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(54) **SYSTEM AND METHOD FOR BLADE CONTROL ON A UTILITY VEHICLE**

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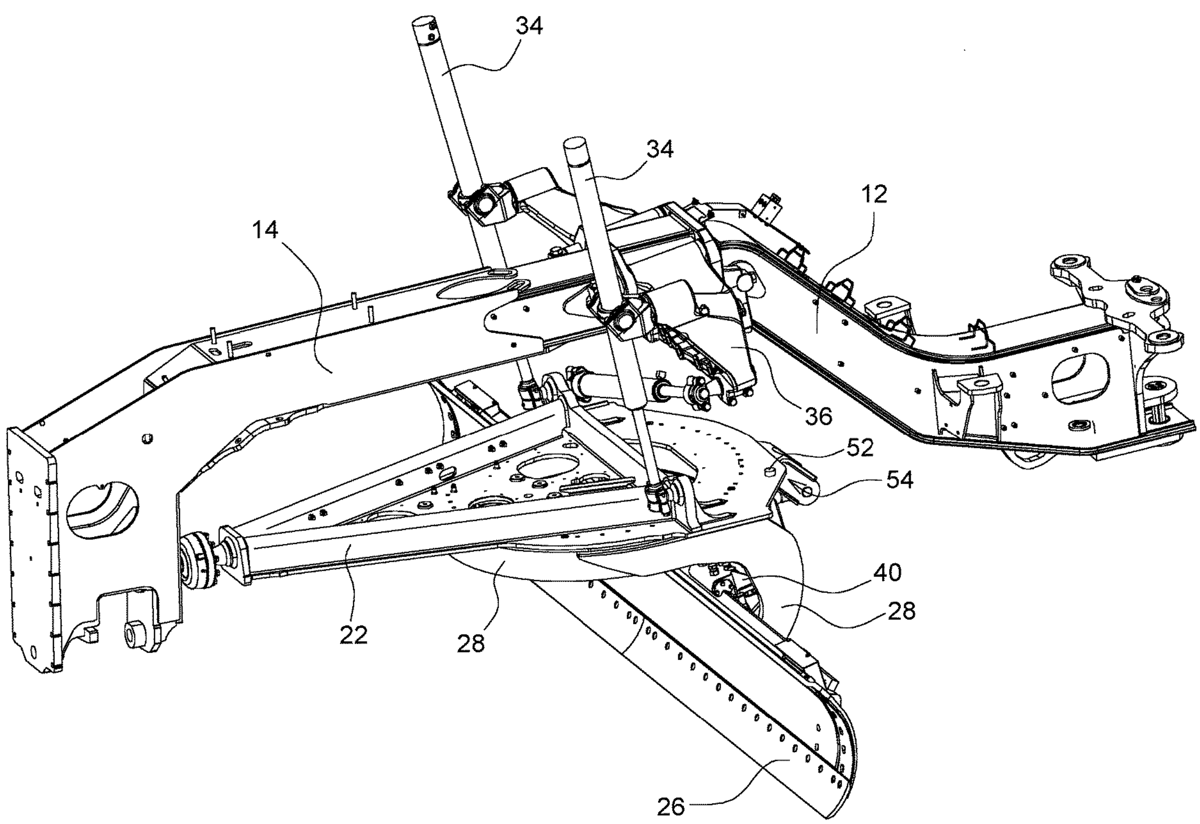
(57) **ABSTRACT**

In accordance with an example embodiment, a work tool control system for a work vehicle, the work tool system comprising at least two hydraulic cylinders, a work tool coupled, directly or indirectly, with the at least two hydraulic cylinders, the work tool configured to move material, a controller, wherein the controller is in communication with the at least two hydraulic cylinders, an operator interface, wherein the operator interface is in communication with the controller, wherein when the controller receives a first signal from the operator interface the controller sends a second signal to the at least two hydraulic cylinders, where the first signal is a vehicle reverse signal and the second signal is a work tool lift signal.



