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(54) **BOOM MOUNTED PUMP**

(71) Applicant: **Nuhn Industries Ltd.**, Sebringville (CA)

(72) Inventor: **Ian Dennis NUHN**, Stratford (CA)

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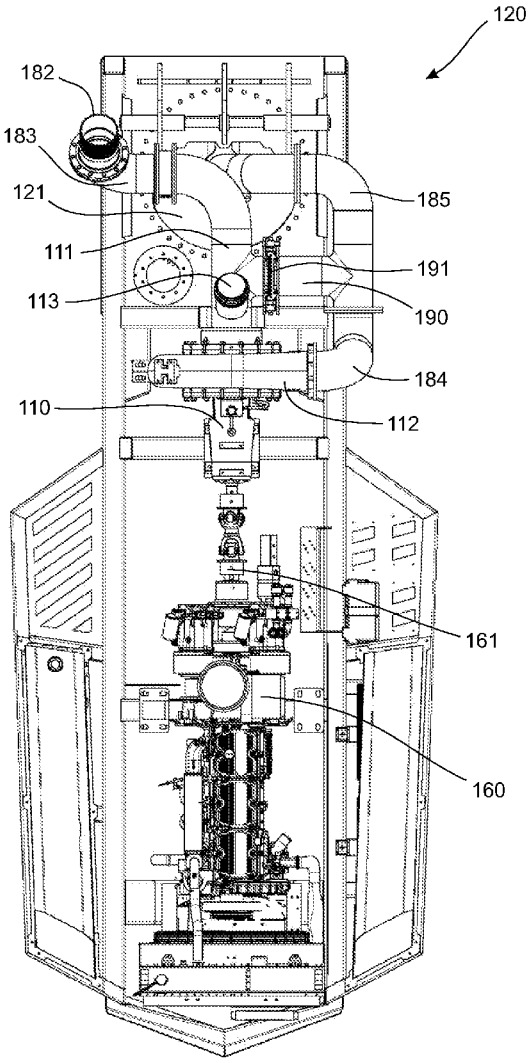
(57) **ABSTRACT**

A liquid pumping vehicle has: a platform rotatably mounted on a frame; an articulated boom mounted on the platform; a first liquid pump mounted on the boom; a second liquid pump mounted on the platform on the engine-side, the second liquid pump in fluid connection with a fluid conduit through which the first liquid pump pumps the liquid, and an engine mounted on the platform, so that a rotation axis of the platform is between the boom and the engine and so that a weight of the engine, the second liquid pump and other components on an engine-side of the platform acts as a counterbalance to a weight of the boom and other components on a boom-side of the platform; and, The vehicle is better balanced for greater stability when in use for pumping a liquid, e.g., liquid manure.



