US 20250266600A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0266600 A1**

Hettinger et al. (43) **Pub. Date: Aug. 21, 2025**

(54) **ROCK GUARD FOR GNSS SIGNAL AVOIDANCE**

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(21) Appl. No.: **18/443,218**

(22) Filed: **Feb. 15, 2024**

Publication Classification

(51) **Int. Cl.**

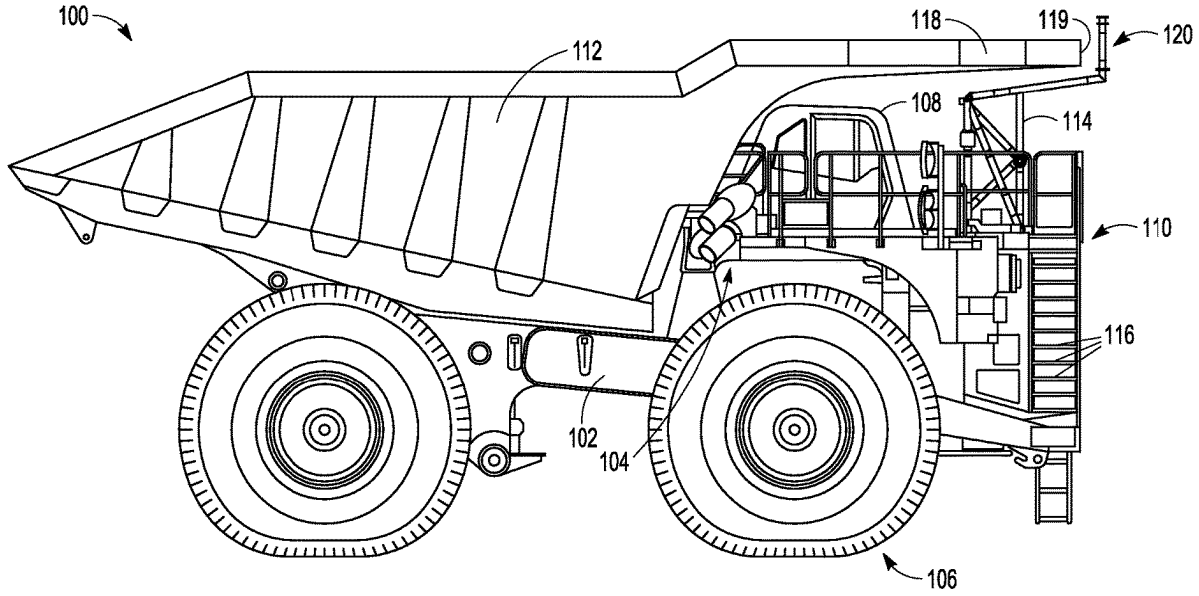
H01Q 1/42	(2006.01)
H01Q 1/00	(2006.01)
H01Q 1/32	(2006.01)

(52) **U.S. Cl.**

CPC ***H01Q 1/42*** (2013.01); ***H01Q 1/002*** (2013.01); ***H01Q 1/3208*** (2013.01); ***H01Q 1/325*** (2013.01)

(57) **ABSTRACT**

A haul truck can include a frame, a traction system for moving the frame, an access platform coupled to the frame, a truck bed having a canopy extending over the access platform, an antenna support structure arranged on the access platform, the antenna support structure extending upward to support a GNSS receiver positioned proximate a front of the canopy, and a non-metallic protective barrier coupled to the canopy and positioned towards the front of the canopy and positioned to deflect objects from striking the GNSS receiver.