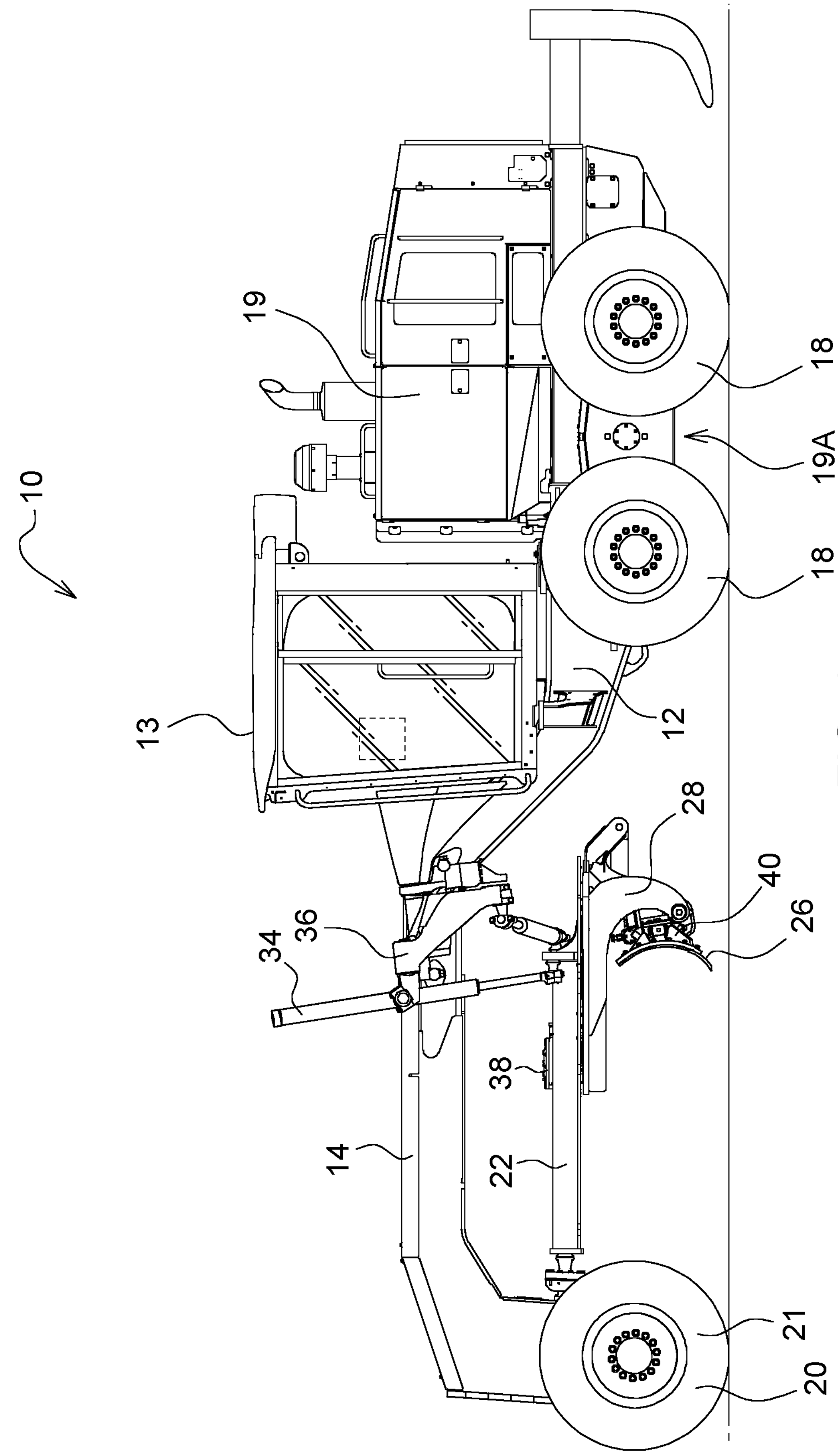


FIG. 1