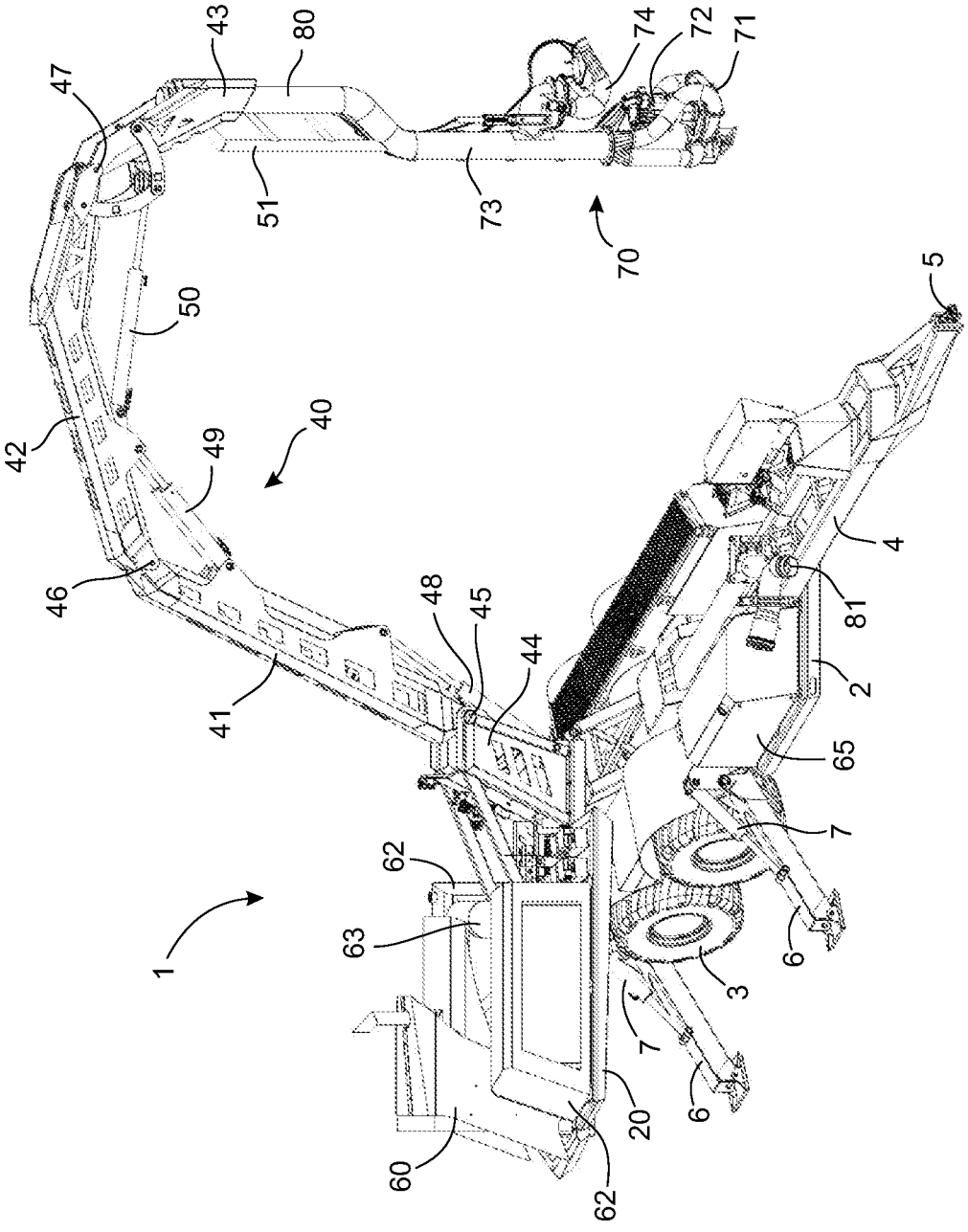

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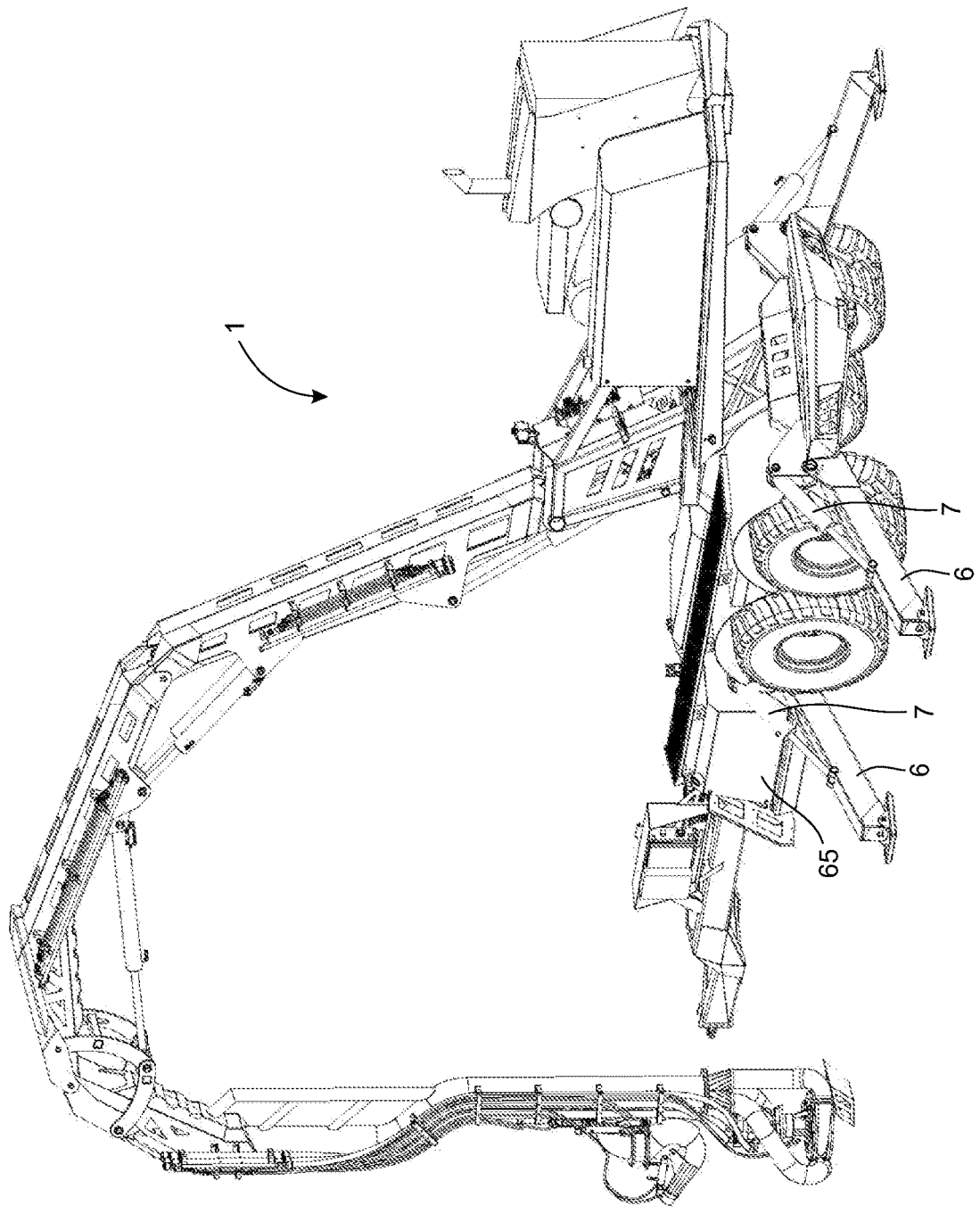
Fig. 1



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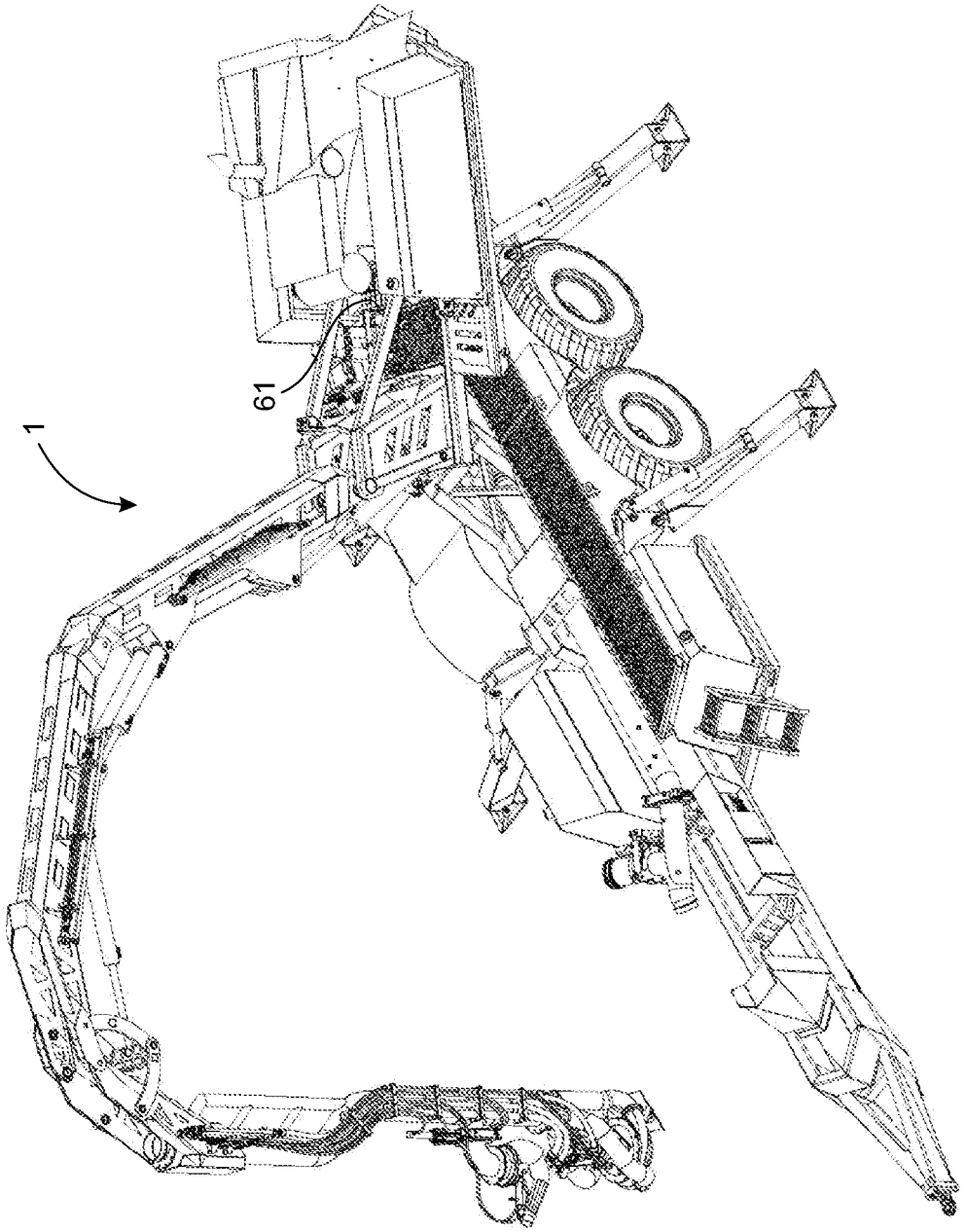