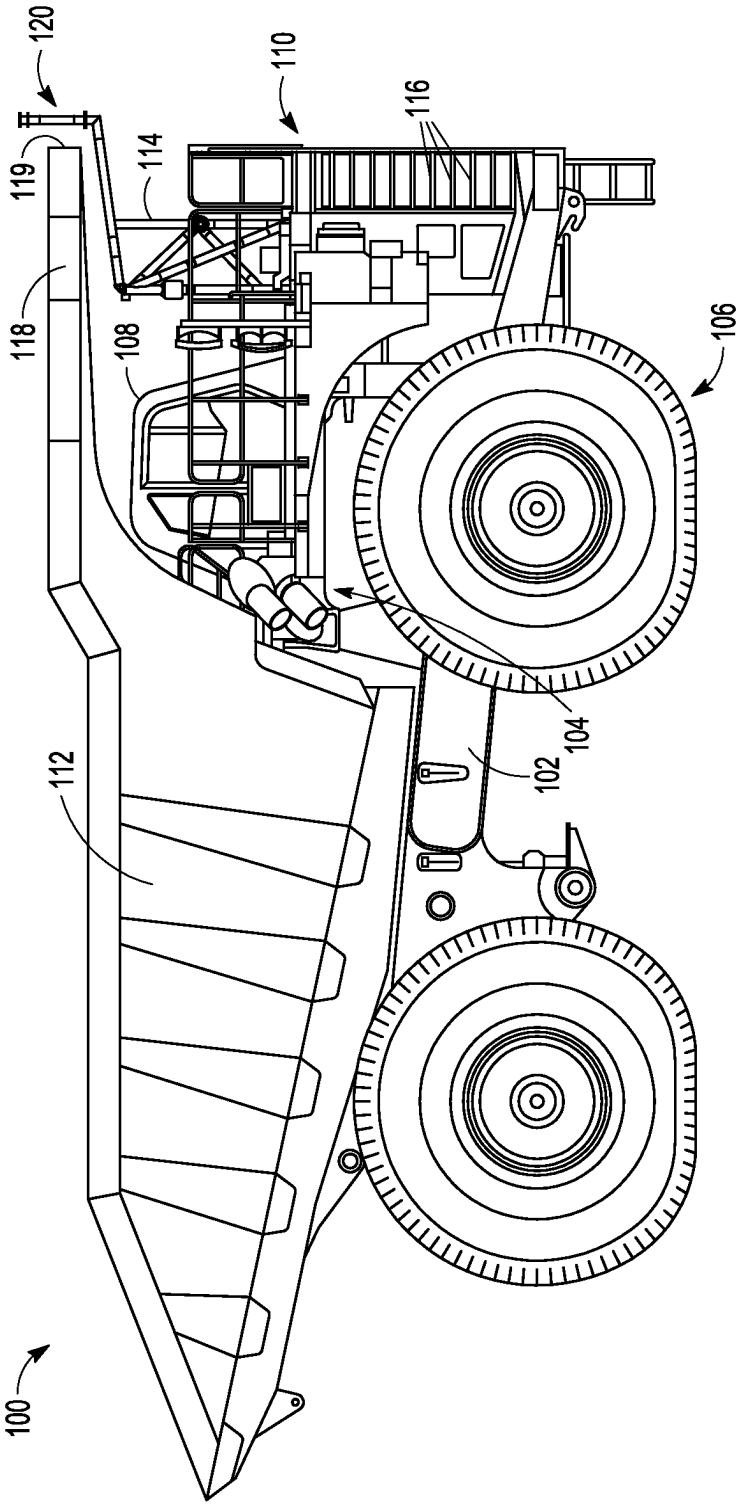


FIG. 1

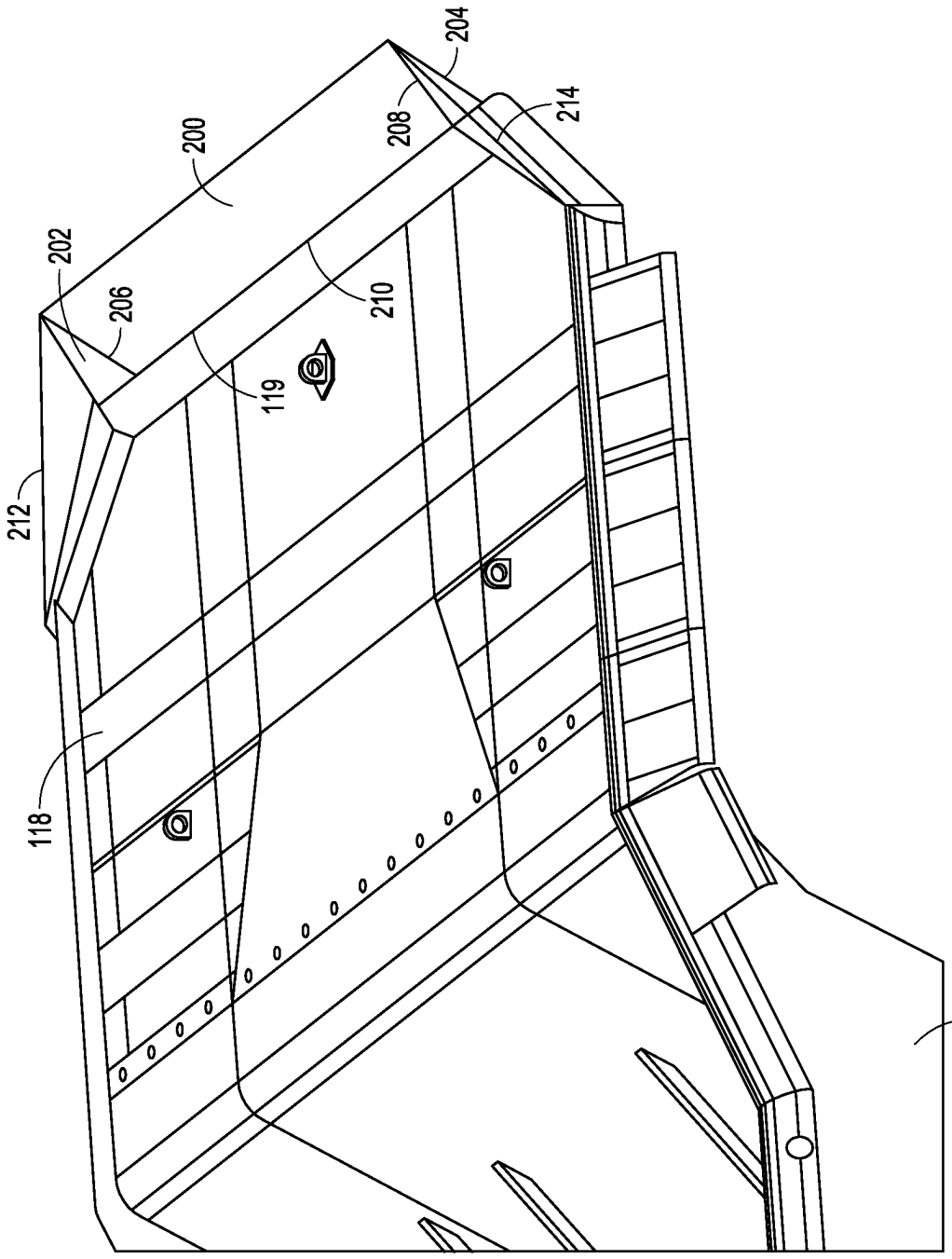


FIG. 2

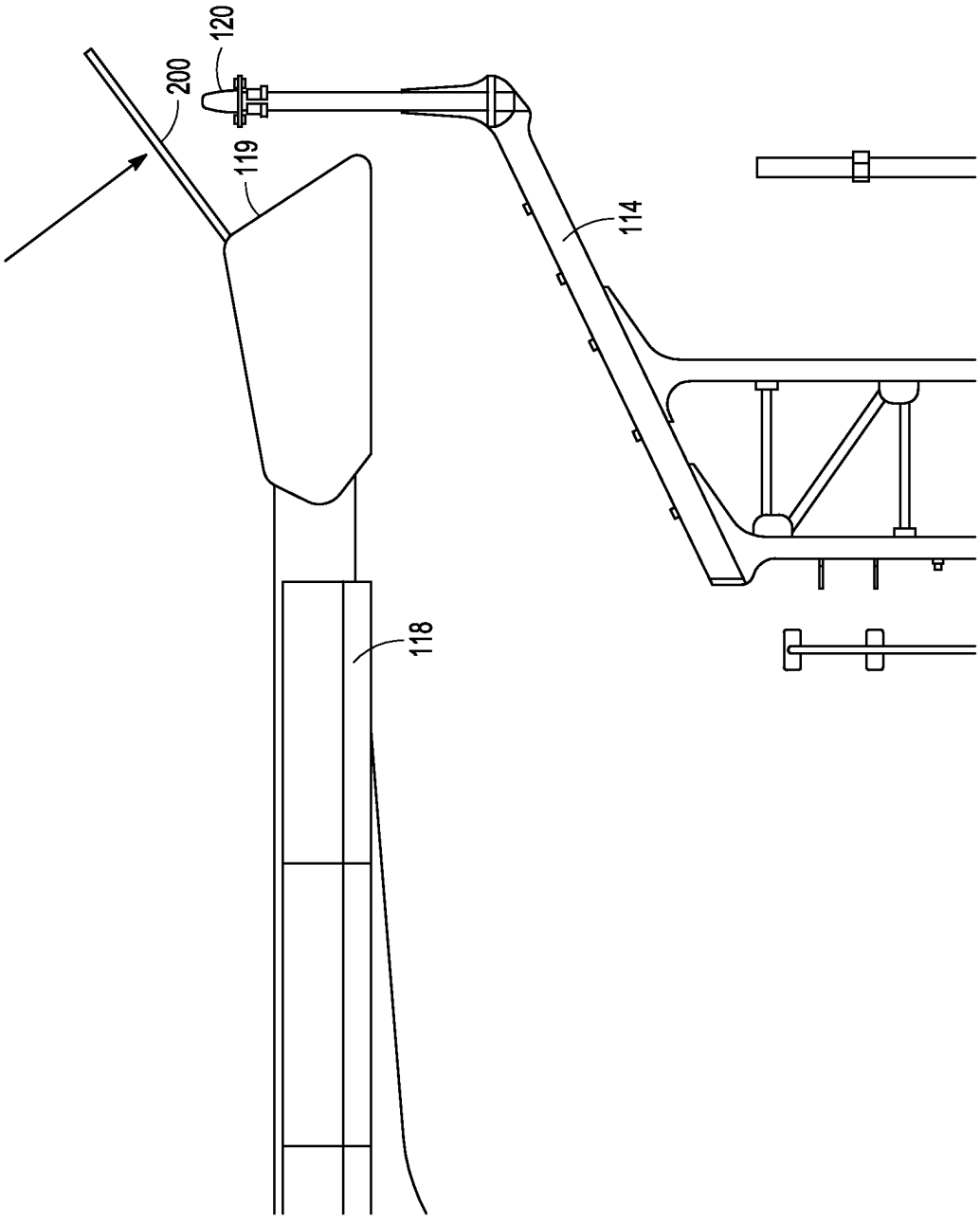


FIG. 3

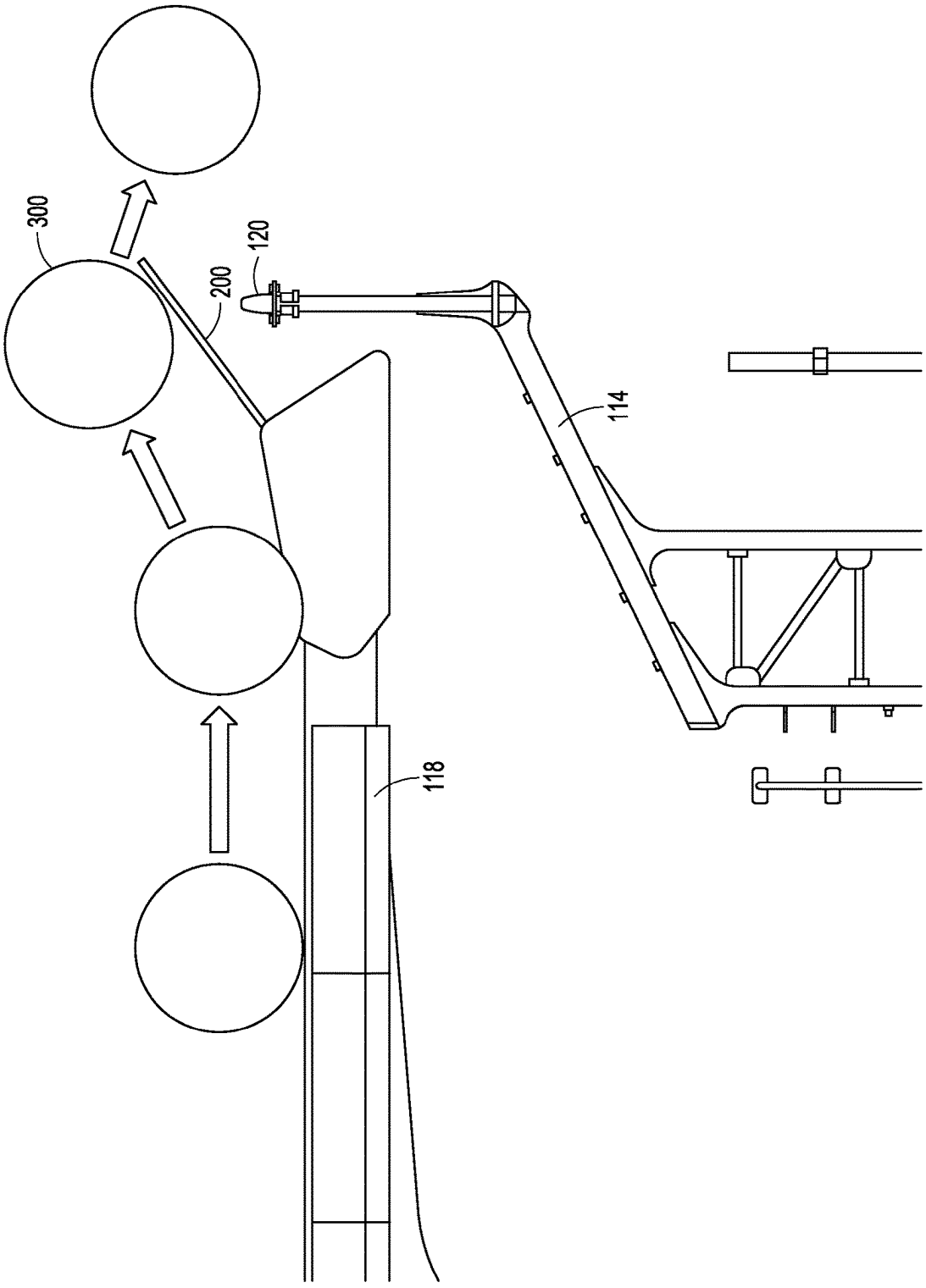


FIG. 4

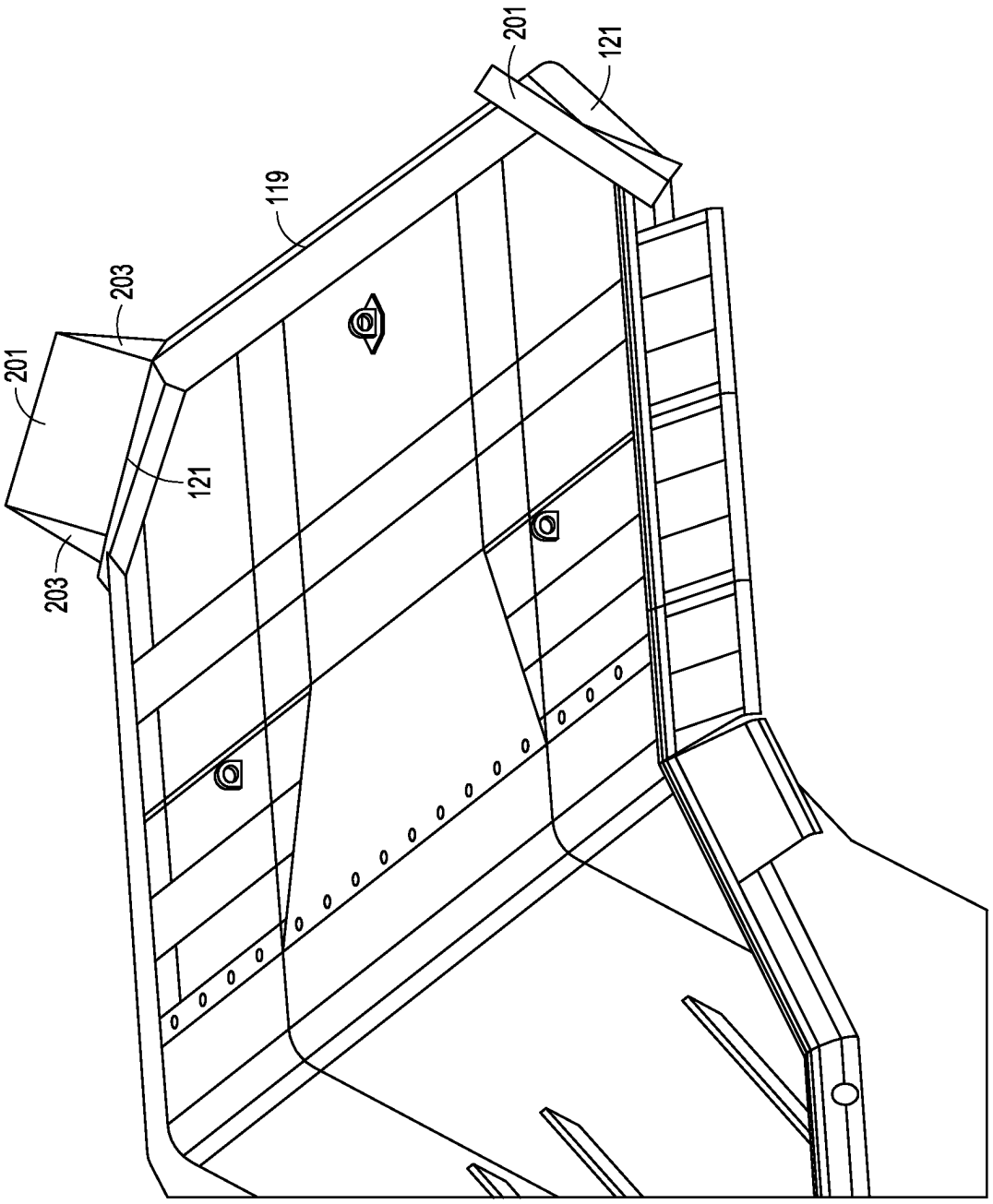


FIG. 5

ROCK GUARD FOR GNSS SIGNAL AVOIDANCE

TECHNICAL FIELD

[0001] The present disclosure generally relates to a work machine. More particularly, the present disclosure relates to a rock guard for a haul truck.

BACKGROUND

[0002] Work machines and other vehicles can include antennas or other communication devices for wirelessly transmitting and/or receiving signals. Receiver antennas for accessing global navigational satellite systems (GNSS), such as global positioning systems (GPS), may be present on vehicles or work machines for helping to identify positional information of vehicles or work machines. For example, and particularly in the context of autonomous work machines, positional information may be used by remote operators or operator systems to manipulate autonomous work machines on a job site, a project, a mining operation, or for other purposes.

[0003] In the context of haul trucks, such as quarry trucks, mining trucks, or other heavy equipment type trucks, finding or providing mounting locations for antennas may be a difficult problem. That is, for example, haul trucks may include a very large truck bed