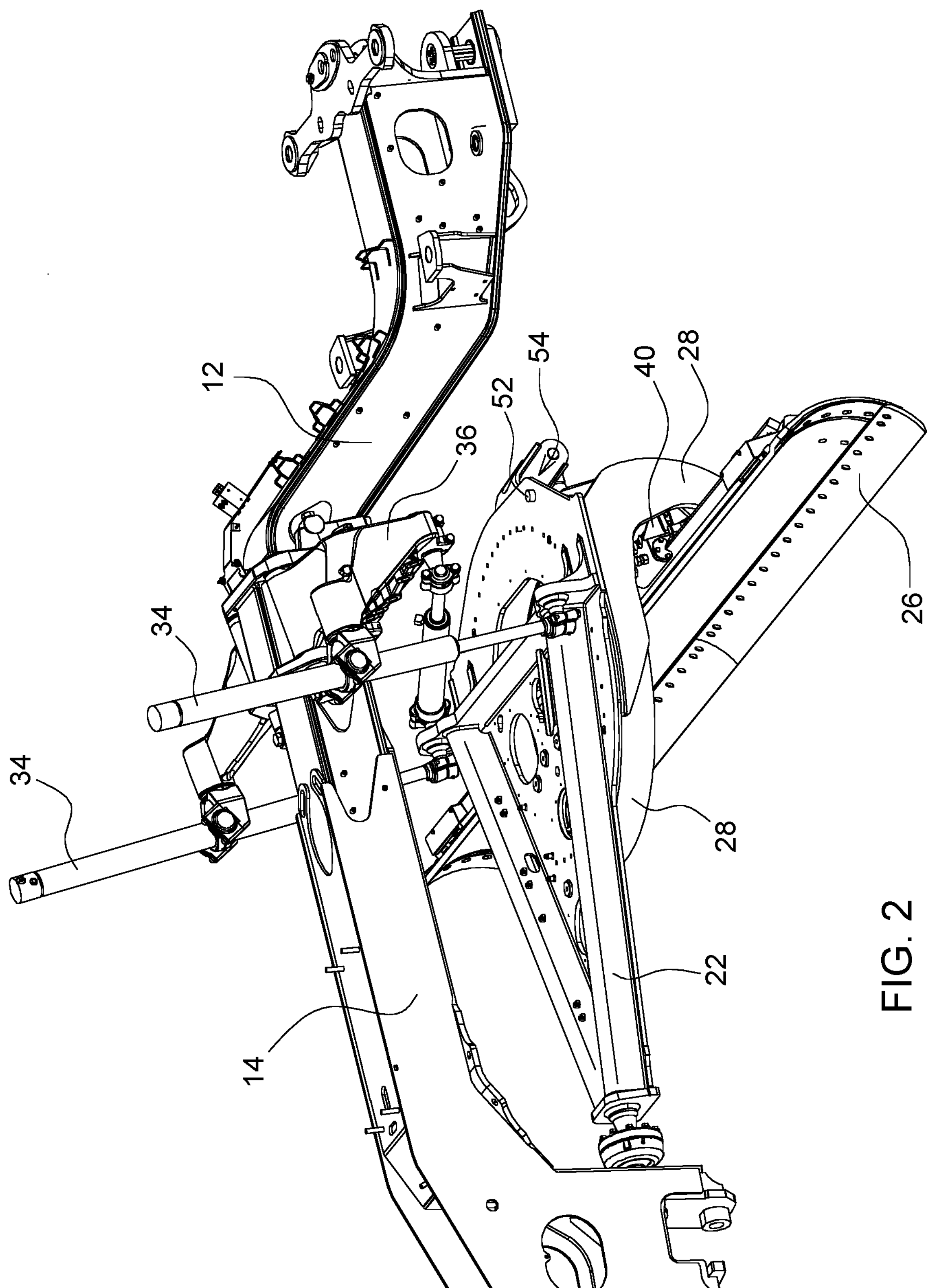
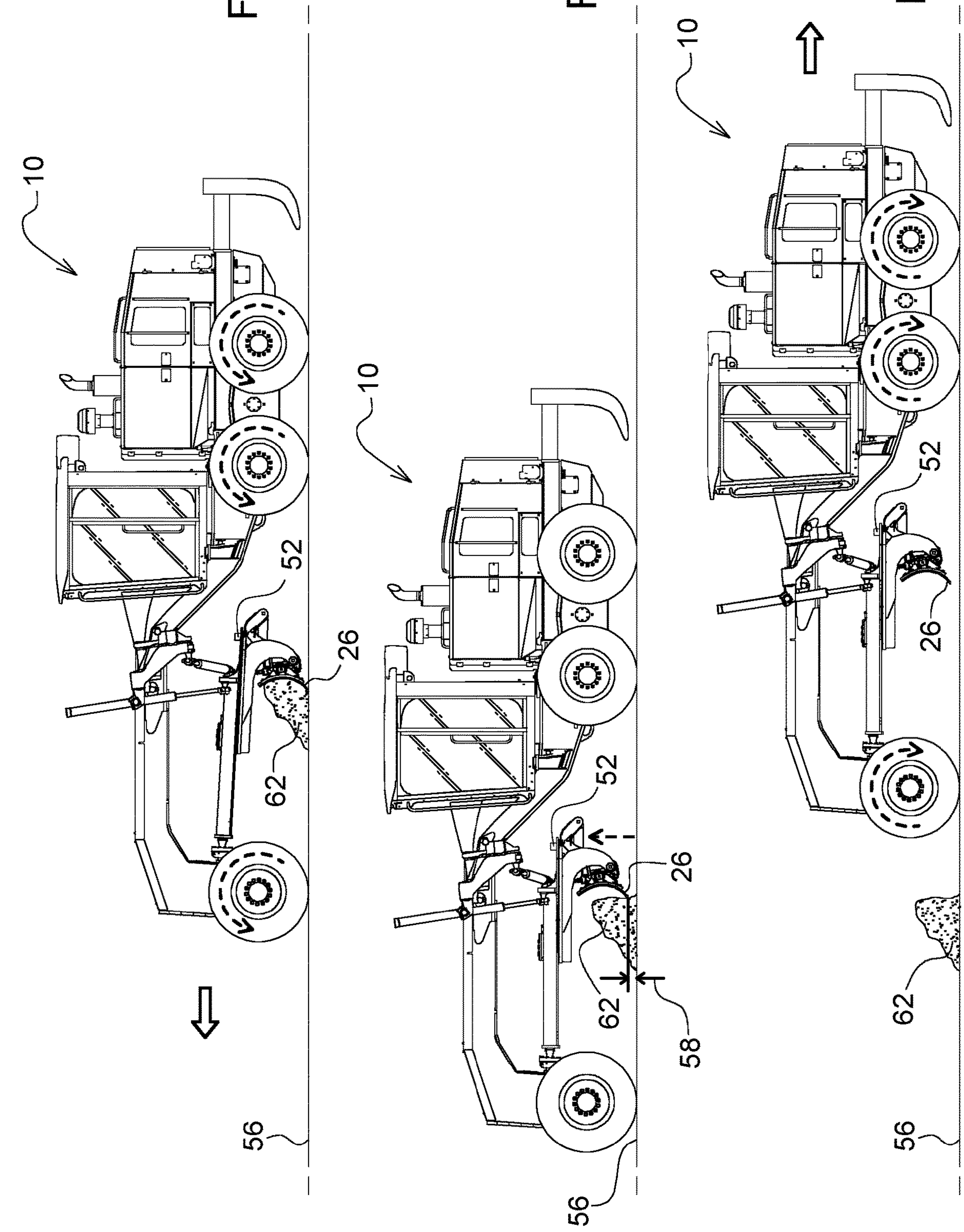