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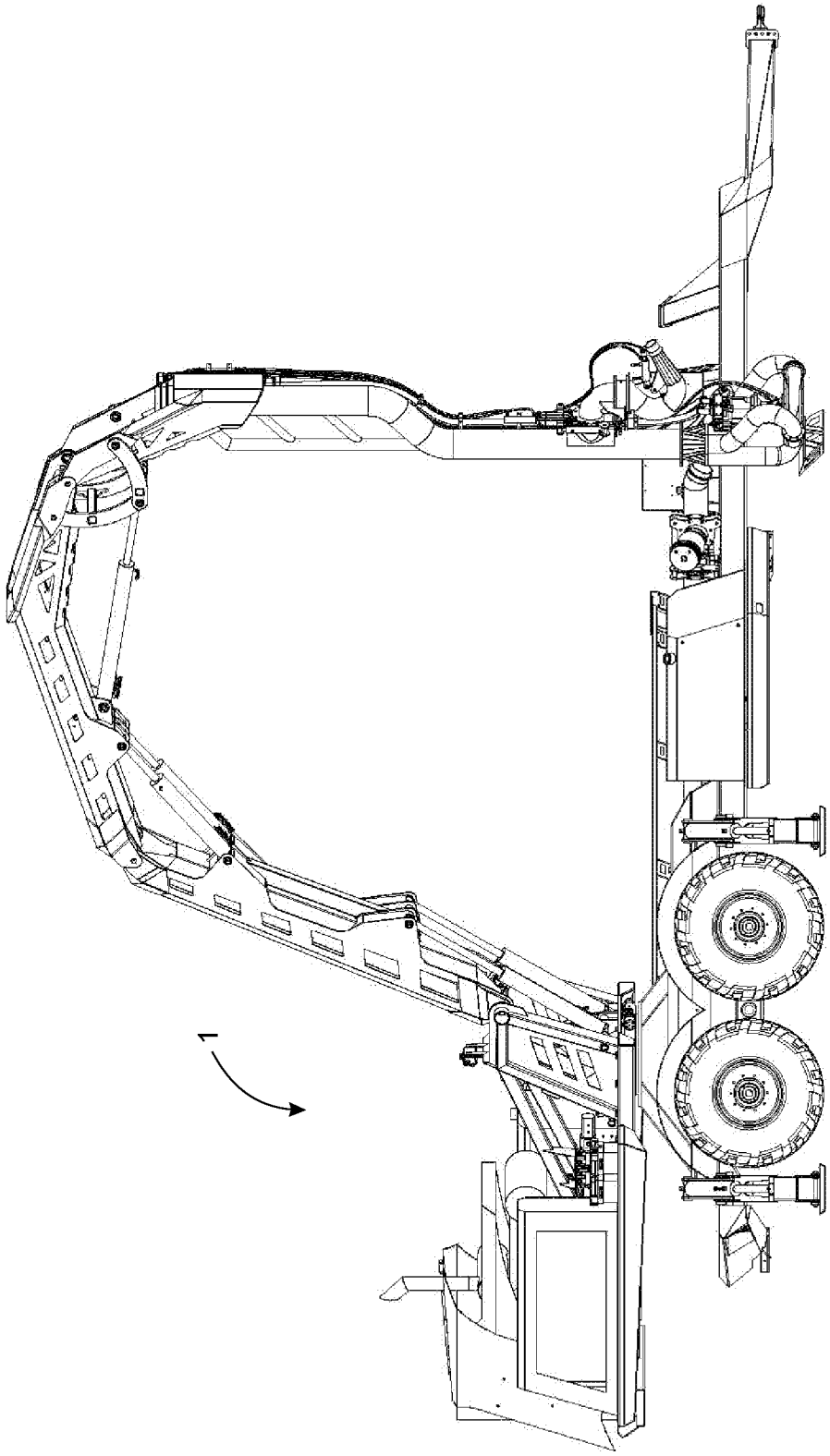

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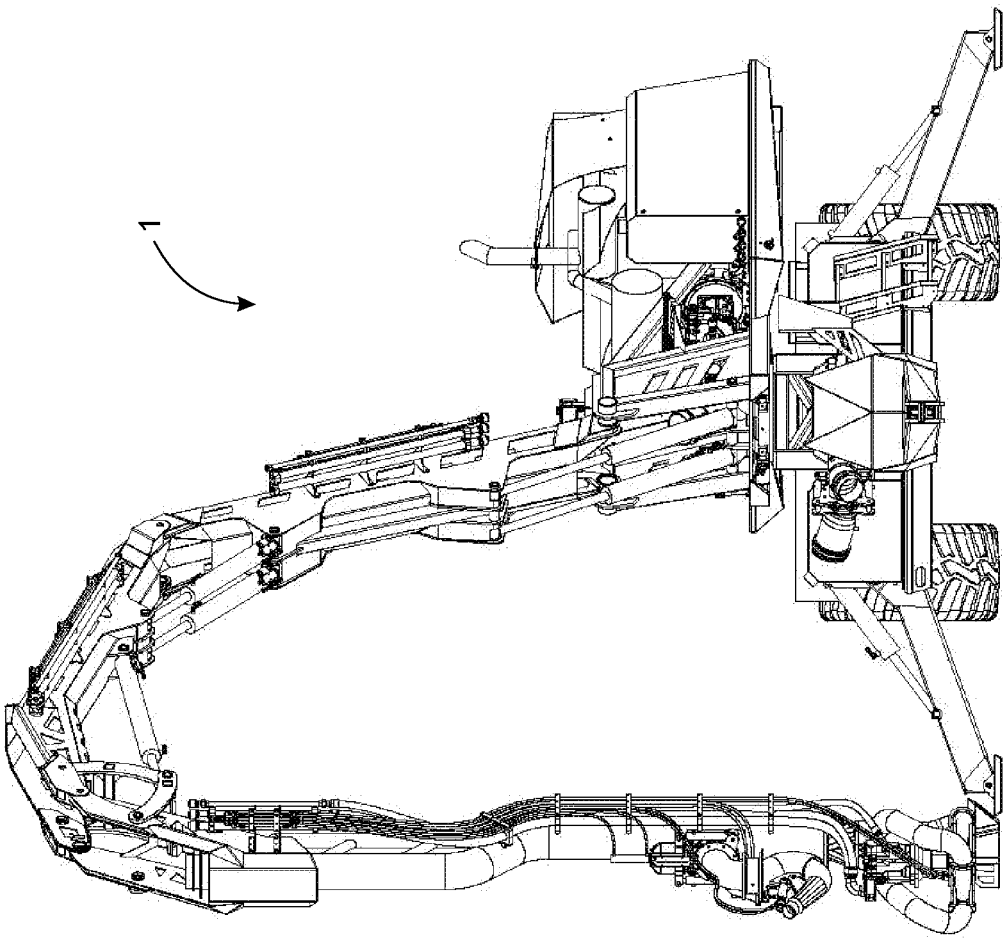

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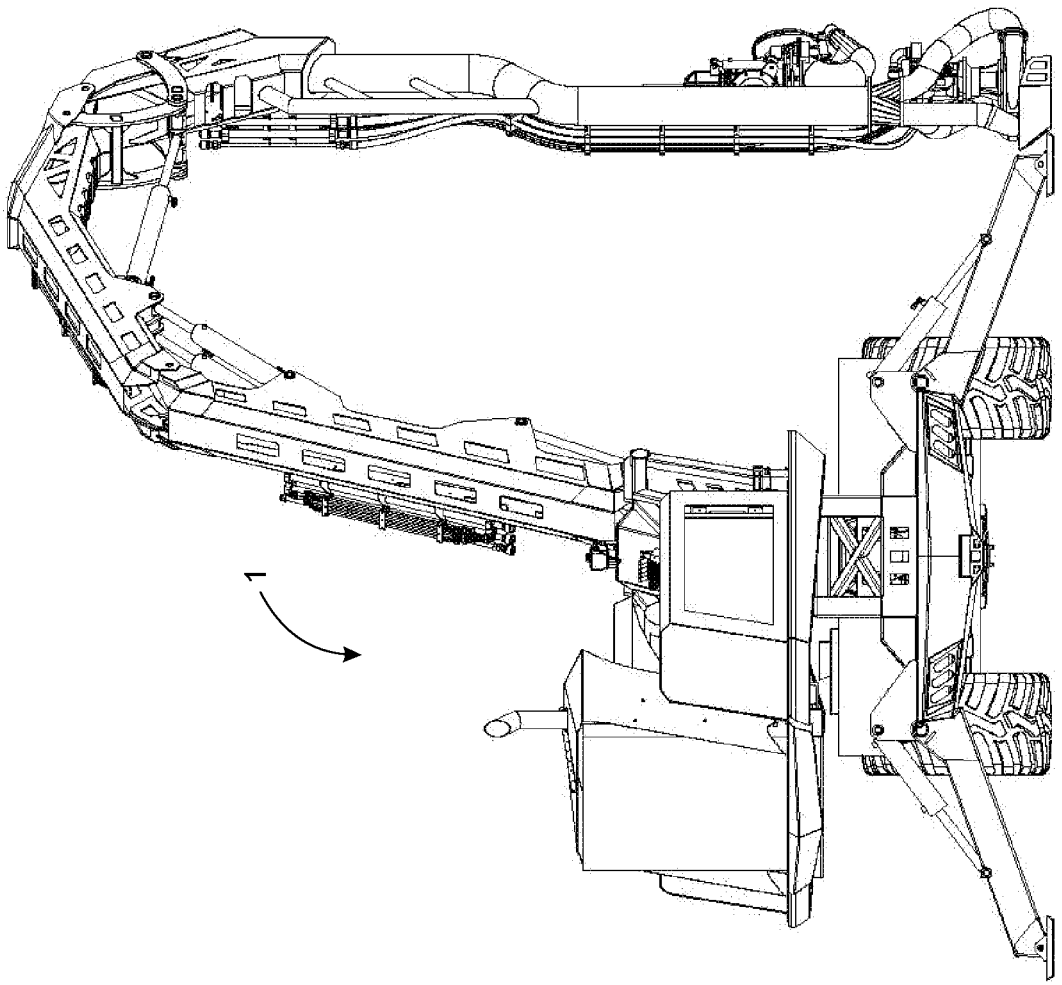