that may include a canopy extending forward from the truck bed and above the cab of the truck to protect the cab from falling rock or other damaging debris. GNSS receiver antennas, in particular, may perform better when they have a 360 degree field of view. Given the nature of haul trucks, finding a mounting location that allows the antennas to extend above the top of the rest of the parts of the truck to provide a **360** degree field of view may often involve a support structure that extends from a service or access platform around the cab. However, this leaves the receiver antenna exposed to falling rocks and other material.

[0004] CN 215117267 discusses a truck having a communication device which is provided with a protective cover so that falling rocks in a mining area are prevented from hitting the communication device.

SUMMARY

[0005] In an example according to this disclosure, a haul truck can include a frame, a traction system for moving the frame, an access platform coupled to the frame, a truck bed having a canopy extending over the access platform, an antenna support structure arranged on the access platform, the antenna support structure extending upward to support a GNSS receiver positioned proximate a front of the canopy, and a non-metallic protective barrier coupled to the canopy and positioned towards the front of the canopy and positioned to deflect objects from striking the GNSS receiver.

[0006] In one example, a canopy extension for a haul truck can include a non-metallic protective barrier coupled to a canopy of the haul truck and positioned towards a front of the canopy and positioned to deflect objects from striking a GNSS receiver, which is positioned proximate the front of the canopy.

[0007] In one example, a method of protecting a GNSS receiver mounted on a haul truck can include providing a non-metallic protective barrier, and mounting the non-metallic protective barrier towards a front of a canopy of the haul truck to provide a canopy extension positioned to deflect objects from striking a GNSS receiver which is positioned proximate the front of the canopy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The drawings illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0009] FIG. **1** shows a side view of a haul truck, in accordance with one embodiment.

[0010] FIG. **2** shows a top perspective view of a protective barrier for the haul truck, in accordance with one embodiment.

[0011] FIG. **3** shows a schematic side view of the protective barrier and a receiver, in accordance with one embodiment.

[0012] FIG. **4** shows a schematic side view of the protective barrier in use, in accordance with one embodiment.

[0013] FIG. **5** shows a top perspective view of a protective barrier for the haul truck, in accordance with one embodiment.

DETAILED DESCRIPTION

[0014] FIG. **1** is a perspective view of a haul truck **100**. The haul truck may be configured for hauling heavy rock, debris, equipment, or other items. In one or more embodiments, for example, the haul truck may be adapted for working in a rock quarry, for example, where rock mining and digging is performed and the mined material is in need of transport to crushers, other processing equipment, or to trucks more suitable for over-the-road transport. As shown, the haul truck **100** may include a frame **102**, an engine **104** positioned on the frame, a traction system **106**, a cab **108**, an access platform **110**, a truck bed **112**, and an antenna support structure **114** for a receiver **120**.

[0015] The haul truck frame **102** may be configured to support the loads imparted on the truck and transfer the loads the traction components. The frame may, thus, extend between rear and front components of the traction system **106** and provide a support point for the truck bed **112** and a support system for the engine **104**. The frame **102** may also extend forward of the front component of the traction system **106** to provide support for the access platform **110**, the cab **108**, the antenna support structure **114** and other features of the haul truck **100**.

