, but doing so in an indirect manner. The strategy **80** shown in FIG. **5** approaches this problem directly by commanding an engine power limit by passing the transmission output speed error **76** into a PID controller **87** to arrive at an engine power limit **240**. This engine power limit is communicated to the electronic engine controller **29**, which executes its engine control algorithm to limit power and hence limit the vehicle speed due to vehicle mass properties and system responses as shown at Item **55**.

### INDUSTRIAL APPLICABILITY

[0025] The present disclosure finds potential application in any machine with an electronically controlled drive train in need of vehicle speed limiting. For instance, some fleet owners desire their machines to be limited in speed, and/or vehicle speed limits may be required by regulation in certain jurisdictions. Other reasons for limiting speed may be due to machine function. The present disclosure is especially applicable to machines that do not include vehicle speed limiting algorithms resident on their electronic engine controller. For instance, the present disclosure is applicable to machines that utilize so called industrial engines, such as for use in off-highway applications. The present disclosure is also applicable to machines that use transmissions and engines from different manufacturers. In other cases it may be desirable to limit vehicle speed in response to a certain vehicle function.

[0026] In some cases it may be desirable for a vehicle to have more than one programmed vehicle speed limit **61**. For example, a dump truck having a tilting dump body may have an owner-preferred maximum speed limit of 65 mph. An example of such a dump truck is depicted in FIG. **6a**. This speed limit could be defined as VSL0 and could serve as the default speed limit for the dump truck. In addition, the dump truck could have a second vehicle speed limit VSL1 of, say, 3 mph that is linked to a sensed machine state MSS1. An example of a sensed machine state could be a switch that determines when the dump body is not in the lowered position. The switch would connect to electronic transmission controller **28**. The electronic transmission controller **28** would recognize the active signal of MSS1 and therefore activate VSL1. The electronic transmission controller **28** would compare VSL0 (65 mph) and VSL1 (3 mph) and choose the lower (3 mph) to use in the vehicle speed limit control algorithm **140** or **240**. Limiting the vehicle speed in such a way would allow the dump truck to smoothly and consistently distribute material, such as sand, gravel, or asphalt material. Using such a technique, the dump truck could also coordinate with another vehicle with the same programmed VSL so that material could be transferred from

one to another, such as from a dump truck to an asphalt paver. It is also conceived that the appropriate VSL could be sent to both the dump truck and paver by a vehicle communication system rather than a service tool. In this manner, the paver and any number of dump trucks could be programmed with the same VSL in order to coordinate on a job site.

[0027] A truck mounted with a power take off (PTO) **35** is another example of a case where it may be desirable for a vehicle to have more than one programmed vehicle speed **61**. Such a truck may have an owner-preferred maximum speed limit of 65 mph. This speed limit could be defined as VSL0 and could serve as the default speed limit for the truck. In addition, the truck could have a second vehicle speed limit VSL1 of, say, 15 mph that is linked to a sensed machine state MSS1. The PTO **35** could be engaged by a switch or other command. The electronic transmission controller **28** could then detect the message on the control network corresponding to an active signal for MSS1. The electronic transmission controller **28** would therefore activate VSL1. Other examples of an appropriate MSS1 could come from a switch in the PTO activation circuit, a pressure sensor relative to a driven pump, or a speed sensor. The electronic transmission controller **28** would compare VSL0 (65 mph) and VSL1 (15 mph) and choose the lower (15 mph) to use in the vehicle speed limit control algorithm **140** or **240**. Limiting the vehicle speed in such a way would have uses on trucks that use a PTO **35** to power accessories. Such applications include water trucks, herbicide/insecticide sprayers, highway stripers, and cement trucks. An example of such a PTO-equipped truck is depicted in FIG. **6***b*.