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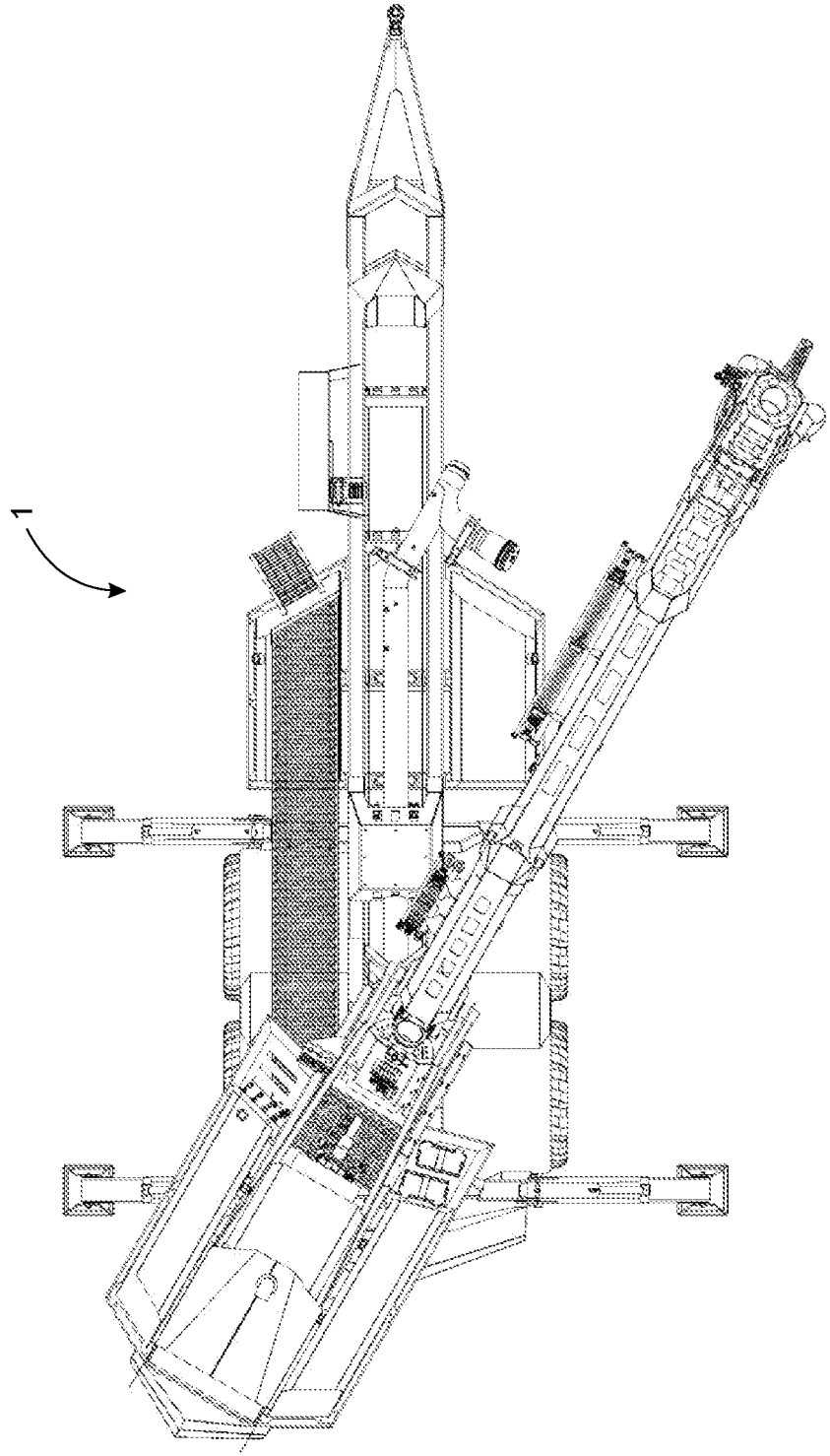

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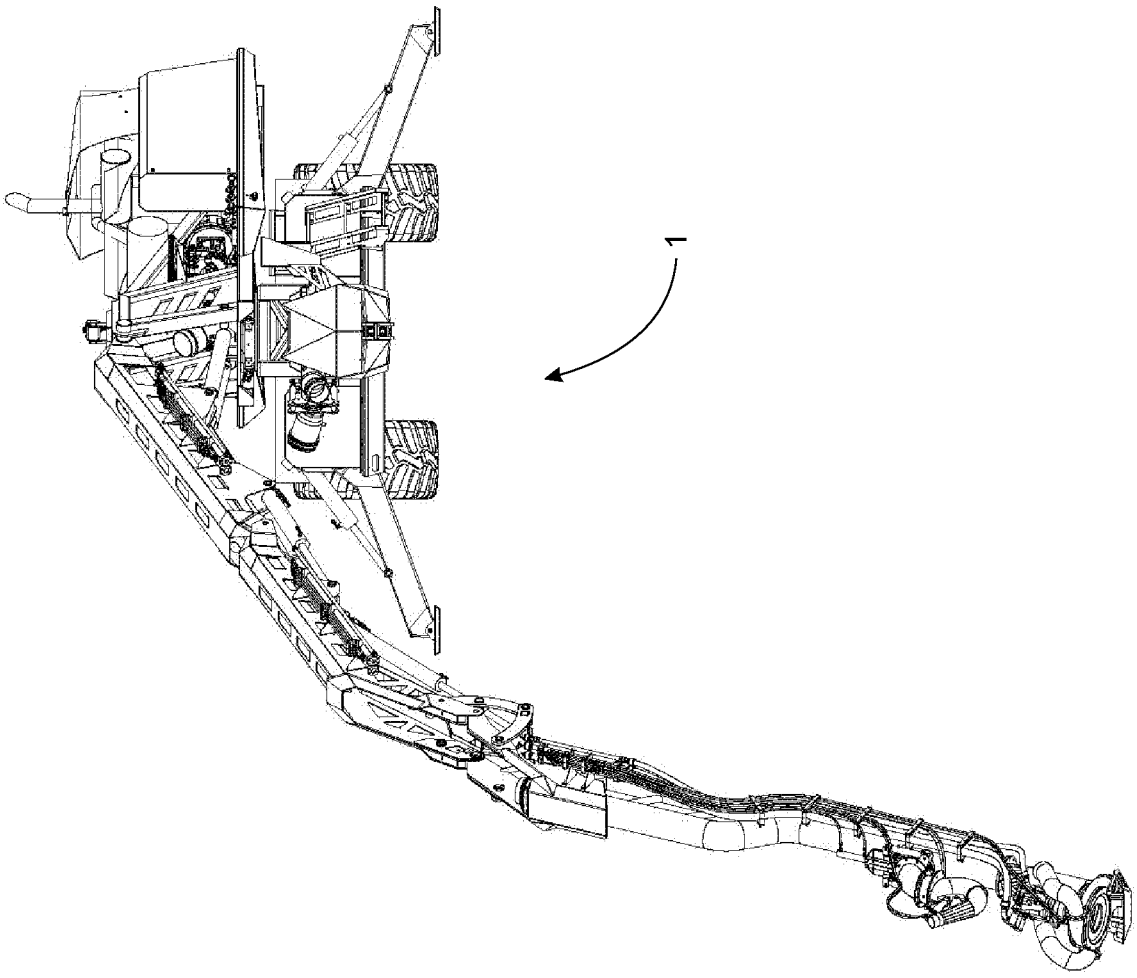