[0016] The engine **104** may be adapted to provide power to the haul truck **100**. In particular, the engine **104** may be adapted to provide motive power to the traction system **106** to allow the haul truck **100** to be driven from place to place and may provide power to a hydraulic or other actuation system for the truck bed **112**, for example. In one or more embodiments, the engine **104** may include an internal, or external, combustion engine. Alternatively, or additionally, electric power may be provided via a turbine or battery source and an electric motor may be provided for powering the traction system **106** and/or the hydraulic system. Still other sources of power may be provided.

[0017] The traction system **106** may be configured for moving the haul truck **100** relative to a ground surface. The

traction system **106** may include a system of wheels, as shown, or a track type system may be provided. Still other traction systems may be provided.

[0018] The cab **108** may be configured to provide a location for an operator to operate the haul truck **100** and, as such, may include one or more operational interfaces such as gas, brake, and steering as well as truck bed controls, and other control interfaces. The cab **108** may be located relatively high on the haul truck **100** to allow for visibility by the operator in front of and to the sides of the haul truck. In one or more embodiments, the cab may be arranged above the height of the traction system **106** as shown. It is to be appreciated that while a cab **108** is shown, the haul truck **100** may be operable autonomously as well as via an operator present in the cab **108**. In one or more embodiments, where on-truck operation by an operator is not provided, the cab **108** may be omitted, for example.

[0019] The access platform **110** may be configured to provide an operator with access to the cab **108**. For example, as shown, the access platform **110** may include a stairway **116** extending from ground level upward to a height above the traction system **106**. The access platform **110** may be arranged on the frame **102** and provide a relatively flat walking and supporting surface above the traction system **106**. In one or more embodiments, the access platform **110** may provide a support surface for other equipment such as hydraulic reservoirs, brake fluid tanks, air tanks, and/or other systems and components.

[0020] The truck bed **112** may be configured for receiving and holding large quantities of material. As shown, the truck bed **112** may include a large bucket like system arranged generally on the rear of the haul truck **100**. The large bucket like system may include a forward sloping bottom, sidewalls, a front wall arranged behind the cab **108**, and a protective platform or canopy **118** extending forwardly from a top edge of the front wall and above the cab **108** and over the access platform **110**. The truck bed **112** may be articulable in a pivoting motion relative to the frame **102** via a hydraulic cylinder or cylinders to allow for selective dumping of the material within the bed **112**.

[0021] As shown and mentioned, the haul truck **100** may include the antenna support structure **114** for the receiver **120**. The antenna support structure **114** may be adapted to provide a support location for the receiver **120** outside of the protective overhead coverage of the canopy **118**, such that the canopy **118** is not located over the vertical axis of the receiver **120**. For example, the receiver **120** can be positioned in front of the canopy **118** or to a front corner side of the canopy **118** and at a height sufficient to allow the receiver **120** to extend above the height of the truck bed **112** and the canopy **118** to allow for a 360 degree field of view.

[0022] As shown, the antenna support structure **114** may be supported by and/or secured to the access platform **110** and be arranged generally below the canopy **118**. The antenna support structure **114** can then extend upward and forward from the access platform **110** and may provide support for the receiver **120** towards a front of the canopy **118**. The antenna support structure **114** may be arranged at a height generally flush with or near a bottom of the canopy **118** such that when the receiver **120** is mounted thereon, the receiver **120** extends above the canopy **118** so as to have a 360 degree coverage.

[0023] As used herein, the receiver **120** can include any of a GNSS or GPS receiver, a GNSS or GPS antenna, or a GNSS or GPS receiver antenna. As noted, the receiver **120** can be positioned in front of or to the side of a front edge **119** the canopy **118**, such that the receiver **120** is not protected by the canopy **118**. The receiver **120** can be positioned so that a top of the receiver **120** is higher than an upper surface of the canopy **118** such that the receiver **120** is higher than the canopy **118**.

[0024] As noted, a problem that can arise is falling debris striking the relatively open receiver **120** of the haul truck since the receiver **120** is positioned outside of the protective coverage of the canopy. Current guarding methods for protection of GNSS/GPS receiver antennas at the front of mining trucks currently utilize large metal guards. However, such metal guards typically interfere with the GNSS signal. If the guard is low enough to avoid disruption of the GNSS signal, the potential arises for material to travel over the top of the metal guard striking the receiver and rendering the guard ineffective.

[0025] As will be detailed below, the present system includes a protective barrier located towards the front of the canopy of a mining truck for autonomous applications to provide additional protection for the receiver(s) **120** that are attached to the support structure **114** on the front of the truck **100**. The protective barrier can be constructed of non-metallic material and function as a canopy extension that can extend above the height of the GNSS receivers, providing protection from rocks that may otherwise bounce over existing guards, while not interfering with the GNSS signals.

[0026] For example, FIG. **2** shows a top perspective view of a protective barrier **200** for the haul truck, in accordance with one embodiment, and FIG. **3** shows a schematic side view of the protective barrier **200** and the receiver **120**.