FIG. 2

FIG. 3A

FIG. 3B

FIG. 3C



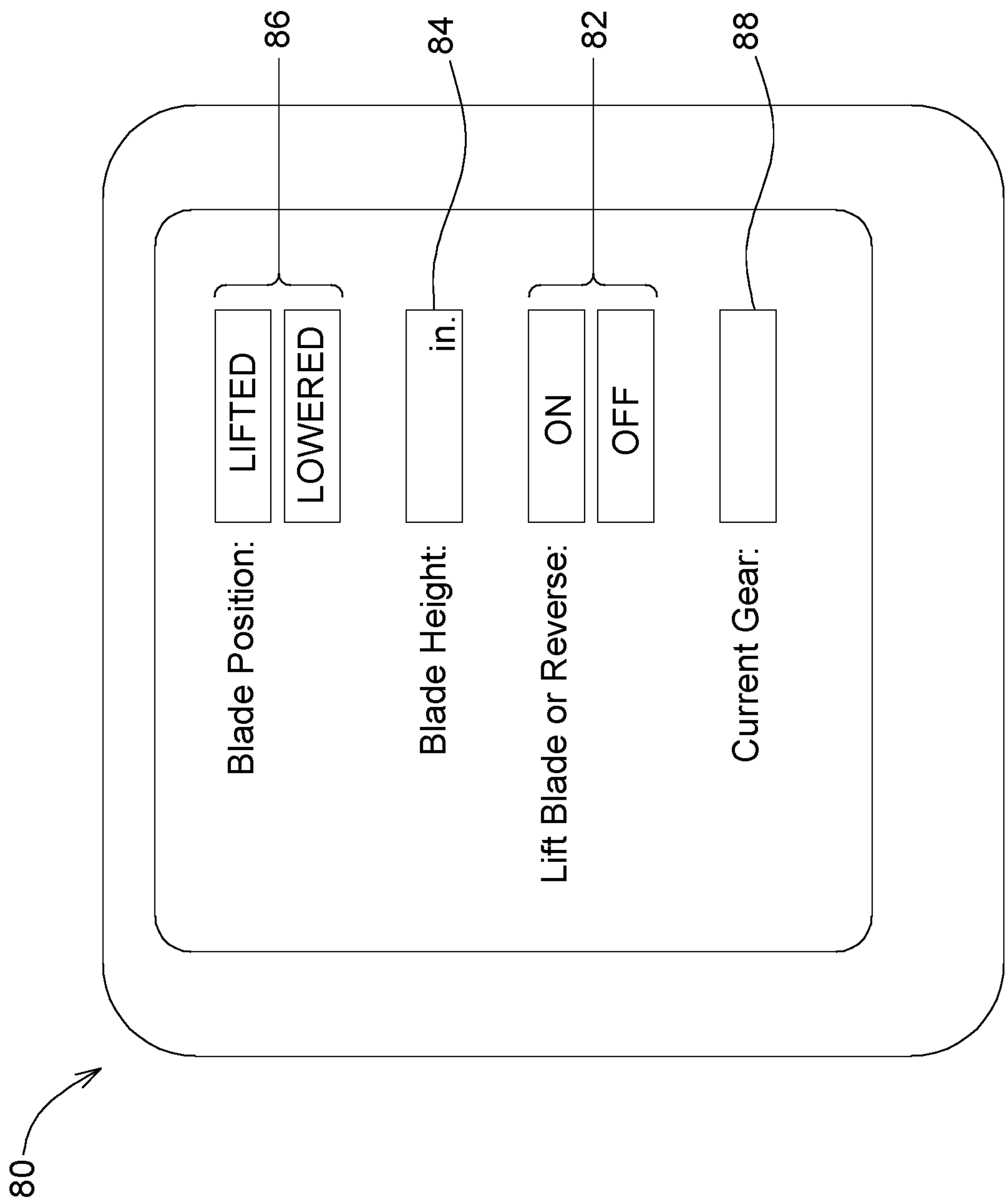

86
84
82
88
Blade Position:
LIFTED
LOWERED
Blade Height:
in.
Lift Blade or Reverse:
ON
OFF
Current Gear:
80

FIG. 4

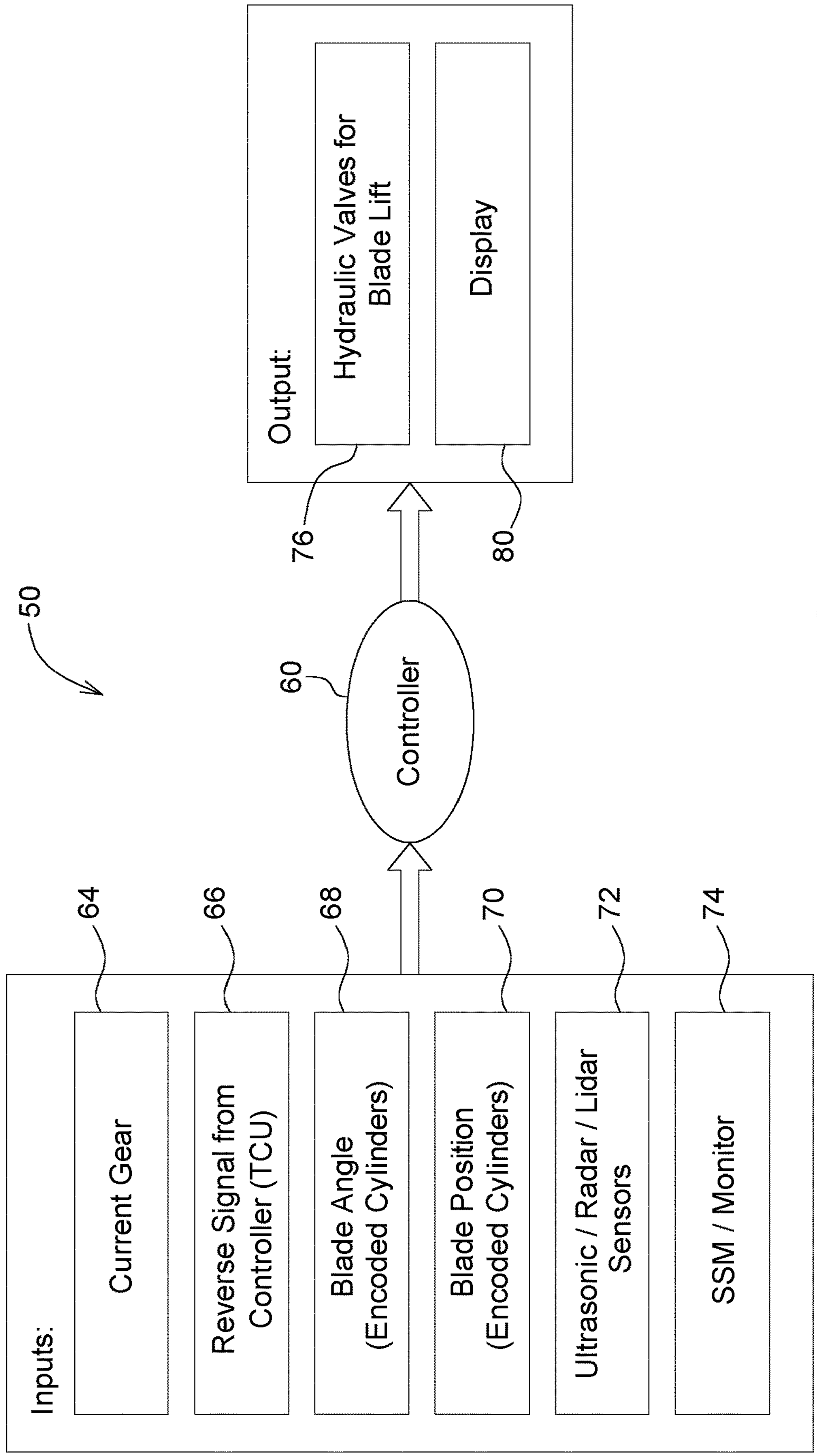

50
Output:
Hydraulic Valves for Blade Lift
Display
76
80
Controller
60
Inputs:
Current Gear
Reverse Signal from Controller (TCU)
Blade Angle (Encoded Cylinders)
Blade Position (Encoded Cylinders)
Ultrasonic / Radar / Lidar Sensors
SSM / Monitor
64
66
68
70
72
74