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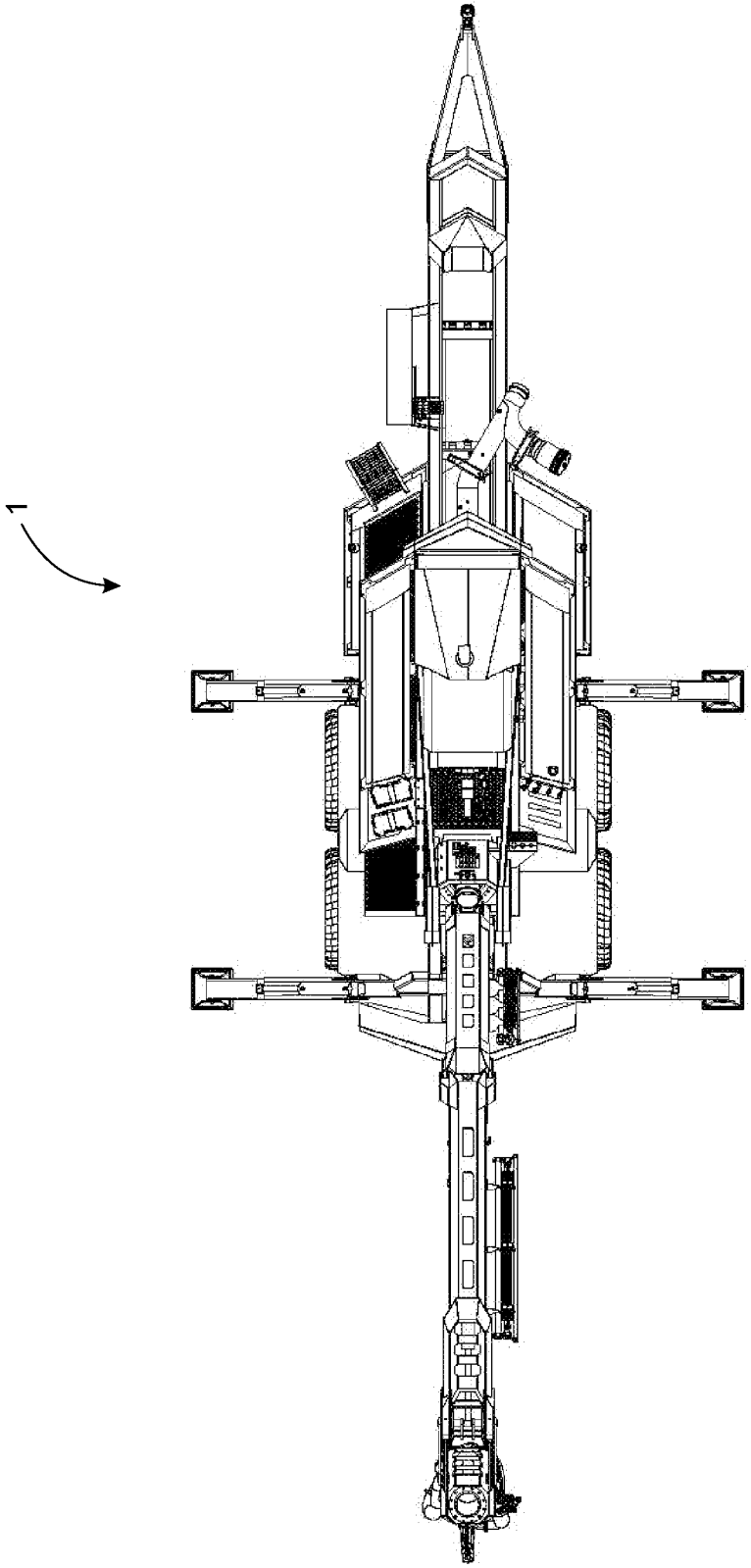

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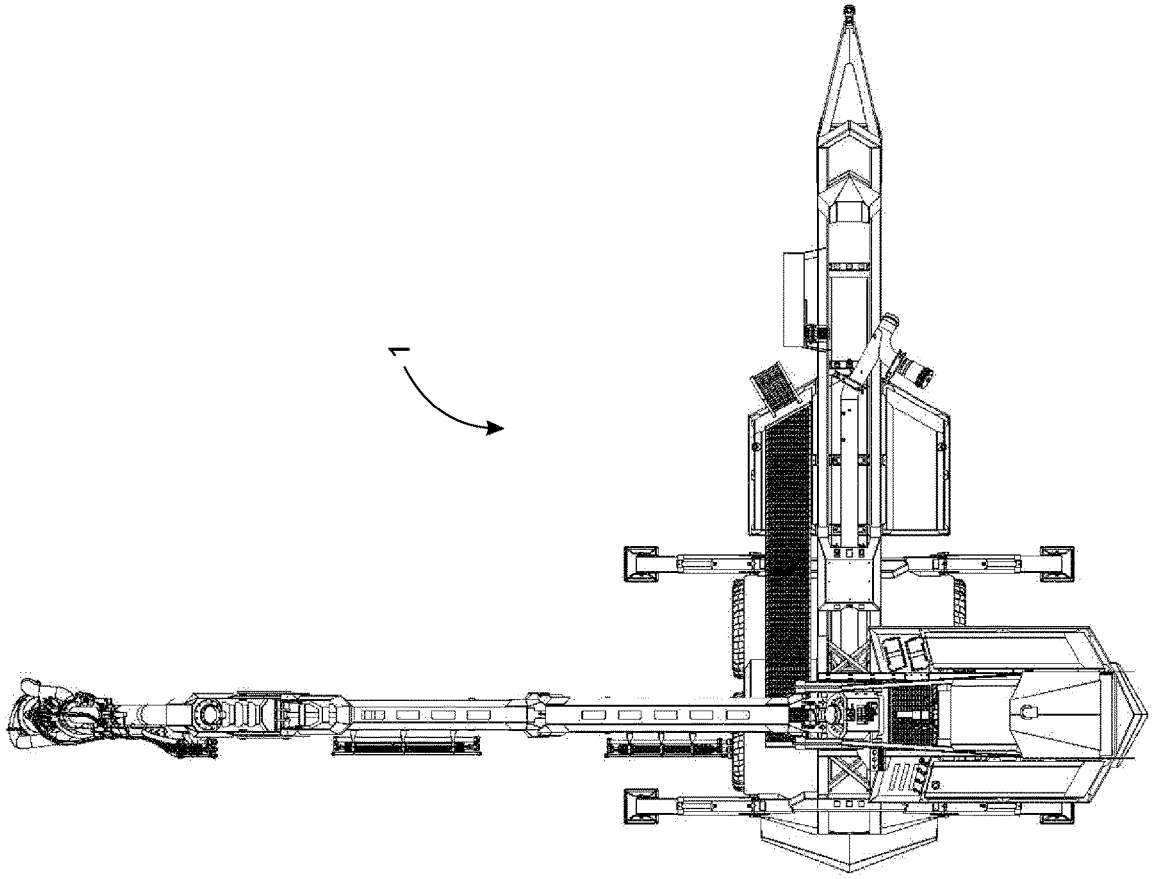