[0027] In this example, the protective barrier **200** can be coupled to and stretched between the outer edges of the canopy **118** and coupled proximate a front of the canopy **118** at the front edge **119** of the canopy **118** and positioned to deflect objects from striking the GNSS receiver **120**. In one example, the protective barrier **200** can be wide enough so to be as wide is the front edge **119** of the canopy **118**. As will be discussed below, in some embodiments, the protective barrier can cover the side or front corner edges of the canopy **118** also. In one example, the protective barrier **200** can extend beyond the outer front edge **119** of the canopy **118** at an angle so as to be positioned over the top of the receiver **120**. For example, referring to FIG. **3**, the protective barrier **200** can be sized and positioned so as to be positioned over the vertically extended axis of the receiver **120**. The protective barrier **200** is configured and positioned to deflect objects from hitting the receiver **120**. Accordingly, the protective barrier **200** acts as an extension of the canopy **118**.

[0028] In one embodiment, the protective barrier **200** can be coupled between first and second braces **202**, **204** attached to the canopy **118** and located at the front edge **119** of the canopy **118** with the first brace **202** on one side of the canopy **118** and the second brace **204** on an opposite side of the canopy **118**. The first and second braces **202**, **204** can be angled outward from the leading edge **119** of the canopy **118**. In one example, the braces **202**, **204** can be detachable and easily replaceable. For example, the braces **202**, **204** can be metallic members bolted or otherwise removable fastened to the leading edge of the canopy **118**. The protective barrier **200** can be stretched between and fastened at both ends to the respective braces **202**, **204**. For example, first and second edges **206**, **208** of the protective barrier **200** can be bolted or

otherwise fastened to the braces **202**, **204**, respectively. A bottom edge **210** of the protective barrier **200** can be loose from, or attached to, the canopy **118** at the front edge **119**, if desired.

[0029] In one embodiment, first and second support members **212**, **214**, such as guy wires, can be attached at one end to an upper end of the first and second braces **202**, **204**, respectively, and attached at a second end to the canopy **118**. In other embodiments, the support members **212**, **214** for the braces **202**, **204** can include a plate that extends from a side of the canopy to the braces **202**, **204**, or the support could be provided by a second (and third) non-metallic protective barrier elements positioned where the support members **212**, **214** are shown.

[0030] The protective barrier **200** can include a non-metallic material configured to not interfere with the GPS signal being received by the receiver **120**. In one example, the protective barrier **200** can include a flexible mesh material. For example, the flexible mesh material can include a cargo net webbing, or a nylon mesh or netting strong enough to not be torn by rocks and heavy objects falling into the protective barrier **200**. In one example, the protective barrier **200** can include a solid, non-metallic barrier material, such as a polycarbonate plate.

[0031] Depending on the size of the haul truck **100**, the protective barrier **200** can have a width up to the width of the front edge of the canopy **118** and have a height necessary to provide protective coverage of the receiver **120**. In one example, the non-metallic protective barrier **200** and the braces **202**, **204** can have an angle relative to the canopy **118** of between 0 degrees to 90 degrees. In one example, the non-metallic protective barrier **200** and the braces **202**, **204** can have an angle relative to the canopy of about 45 degrees. In some examples, the protective barrier **200** extends over and covers the vertical axis of the receiver **120**. In other examples, the protective barrier **200** can be positioned to extend 90 degrees vertically so as to be above (higher than, but not necessarily over) the receiver **120** to protect the receiver **120** from falling materials, while still permitting the receiver **120** to have a **360** degree field of view.

[0032] FIG. **4** shows a schematic side view of the protective barrier **200** in use, in accordance with one embodiment. Here, it is shown how rocks or other objects **300** that roll/bounce can be deflected from striking the receiver **120** by the protective barrier **200** unless the protective barrier **200** is overloaded by force.

[0033] FIG. **5** shows a top perspective view of a protective barrier **201** for the haul truck, in accordance with one embodiment. In this example, one or more protective barriers **201** can be positioned at front corner edges **121** proximate a front of the canopy **118**. The protective barrier (s) **201** can be held in place by one or more braces **203** attached to the canopy **118**. In this example, if the receiver **120** (FIG. **1**) were located towards the front corner sides of the canopy **118** instead of directly in front of the canopy **118**, the protective barriers **201** would provide protection, as discussed above. Again, as discussed above, protective barriers **201** can be made of a non-metallic material so as not to interfere with the GPS signals while still providing protection. The protective barriers **201** can also be angled out from the canopy **118**, as discussed above.

[0034] In one embodiment, the examples of FIG. **2** and FIG. **5** can be combined and the protective barriers **200**, **201** can be located around all the front edges of the canopy **118**, including the front edge **119** and the front corner edges **121**.

INDUSTRIAL APPLICABILITY

[0035] The present system is applicable to a haul trucks configured for hauling heavy rock, debris, equipment, or other items. In one or more embodiments, for example, the haul truck may be adapted for working in a rock quarry where rock mining and digging is performed and the mined material is in need of transport to crushers, other processing equipment, or to trucks more suitable for over-the-road transport. The present system is especially applicable to hauls trucks that are autonomous or semi-autonomous utilizing GNSS navigation.

[0036] Referring again to FIGS. **1-5**, in use, the present system provides a method of protecting a GNSS receiver mounted on a haul truck. The method can include providing a non-metallic protective barrier **200**, **201** and mounting the non-metallic protective barrier **200**, **201** proximate a front of a canopy **118** of the haul truck to provide a canopy extension positioned over the GNSS receiver of the haul truck. The non-metallic protective barrier **200**, **201** can be mounted towards a front edge or front corner edges of the canopy **118** to provide a canopy extension positioned to deflect objects from striking the GNSS receiver **120**, which can be positioned in front of a front edge of the canopy, or off to a front corner side, or otherwise not protected by the canopy **118**.