[0028] A refuse truck is another example of a case where it may be desirable for a vehicle to have more than one programmed vehicle speed limit **61**. Such a refuse truck could include controls on both the driver side and passenger side. In some jurisdictions a vehicle driven from passenger side controls is to be limited to a lower speed, say 20 mph. The refuse truck could also include a dumpster hoist. It may be desirable to limit the refuse truck speed to 5 mph when the hoist is not in the lowered position. Such a refuse truck could have as many as three programmed vehicle speed limits. The first, VSL0, could be programmed with the default value of 65 mph. The second, VSL1, could be programmed with 20 mph. VSL1 would be activated when an active signal from MSS1 is detected by the electronic transmission controller **28**. MSS1 could correspond to something related to the passenger side controls of the refuse truck, such as a seat occupant switch, a gear selector switch, or a J1939 message from one of the inputs. A third vehicle speed limit, VSL2, could be programmed with 5 mph. VSL2 would be activated when an active signal from MSS2 is detected by the electronic transmission controller **28**. MSS2 could correspond to a switch or position sensor in communication with the refuse truck dumpster hoist system. In the refuse truck example, the default vehicle speed limit VSL0 (65 mph) is selected by electronic transmission controller **28** when there are no active signals from machine state sensors **5**.

[0029] If the refuse truck is operated from passenger side controls, an active signal is created from machine state sensor **5**, MSS1. The active signal from MSS1 is detected by electronic transmission controller **28** which selects vehicle speed limit VSL1 (20 mph).

[0030] If the refuse truck is operated with the dumpster hoist out of the lowered position, an active signal is created from machine state sensor **5**, MSS2. The active signal from MSS2 is detected by electronic transmission controller **28** which selects vehicle speed limit VSL2 (5 mph).

[0031] If the electronic transmission controller **28** detects more than one active machine state sensor, it selects the vehicle speed limit with the lowest speed value. In the refuse truck example, if the truck was operated from the passenger side and the dumpster hoist was not in the lowered position, the electronic transmission controller **28** would select VSL2 (5 mph).

[0032] Other examples of where machine function-based vehicle speed limiting could be used are cement trucks, water spraying trucks, highway stripers, mobile cranes, agricultural tractors, and construction machines.

[0033] Examples of machine state sensors could be limit switches, linear and rotary position sensors, rotary speed sensors, temperature sensors, pressure sensors, or other devices that produce an electrical output from a physical input.

[0034] In all applicable cases, an electronically controlled transmission includes an electronic transmission controller that executes a vehicle speed limit algorithm to determine an engine control message. The engine control message is communicated to the electronic engine controller. The present disclosure might also have potential application in limiting vehicle speeds in other applications, such as low speeds associated with paint sprayers and/or highway herbicide sprayers where the engine resident VCL or vehicle speed limiting strategy or cruise control strategies in the on-highway engines are not sufficiently designed to operate at low speeds. The present disclosure is also applicable to transmission manufacturers whose electronically controlled transmissions may be mated to divergent engines when installed in a machine that is subject to vehicle speed limiting regulations and/or other requirements. For instance, the present disclosure is applicable to transmissions that might be paired with either on-highway or off-highway machines.

[0035] The vehicle speed limit strategy using engine speed control strategy **60** of FIG. **2** as well as the torque control strategy **70** of FIG. **4** might utilize standard engine control message protocols. This might be particularly appropriate for machines in which the engine **16** originates from one manufacturer and the transmission **15** originates from a second manufacturer, but the two communicate via the standard protocols associated with the J1939 data link. The vehicle speed limiting via the engine power limit strategy **80** shown in relation to FIG. **5** might find particular application in those cases where the engine **16** and transmission **15** originate from the same manufacturer so that the use of proprietary communication strategies presents little to no obstacle.

[0036] Other considerations might also apply. For instance, the engine speed limit strategy **60** of FIG. **2** has the advantage of being a relatively simple algorithm with no tuning required. In addition, it also may leverage the engine speed governor by providing less latency, which is well understood and therefore should be well tuned. On the other hand, the engine speed control strategy **60** may produce less attractive performance during shifts and cannot account for drive train variations upstream from the transmission, such as a power divider. In addition, the engine speed limit strategy **60** in FIG. **2** may produce less satisfactory performance if a torque converter is in a drive mode. The engine torque limit strategy **70** shown in FIG. **4** may have the advantage of better performance during shifts and provide better performance while a torque converter is in a drive mode. In addition, this strategy