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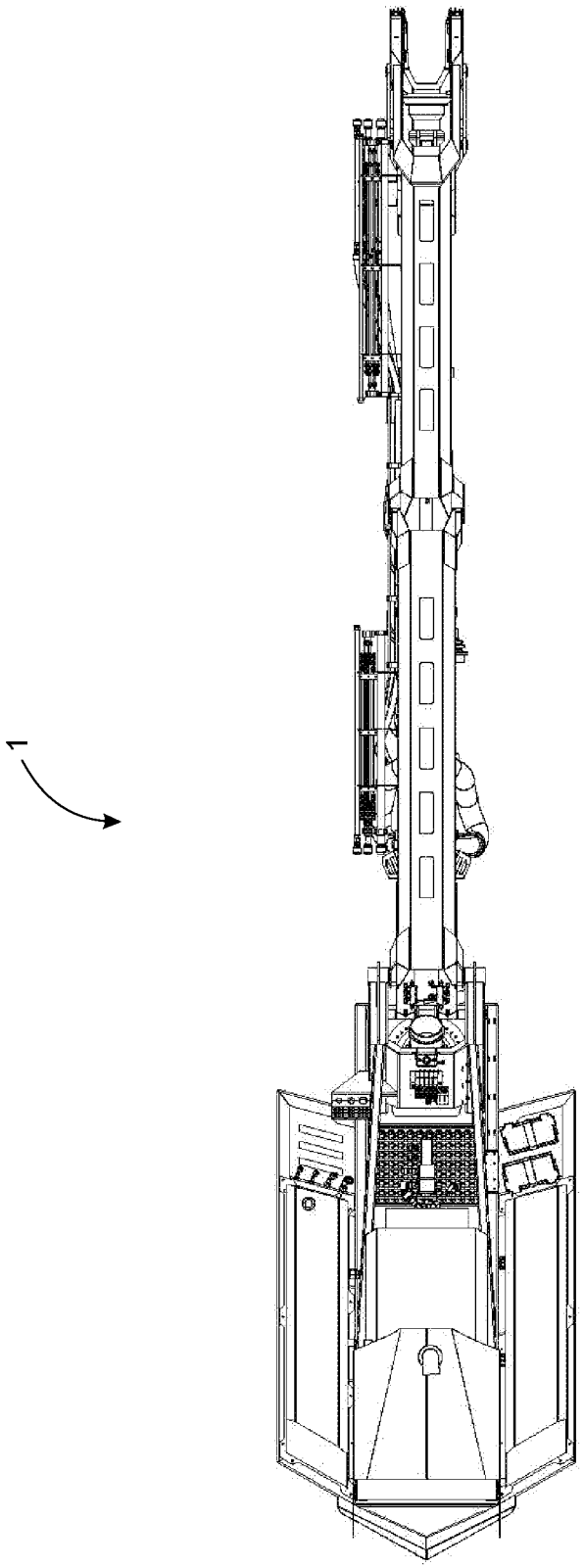

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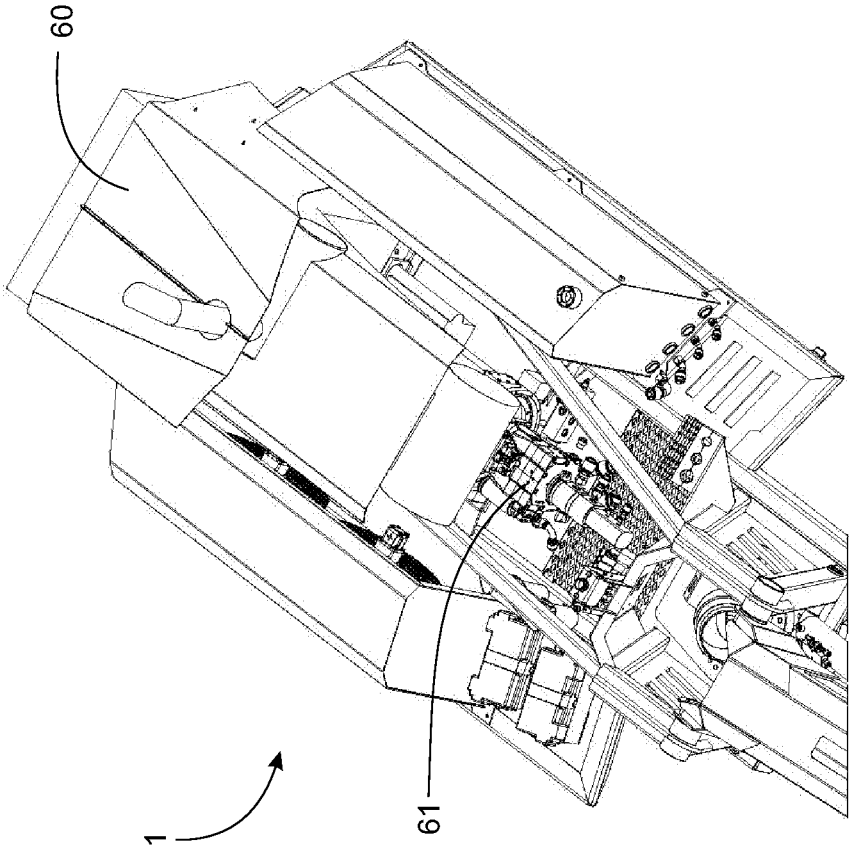

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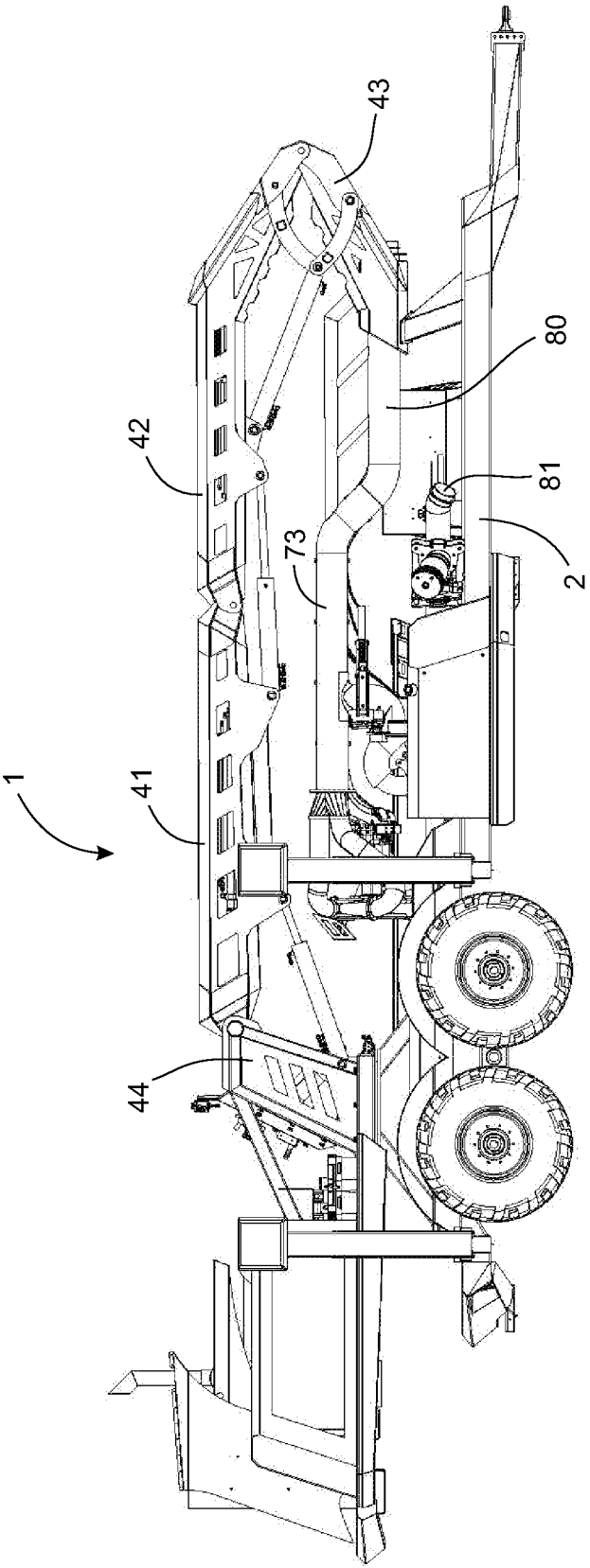