FIG. 5

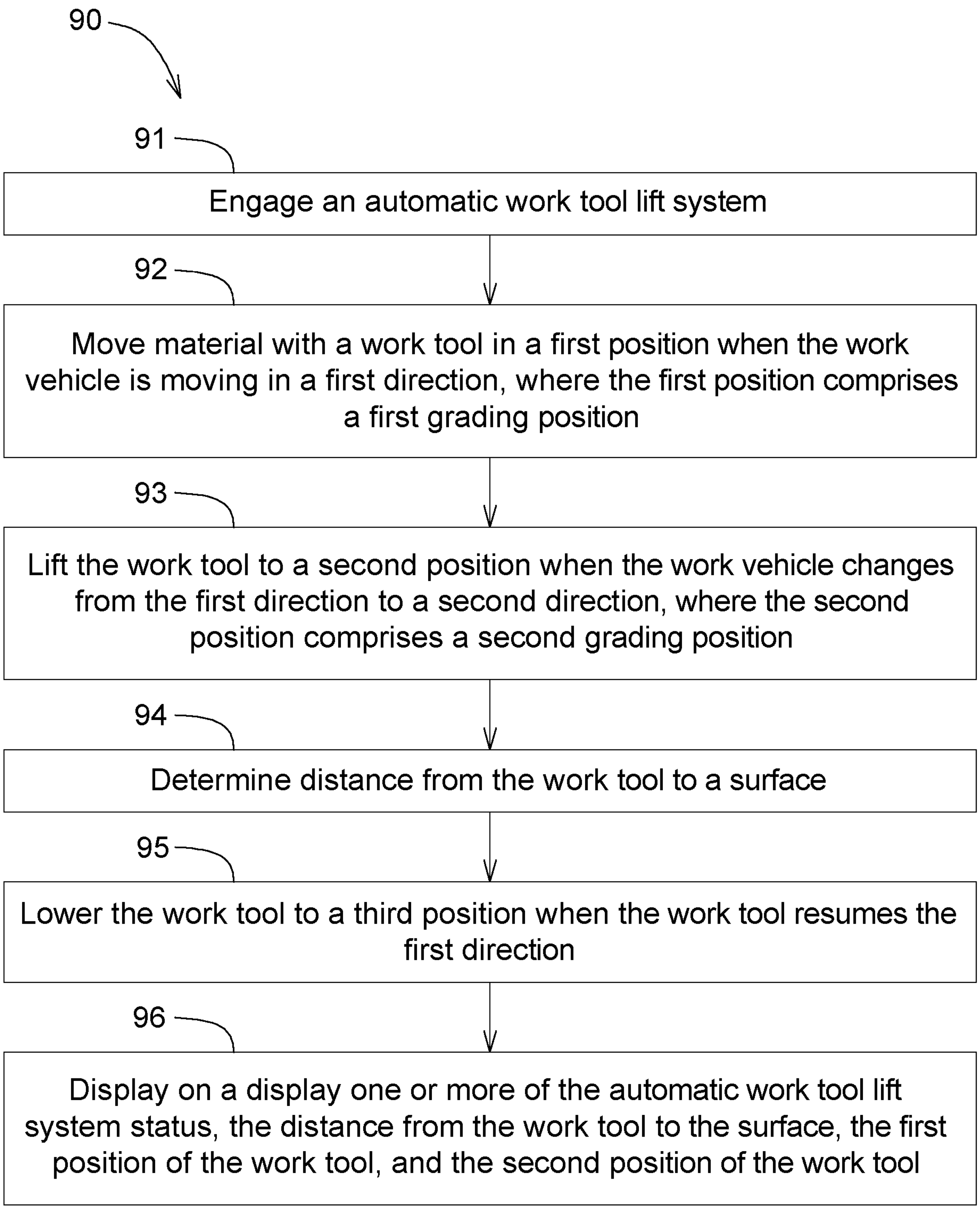

90
91
Engage an automatic work tool lift system
92
Move material with a work tool in a first position when the work vehicle is moving in a first direction, where the first position comprises a first grading position
93
Lift the work tool to a second position when the work vehicle changes from the first direction to a second direction, where the second position comprises a second grading position
94
Determine distance from the work tool to a surface
95
Lower the work tool to a third position when the work tool resumes the first direction
96
Display on a display one or more of the automatic work tool lift system status, the distance from the work tool to the surface, the first position of the work tool, and the second position of the work tool

FIG. 6

SYSTEM AND METHOD FOR BLADE CONTROL ON A UTILITY VEHICLE

TECHNICAL FIELD

[0001] The present disclosure generally relates to a utility vehicle. An embodiment of the present disclosure relates to system and method for controlling a blade on utility vehicles.

BACKGROUND

[0002] Utility vehicles, such as motor graders, bulldozers, crawlers, feller bunchers, scrapers, excavators, skid and track loaders often move material in repetitive movements. During various grading movements, an operator often is moving material while going forward during a grading pass, lifting the work tool, switching to reverse to move back to a starting point, stopping, lowering the work tool, and then resuming forward movement while doing additional grading. This movement is very repetitive and requires many repeat actions by the operator.

SUMMARY

[0003] Various aspects of examples of the present disclosure are set out in the claims.

[0004] According to a first aspect of the present disclosure, a work tool control system for a work vehicle, the work tool system comprising at least two hydraulic cylinders, a work tool coupled, directly or indirectly, with the at least two hydraulic cylinders, the work tool configured to move material, a controller, wherein the controller is in communication with the at least two hydraulic cylinders, an operator interface, wherein the operator interface is in communication with the controller, wherein when the controller receives a first signal from the operator interface the controller sends a second signal to the at least two hydraulic cylinders, where the first signal is a vehicle reverse signal and the second signal is a work tool lift signal.

[0005] According to a second aspect of the present disclosure, a work vehicle comprising at least two hydraulic cylinders, a work tool coupled, directly or indirectly, with the at least two hydraulic cylinders, the work tool configured to move material, a controller, wherein the controller is in communication with the at least two hydraulic cylinders, wherein when the controller sends a second signal to the at least two hydraulic cylinders, where the first signal is vehicle reverse signal and the second signal is a work tool lift signal.