may interact better with other TSC limits, such as anti-lock brake system traction control strategies. In addition, the torque limit strategy **70** is also not likely affected by possible extra components, such as a power divider between the engine **16** and transmission **15**. On the other hand, the torque limit strategy **70** of FIG. **4** may have disadvantages relative to the other strategies in that it may not perform as well during non-shifting transient performance due to delays involved a more complicated algorithm. In addition, that strategy may require application based tuning in some cases and may be more likely to limit cycle. The engine power limit strategy **80** of FIG. **5** has the advantage of likely performing best during shifts and can tolerate possible extra components, such as a power divider, between the engine **16** and transmission **15**. On the other hand, this strategy currently might require a new likely proprietary power limit data link message to be developed and implemented on both the electronic engine controller **29** and the electronic transmission controller **28**. In addition, it may require some application tuning as it may not perform as it does not use a well tuned engine speed governor.

[0037] In some configurations, the vehicle speed limit algorithm may detect when the vehicle ground speed is approaching within the predetermined vehicle speed limit. When that vehicle speed is within a tolerance of the vehicle's speed limit, the vehicle speed limit algorithm **40** generates an engine control message that is communicated to the electronic engine controller **29** to limit power output from the engine via an engine speed limit control message, an engine torque limit control message or an engine power limit control message. When the electronic engine controller **29** executes its engine control algorithm, the resulting limitation in power output carries through the vehicle dynamics to result in the vehicle speed limit not being exceeded. Implementation of a vehicle speed limit algorithm **40** according to the present disclosure might utilize the standard gear binding vehicle speed limit strategy in the default and only enable the alternative vehicle speed limit strategies previously discussed if certain conditions are met, such as an appropriate communication link being maintained between electronic transmission controller **28** and the electronic engine controller **29**. The present disclosure also contemplates implementations of the vehicle speed limit algorithm that may allow the operator to selectively enable the vehicle speed limit algorithm **40** through some type of Boolean input, such as a hard-wired switch, a J1939 message or some mode button. In addition, the present disclosure contemplates implementations of vehicle speed limiting that may also eventually allow the operator to actively change the prescribed vehicle speed limit via some appropriate interface. The present disclosure also contemplates an error detection mode where, if the vehicle speed exceeds a vehicle speed limit by some margin, then the algorithm may assume that the engine is no longer accepting engine control messages from the electronic transmission controller **28**. In such a case, the transmission may revert to gear binding as a method of limiting vehicle speed.

[0038] A vehicle speed limit strategy resident in the electronic transmission controller has several advantages over conventional gear binding strategies known in the art. For instance, operator perception should be more favorable with an engine controlled according to the present disclosure. In addition, fuel savings could be substantial due to the fact that an operator can do the same work at a lower engine RPM and hence consume far less fuel than what might be consumed using a gear binding vehicle speed limiting strategy. For instance, the fuel savings can be on the order of 15-20% or more. In addition, apart from the fuel savings and efficiency increase, one could expect far less noise by the need to rev the engine at a lower RPM to achieve the same vehicle speeds than RPM's associated with gear binding strategies.

[0039] It should be understood that the above description is intended for illustrative purposes only, and is not intended to limit the scope of the present invention in any way. Thus, those skilled in the art will appreciate that other aspects of the invention can be obtained from a study of the drawings, the disclosure and the appended claims.

What is claimed is:

1. A method of limiting ground speed of a machine, comprising the steps of:
 propelling the machine at a speed by transmitting engine power to a ground engaging member of the machine via a drive train that includes a transmission;
 sensing at least one machine state in an electronic transmission controller,
 selecting a vehicle speed limit in the electronic transmission controller in response to the at least one machine state,
 executing a vehicle speed limit algorithm in the electronic transmission controller to determine an engine control message;
 communicating the engine control message to an electronic engine controller via a communication link; and
 limiting the speed responsive to the engine control message by executing an engine control algorithm in an electronic engine controller.

2. The method of claim **1** including a step of storing a vehicle speed limit in a memory coupled to the electronic transmission controller.

3. The method of claim **1** including a step of storing data relating vehicle speed to transmission output speed in a memory coupled to the electronic transmission controller.

4. The method of claim **1** including a step of determining a transmission gear ratio.

5. The method of claim **1** wherein the engine control message is part of a standardized torque/speed control message communicated via a public data bus communication standard.