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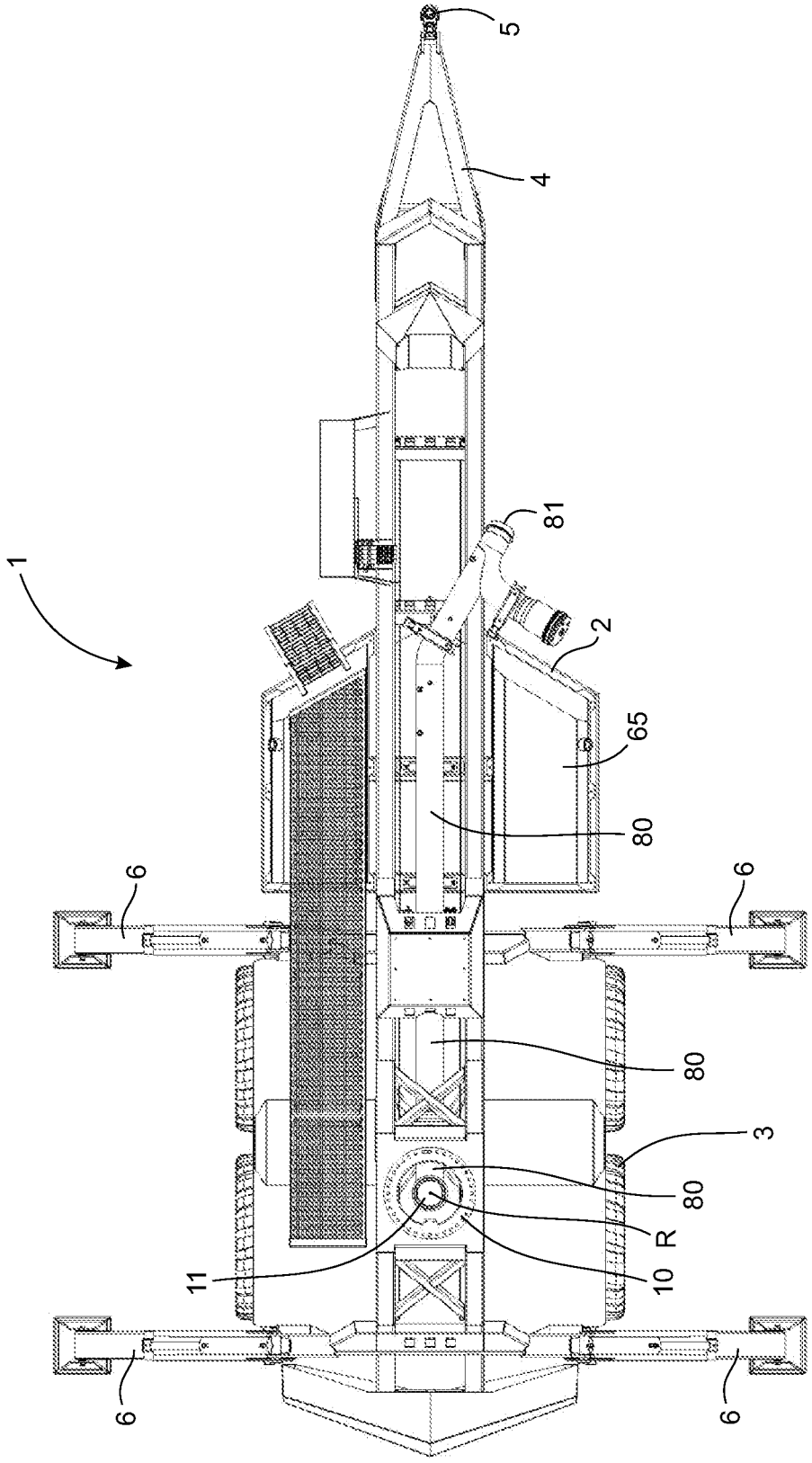

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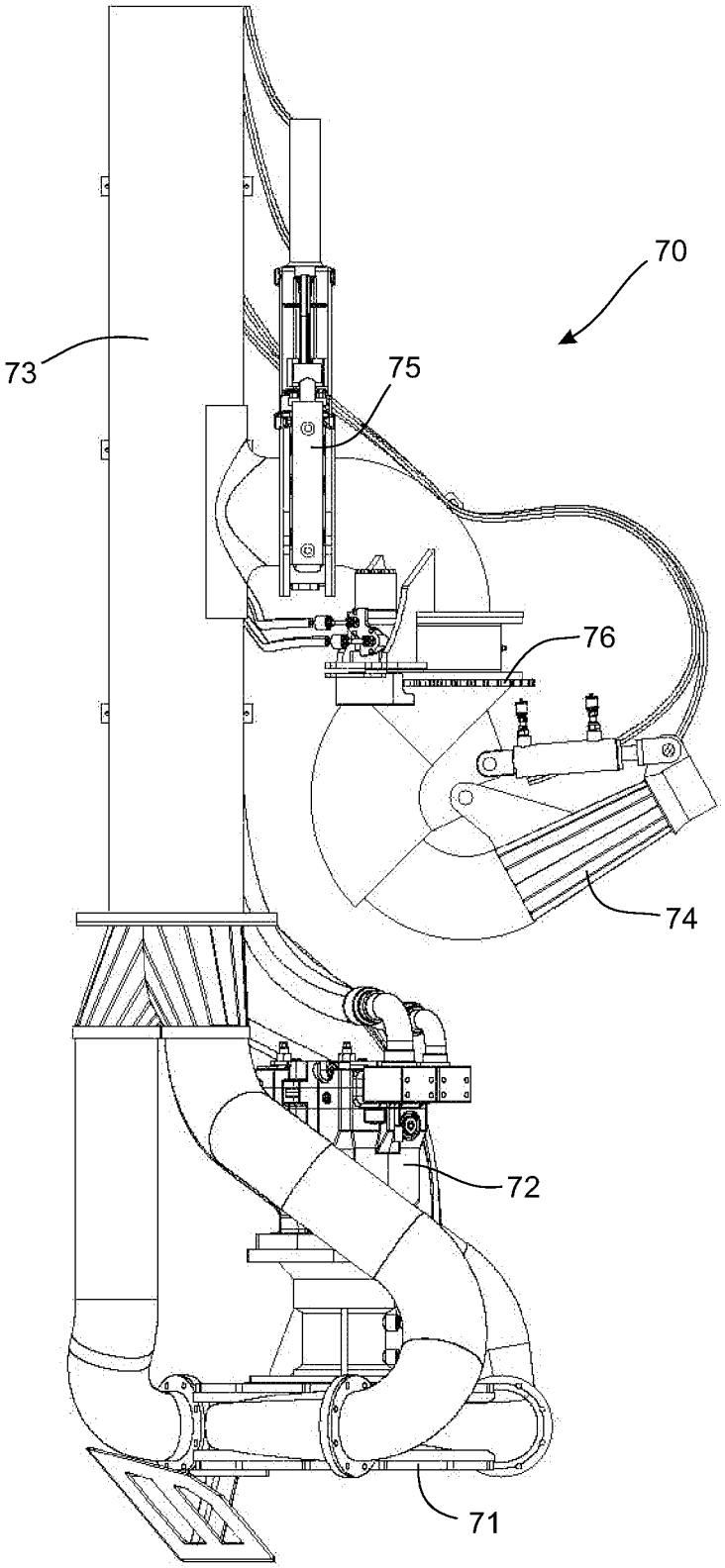