[0006] According to a third aspect of the present disclosure, a method of moving material with a work vehicle, the method comprising engaging an automatic work tool lift system, moving material with a work tool in a first position when the work vehicle is moving in a first direction, lifting the work tool to a second position when the work vehicle changes from the forward direction to a second direction, determining a distance from the work tool to a surface, and lowering the work tool to a third position when the work vehicle returns to the forward direction.

[0007] The above and other features will become apparent from the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The detailed description of the drawings refers to the accompanying figures in which:

[0009] FIG. **1** is a side view of a utility vehicle with a blade, consistent with embodiments of the present disclosure;

[0010] FIG. **2** is a side view of the utility vehicle of FIG. **1** with a work tool control system, including a work tool height sensor, consistent with embodiments of the present disclosure;

[0011] FIGS. **3**A-C are side views of a utility vehicle with the work tool of a utility vehicle moving material while traveling forward, raising the blade, and then traveling in reverse, consistent with embodiments of the present disclosure;

[0012] FIG. **4** is a representative view of a display showing information related to the work tool control system, consistent with embodiments of the present disclosure;

[0013] FIG. **5** is a schematic diagram of the work tool control system, consistent with embodiments of the present disclosure; and

[0014] FIG. **6** is a flow diagram showing a method of moving material, consistent with embodiments of the present disclosure.

[0015] Like reference numerals are used to indicate like elements throughout the several figures.

DETAILED DESCRIPTION

[0016] At least one example embodiment of the subject matter of this disclosure is understood by referring to FIGS. **1** through **6** of the drawings.

[0017] While the present disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description is not restrictive in character, it being understood that illustrative embodiment(s) have been shown and described and that all changes and modifications that come within the spirit of the present disclosure are desired to be protected. Alternative embodiments of the present disclosure may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may devise their own implementations that incorporate one or more of the features of the present disclosure and fall within the spirit and scope of the appended claims.

[0018] Currently in motor graders, in certain scenarios after a pass of grading, an operator lifts up the blade and reverses the motor grader to be ready to make another grading pass. After reversing, the operator brings the blade down to the grading position and then starts the grading operation. This operation, when done multiple times can lead to loss of productivity and operator fatigue.

[0019] The above repeated back-and-forth operation often occurs in an area where the operator doesn't take a U-turn (or is unable to make a U-turn). Or when the operator prefers to lift the blade and reverse the motor grader. After reversing, and before resuming forward motion and another grading pass, the operator needs to lower the blade to the desired grading position manually.

[0020] In some situations, an operator may want to spread material while moving in reverse, depositing some of the material that accumulated on the blade during the forward grading pass. Again, this becomes a manual operation where the operator is required to, after completing a forward grading pass, to lift the blade some amount when reverse is engaged to spread the material while reversing.

[0021] Advantages for the embodiments described herein include: increased productivity as operator doesn't have to repeated blade lift and blade down operations, reduction in operator fatigue, improvements to precision grading, and helpful for inexperienced operators during grading operations without affective productivity of the operator.

[0022] The embodiments described herein provide automation to this process and improve it by using sensors capable of determining a distance, including for example, ultrasonic, radar, lidar, and other similar sensors, to take intelligent decisions on next grading position and material spread and could assist in precision grading every time without operator intervention or with limited operator intervention. This process can also reduce operator fatigue and increase operator productivity.

[0023] FIG. **1** is a side view of a utility vehicle with a blade, consistent with embodiments of the present disclosure. FIG. **1** illustrates a utility vehicle in the form of a motor grader **10**. Although a utility vehicle is illustrated and described as the motor grader **10**, the utility vehicle may include, for example, bulldozers, crawlers, feller bunchers, scrapers, excavators, skid and track loaders, or any other utility vehicle that uses a work tool (e.g., a bucket, a blade, a moldboard, etc.) to move material such as dirt, soil, sand, gravel, rock, etc.

[0024] The motor grader **10** (i.e., work vehicle, utility vehicle, vehicle) includes a main frame **12** and an articulated frame **14** which is pivotable with respect to main frame **12**. Operator cab **13** is mounted atop articulated frame **14**. Operator cab **13** includes operator controls, such as display unit xx shown in FIG. **5** and described in detail below, such that a human operator can control the vehicle **10** or the vehicle can be controlled autonomously.

[0025] Motor grader **10** has two leanable front traction wheels **20** and four non-leanable rear fraction wheels **18**. All of wheels **18**, **20**, and **21** are operably coupled to engine **19** with a transmission **19**A such that wheels **18**, **20**, **21** may be selectively driven to propel frames **12** and **14** respectively along the ground. In particular, main frame **12** supports internal combustion engine **19** (e.g., a diesel engine) with the transmission **19**A of the vehicle **10**.

[0026] The articulated frame **14** includes a moldboard **26** (e.g., a blade) mounted thereto. The blade **26** is configured for spreading, leveling, or otherwise moving earthen or other material. In order to facilitate such operations, blade **26** is mounted to frame **14** such that blade **26** is selectively moveable in a number of directions. A draft frame **22** is coupled to articulated frame **14** toward the front via a ball-and-socket joint. A circle frame **28** is coupled to the draft frame **22** to rotate relative thereto by use of a circle drive **38** mounted to the draft frame **22**. A tilt frame **40** holds the blade **26** and is coupled pivotally to the circle frame **28** for pivotal movement of the tilt frame **40** and the blade **26** held thereby relative to the circle frame **28** about a tilt axis by use of a tilt cylinder (not shown in FIG. **1**).

[0027] The tilt cylinder is connected to circle frame **28** and tilt frame **40**, such that actuation of tilt cylinder **30** changes the pitch of tilt frame **40** (and thus the moldboard **26**) relative to circle frame **28**. Left and right blade-lift cylinders **34** (i.e., hydraulic lift cylinders) are connected to saddle **36** (which in turn is fixed to articulated frame **14**) and draft frame **22** such that actuation of left and right blade lift cylinders **34** raises and lowers the sides of draft frame **22**, and thus the moldboard **26**, relative to articulated frame **14**.