6. The method of claim **5** wherein the engine control message is contained in a speed limit data field of a Torque/Speed Control #1 (TSC1) message of an SAE J1939 data bus communication standard.

7. The method of claim **5** wherein the engine control message is contained in a torque limit data field of a Torque/Speed Control #1 (TSC1) message of an SAE J1939 data bus communication standard.

8. The method of claim **1** wherein the engine control message includes an engine power limit.

9. The method of claim **1** wherein the step of executing the vehicle speed limit algorithm includes determining which of a speed limit and a torque limit to include in the engine control message.

10. The method of claim **1** wherein the step of executing the vehicle speed limit algorithm includes determining the speed of the machine;
 determining if the speed is within a predetermined tolerance of a predetermined speed limit; and
 generating the engine control message if the speed is within the predetermined tolerance of the predetermined speed limit.

**11**. The method of claim **1** including a step of determining a failure in at least one of the executing a vehicle speed limit algorithm step and the communicating step; and

enabling a gear binding speed limit algorithm responsive to the failure.

**12**. The method of claim **11** including a step of storing a vehicle speed limit in a memory coupled to the electronic transmission controller;

storing data relating vehicle speed to transmission output speed in a memory coupled to the electronic transmission controller;

the engine control message is part of a standardized torque/speed control message communicated via a public data bus communication standard;

the step of executing the vehicle speed limit algorithm includes determining the speed of the machine;

determining if the speed is within a predetermined tolerance of a predetermined speed limit; and

generating the engine control message only if the speed is within the predetermined tolerance of the predetermined speed limit.

**13**. A transmission comprising:

a housing;

an electronic transmission controller attached to the housing and including means for establishing a communication link with an electronic engine controller; and

the electronic transmission controller being configured to sense at least one machine state, select a vehicle speed in response to the at least one machine state, and execute a vehicle speed limit algorithm to generate an engine control message.

**14**. The transmission of claim **13** including means for storing a vehicle speed limit and data relating vehicle speed to transmission output speed in a memory coupled to the electronic transmission controller.

**15**. The transmission of claim **14** wherein the electronic transmission controller is configured for communication according to an SAE J1939 data bus communication standard.

**16**. The transmission of claim **15** including means for executing a gear binding speed limiting algorithm responsive to a predetermined failure.

**17**. A machine comprising:

a chassis;

a plurality of ground engaging members attached to the chassis;

a drive train that includes an engine coupled to the ground engaging members attached to the chassis;

the drive train including a transmission with an electronic transmission controller;

the electronic transmission controller being configured to sense at least one machine state, select a vehicle speed in response to the at least one machine state, and execute a vehicle speed limit algorithm to generate an engine control message;

means for communicating between the electronic transmission controller and an electronic engine controller; and

means for reducing a power output of the engine responsive to communication of the engine control message to the electronic engine controller.

**18**. The machine of claim **17** including means for storing a vehicle speed limit and data relating vehicle speed to transmission output speed in a memory coupled to the electronic transmission controller; and

means for executing a gear binding speed limiting algorithm responsive to a predetermined failure.

**19**. The machine of claim **18** wherein the electronic transmission controller is configured for communication according to an SAE J1939 data bus communication standard.

**20**. The machine of claim **19** wherein the drive train includes a torque converter; and

the engine control message is contained in a torque limit data field of a Torque/Speed Control #1 (TSC1) message of the SAE J1939 data bus communication standard.

**21**. The method of claim **1** wherein the at least one machine state corresponds to a position of a dump body.

**22**. The method of claim **1** wherein the drive train includes an engine; and

wherein the at least one machine state indicates operation of a power take off powered by said engine.

**23**. The transmission of claim **13** wherein the at least one machine state corresponds to a position of a dump body.

**24**. The transmission of claim **13** wherein the drive train includes an engine; and

wherein the at least one machine state indicates operation of a power take off powered by said engine.

**25**. The machine of claim **17** wherein the at least one machine state corresponds to a position of a dump body.

**26**. The machine of claim **17** wherein the drive train includes an engine; and

wherein the at least one machine state indicates operation of a power take off powered by said engine.

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