[0037] In one example, the protective barrier **200** can be coupled between first and second braces **202**, **204** attached to the canopy **118** and located at the front edge **119** of the canopy with the first brace on one side of the canopy and the second brace on an opposite side of the canopy. In an example, first and second support members **212**, **214** can be attached to an upper end of the first and second braces and attached to the canopy. In one example, one or more protective barriers **201** can be mounted to the front corner edges **121** of the canopy **118**, in addition to, or instead of, the protective barrier **200**.

[0038] The protective barrier(s) **200**, **201** can be a flexible mesh material, such as a cargo net webbing or a nylon mesh. In one example, the protective barrier can be a solid non-metallic barrier material, such as a polycarbonate plate extending across the width of the front edge of the canopy. The protective barrier **200**, **201** acts as a canopy extension and is configured and positioned to deflect objects from hitting the receiver, while not interfering with the signals being received by the receiver **120**.

[0039] In one example, the protective barrier **200**, **201** can be positioned to extend beyond an outer front edge of the canopy **118** so as to be positioned over the top of the receiver **120**. In other examples the protective barrier can be angled between 0 degrees to 90 degrees relative to the canopy.

[0040] In summary, the present system can include a non-metallic canopy extension for a mining truck, the canopy extension can include two side braces that can extend at an angle outward from a leading edge of the canopy, and a non-metallic barrier can extend between the two braces. Additional support elements, such as guy wires, can extend from a side of the canopy to the braces. The specific angles of the braces and position of the protective barrier relative to the canopy can vary. The material of the barrier can be solid or mesh, it can be flexible material, designed to be detachable/replaced, or it can be a solid material, such as a polycarbonate panel. The protective

barrier system discussed herein can be provided as a retrofit for an existing vehicle or can be installed on the original equipment.

[0041] Various examples are illustrated in the figures and foregoing description. One or more features from one or more of these examples may be combined to form other examples.

[0042] The above detailed description is intended to be illustrative, and not restrictive. The scope of the disclosure should, therefore, be determined with references to the appended claims, along with the full scope of equivalents to which such claims are entitled.

What is claimed is:

1. A haul truck, comprising:

a frame;

a traction system for moving the frame;

an access platform coupled to the frame;

a truck bed having a canopy extending over the access platform;

an antenna support structure arranged on the access platform, the antenna support structure extending upward to support a GNSS receiver positioned proximate a front of the canopy; and

a non-metallic protective barrier coupled to the canopy and positioned towards the front of the canopy and positioned to deflect objects from striking the GNSS receiver.

2. The haul truck of claim **1**, wherein the non-metallic protective barrier extends beyond an outer edge of the canopy so as to be positioned over a top of the GNSS receiver.

3. The haul truck of claim **1**, wherein the non-metallic protective barrier is coupled between first and second braces attached to the front of the canopy.

4. The haul truck of claim **3**, further including first and second support members which are attached to an upper end of the first and second braces and attached to the canopy.

5. The haul truck of claim **1**, wherein the non-metallic protective barrier includes a flexible mesh material.

6. The haul truck of claim **5**, wherein the non-metallic protective barrier includes a cargo net.

7. The haul truck of claim **1**, wherein the non-metallic protective barrier includes a polycarbonate panel.

8. The haul truck of claim **1**, wherein the non-metallic protective barrier has an angle relative to the canopy of between 0 degrees to 90 degrees.

9. The haul truck of claim **8**, wherein the non-metallic protective barrier has an angle relative to the canopy of about 45 degrees.

10. A canopy extension for a haul truck, the canopy extension comprising:

a non-metallic protective barrier coupled to a canopy of the haul truck and positioned towards a front of the canopy and positioned to deflect objects from striking a GNSS receiver, which is positioned outside of a coverage of the canopy.

11. The canopy extension of claim **10**, wherein the non-metallic protective barrier extends beyond an edge of the canopy so as to be positioned over a top of the GNSS receiver.

12. The canopy extension of claim **10**, wherein the protective barrier is coupled between first and second braces attached to the canopy.

13. The canopy extension of claim **12**, further including first and second support members which are attached to an upper end of the first and second braces and attached to the canopy.

14. The canopy extension of claim **10**, wherein the protective barrier includes a flexible mesh material.

15. The canopy extension of claim **10**, wherein the protective barrier includes a polycarbonate panel.

16. The canopy extension of claim **10**, wherein the non-metallic protective barrier has an angle relative to the canopy of between 0 degrees to 90 degrees.

17. The canopy extension of claim **16**, wherein the non-metallic protective barrier has an angle relative to the canopy of about 45 degrees.

18. A method of protecting a GNSS receiver mounted on a haul truck, the method comprising:

providing a non-metallic protective barrier; and

mounting the non-metallic protective barrier towards a front of a canopy of the haul truck to provide a canopy extension positioned to deflect objects from striking a GNSS receiver which is positioned proximate the front of the canopy.

19. The method of claim **18**, wherein the non-metallic protective barrier is coupled to the canopy and extends beyond an edge of the canopy so as to be positioned over a top of the GNSS receiver.

20. The method of claim **19**, wherein the non-metallic protective barrier is coupled between first and second braces attached to the canopy.

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