[0028] FIG. **2** is a side view of the utility vehicle of FIG. **1** with a work tool control system, including a work tool height sensor, consistent with embodiments of the present disclosure. The utility vehicle **10** can include a work tool control system **50** (now shown in FIG. **2**; see FIG. **5** and related discussion), including a work tool **26** (i.e., the blade **26**) and a work tool height sensor **52**. The work tool height sensor **52** can be coupled with, for example, the draft frame **22**, the circle frame **28**, or other location (e.g., under the operator cab **13** (not shown in FIG. **2**; see FIG. **1**) or on the articulated frame **14**) at a first position **54**, where the first position **54** is rearward of the blade **26** (i.e., behind the blade **26**; closer to the rear wheels **18**). The work tool height sensor **52** can be positioned to determine a height of the blade **26** from the surface below the blade **26** (e.g., the height of the blade **26** off a surface **56** (i.e., the ground)).

[0029] The work tool height sensor **52** can calculate (i.e., determine, measure, etc.) the work tool height **58** (i.e., work tool distance) from the ground **56** (i.e., surface being graded). The work tool height sensor **52** can send a signal to a controller **60** with the work tool height **58**. Software in the controller can use the work tool height **58** to determine, for example, how much the work tool **26** (e.g., blade) needs to be lifted above the ground **56**, for example, when switching from forward grading movement to reverse non-grading movement or how much the work tool **26** needs to be lowered towards the ground **56** when switching from reverse non-grading movement to forward grading movement. The work tool height sensor **52** can use, for example, ultrasonic sensors, radar, lidar, or other similar technology to calculate the height of the work tool **26** above the ground **56** (in addition to blade location information from the encoded blade lift cylinders **34**).

[0030] The work tool height sensor **52**, as part of the system **50**, could also be used to bring the work tool **26** to the last saved grading position while moving forward (along with help from the encoded blade lift cylinders **34**) and/or to bring the work tool **26** to the next grading position, which can depend on how much grading has been done previously and/or the level of precision set for grading.

[0031] Additional sensors similar to the work tool height sensor **52** can be used to provide data to the system **50** regarding a condition of the ground proximate the work vehicle **10**. For example, the system can decide, based in part, on when to spread material with the work tool **26**, when to lift the work tool when reversing,

[0032] A display (e.g., a monitor) can be used to display information related to the work tool control system. See below for additional details.

[0033] FIGS. **3**A-C are side views of a utility vehicle with the work tool of a utility vehicle moving material while traveling forward, raising the blade, and then traveling in reverse, consistent with embodiments of the present disclosure. The operator (or the controller **60**) can cause the work vehicle **10** to move forward to spread material with the blade **26** or cause the work vehicle **10** to move in reverse without spreading material with the blade **26**. In some instances, it can be desirable to move material with the blade **26** while the work vehicle **10** is traveling in reverse.

[0034] As shown in FIG. **3**A, the utility vehicle **10** can move material **62** (e.g., dirt, sand, soil, rock, etc.) while traveling forward. After reaching a desired point, the operator (or the controller) can then stop the utility vehicle **10** and lift (i.e., raise, etc.) the work tool **26** above the surface **56** proximate the work tool **26** as shown in FIG. **3**B. Then, the utility vehicle **10** can travel in reverse, as shown in FIG. **3**C, with the work tool **26** in the raised position until a new starting location is reached for the next grading pass (or a previous starting location for another grading pass with the work tool a different height from the previous pass). Then the process can be repeated with the utility vehicle **10** stopping reverse movement, the work tool **26** being lowered, and then forward motion can resume where the work tool **26** again starts to grade the surface **56** by moving material.

[0035] FIG. **4** is a representative view of a display showing information related to the work tool control system, consistent with embodiments of the present disclosure. A display **80** can show, for example, an engagement status **82** of the work tool control system **50** to show if the system **50** is engaged or disengaged (i.e., turned on or turned off), data **84** from the work tool height sensor **52** such as the work tool height **58** from the surface below the blade **26** (e.g., the height of the blade **26** off the ground **56**).

[0036] The display **80** can also include information **86** about the blade **26** position, such as, whether the blade **26** is in a grading position (e.g., generally in contact with the ground **56** (e.g., material) and cutting into the ground, moving material, etc.) or in a lifted position (e.g., generally not in contact with the ground **56** (e.g., material) and lifted higher than the grading position. The display **80** can also show a current gear **64** of the utility vehicle.

[0037] The display **80** can include one or more of text characters (i.e., letters and/or numbers), and graphical images related to the information described above. For example, the display could include a graphical representation of the blade in the lowered (i.e., grading) position or in the raised (i.e., traveling; non-grading) position or text characters with the same information.

[0038] FIG. **5** is a schematic diagram of the work tool control system, consistent with embodiments of the present disclosure. In FIG. **5**, the various inputs and outputs of the work tool control system **50** are shown. Inputs to the controller **60** of the work tool control system **50** can include, for example, a current gear **64** (i.e., first gear, second gear, third gear, etc.) of a transmission (not shown) of the work vehicle (e.g., work vehicle **10** of FIG. **1**), a reverse gear signal **66** from the transmission controller (transmission control unit (TCU), not shown in FIG. **1**), a blade angle **68** of the blade **26** (e.g., from left and right blade-lift cylinders **34** ; see FIG. **2**), a blade position **70** (also from left and right blade-lift cylinders **34** ; see FIG. **2**), one or more sensors **72** (including, for example, the work tool height sensor **52** (see FIG. **2**) and/or other ultrasonic, radar, or lidar sensors), and a sealed switch module (SSM) or a display **80** with touch capabilities.

[0039] Outputs from the controller **60** can include a hydraulic lift valve signal **76** to the left and right blade-lift cylinders **34** (e.g., to the hydraulic valves for those cylinders to raise or lower the blade **26**). Another output from the controller **60** can include one or more signals to a display **80**.

[0040] FIG. **6** is a flow diagram showing a method of moving material, consistent with embodiments of the present disclosure. The method **90** can include a step **91** of engaging an automatic work tool lift system, a step **92** of moving material with a work tool in a first position when the work vehicle is moving in a first direction, a step **93** of lifting the work tool to a second position when the work vehicle changes from the forward direction to a reverse direction, a step **94** of determining a distance from the work tool to a surface, and a step **95** of lowering the work tool to a third position when the work vehicle returns to the forward direction.

[0041] The first position can comprise, for example, a first grading position and the third position can comprise a second grading position. In one embodiment, the first grading position might be a first pass over a surface being graded with the work vehicle having a blade in a the first grading position and moving forward, then the vehicle would switch to reverse direction, lift the blade to a second position above the surface while reversing, and then stop reversing and return to forward movement and also positioning the blade in a second grading position, where the second grading position has the blade lower (i.e., further from the work vehicle) to move material.

[0042] The method **90** can further comprise displaying on a display (e.g., display **80**) one or more of the automatic work tool lift system status, the distance from the work tool to the surface, the first position of the work tool, and the second position of the work tool.

[0043] As used herein, "e.g." is utilized to non-exhaustively list examples, and carries the same meaning as alternative illustrative phrases such as "including," "including, but not limited to," and "including without limitation." As used herein, unless otherwise limited or modified, lists with elements that are separated by conjunctive terms (e.g., "and") and that are also preceded by the phrase "one or more of," "at least one of," "at least," or a like phrase, indicate configurations or arrangements that potentially include individual elements of the list, or any combination thereof. For example, "at least one of A, B, and C" and "one or more of A, B, and C" each indicate the possibility of only A, only B, only C, or any combination of two or more of A, B, and C (A and B; A and C; B and C; or A, B, and C). As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Further, "comprises," "includes," and like phrases are intended to specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof.

[0044] The detailed description and the drawings or figures are supportive and descriptive of the disclosure, but the scope of the disclosure is defined solely by the claims. While some of the best modes and other embodiments for carrying out the claimed teachings have been described in detail, various alternative designs and embodiments exist for practicing the disclosure defined in the appended claims.

What is claimed is:

1. A work tool control system for a work vehicle, the work tool control system comprising:

at least two hydraulic cylinders;

a work tool coupled, directly or indirectly, with the at least two hydraulic cylinders, the work tool configured to move material;

a controller, wherein the controller is in communication with the at least two hydraulic cylinders;

an operator interface, wherein the operator interface is in communication with the controller

wherein when the controller receives a first signal from the operator interface the controller sends a second signal to the at least two hydraulic cylinders, where the first signal is a vehicle reverse signal and the second signal is a work tool lift signal.

2. The work tool control system of claim **1**, wherein the work tool comprises a blade, a bucket, or a scraper.

3. The work tool control work tool control system of claim **2**, wherein when the controller receives a third signal from the operator interface the control sends a fourth signal to the at least two hydraulic cylinders, where the third signal is a vehicle forward signal and the fourth signal is a work tool lower signal.

4. The work tool control system of claim **1**, wherein the operator interface comprises a switch for engaging the system.

5. The work tool control system of claim **4**, wherein the switch comprises a physical switch or a virtual switch.

6. The work tool control system of claim **1**, wherein the work tool lift signal raises the work tool from a first position to a second position, where the first position is closer to a ground and the second position is further from the ground.

7. The work tool control system of claim **1**, further comprising a work tool height sensor, wherein the work tool height sensor determines a height of the work tool with respect to a ground.

8. The work tool control system of claim **7**, wherein the work tool height sensor comprises one or more of an ultrasonic sensor, a lidar sensor, or a radar sensor.

9. The work tool control system of claim **1**, further comprising a display, wherein the display includes one or more of a first notification for the first signal and a second notification for the second signal.

10. A work vehicle comprising:

at least two hydraulic cylinders;

a work tool coupled, directly or indirectly, with the at least two hydraulic cylinders, the work tool configured to move material;

a controller, wherein the controller is in communication with the at least two hydraulic cylinders; and

an operator interface, wherein the operator interface is in communication with the controller, wherein when the controller receives a first signal from the operator interface the controller sends a second signal to the at least two hydraulic cylinders, where the first signal is a vehicle reverse signal and the second signal is a work tool lift signal.

11. The work vehicle of claim **10**, wherein the work tool comprises a blade, a bucket, or a scraper.

12. The work vehicle of claim **10**, wherein when the controller receives a third signal from the operator interface the control sends a fourth signal to the at least two hydraulic cylinders, where the third signal is a vehicle forward signal and the fourth signal is a work tool lower signal.

13. The work vehicle of claim **10**, wherein the work tool lift signal raises the work tool from a first position to a second position, where the first position is closer to a ground and the second position is further from the ground.

14. The work vehicle of claim **10**, further comprising a work tool height sensor, wherein the work tool height sensor determines a height of the work tool with respect to a ground.

15. The work vehicle of claim **14**, wherein the work tool height sensor comprises one or more of an ultrasonic sensor, a lidar sensor, or a radar sensor.

16. The work vehicle of claim **10**, further comprising a display, wherein the display includes one or more of a first notification for the first signal and a second notification for the second signal.

17. A method of moving material with a work vehicle, the method comprising:

engaging an automatic work tool lift system;

moving material with a work tool in a first position when the work vehicle is moving in a first direction;

lifting the work tool to a second position when the work vehicle changes from a forward direction to a reverse direction;

determining a distance from the work tool to a surface; and

lowering the work tool to a third position when the work vehicle returns to the forward direction.

18. The method of claim **17**, wherein the first position comprises a first grading position and the third position comprises a second grading position.

19. The method of claim **17**, further comprising displaying on a display one or more of a status of the automatic work tool lift system, the distance from the work tool to the surface, the first position of the work tool, and the second position of the work tool.

* * * * *