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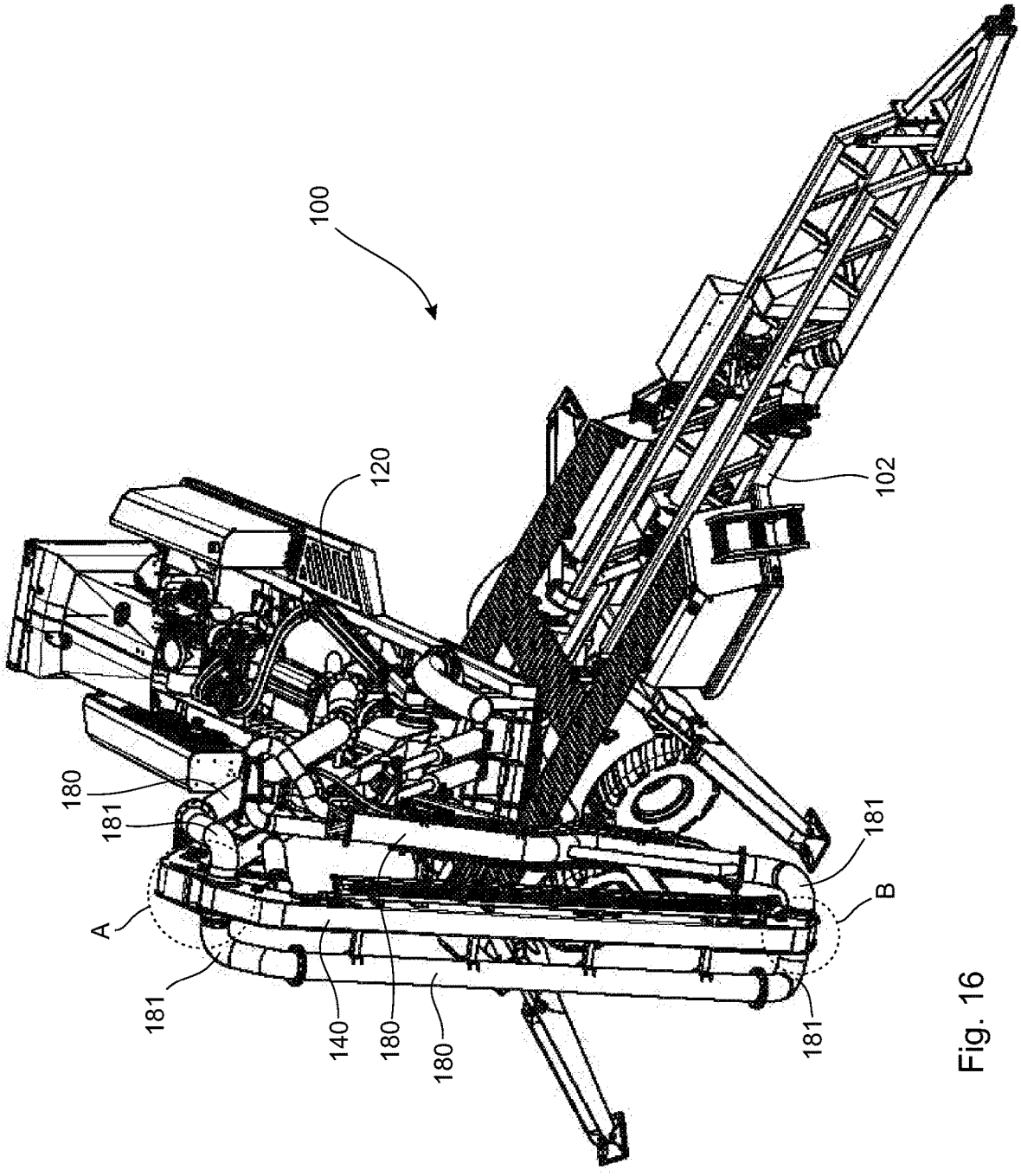

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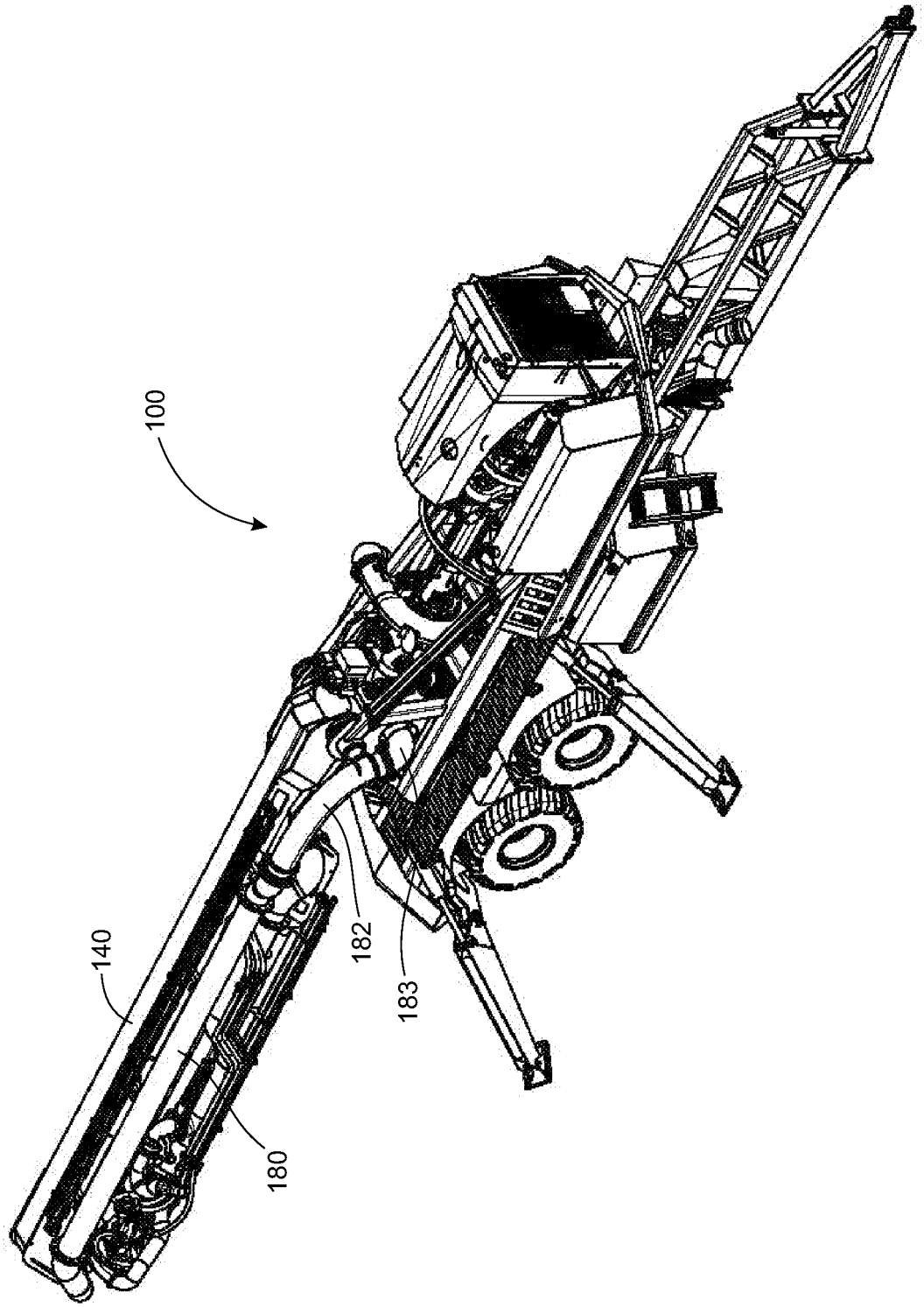

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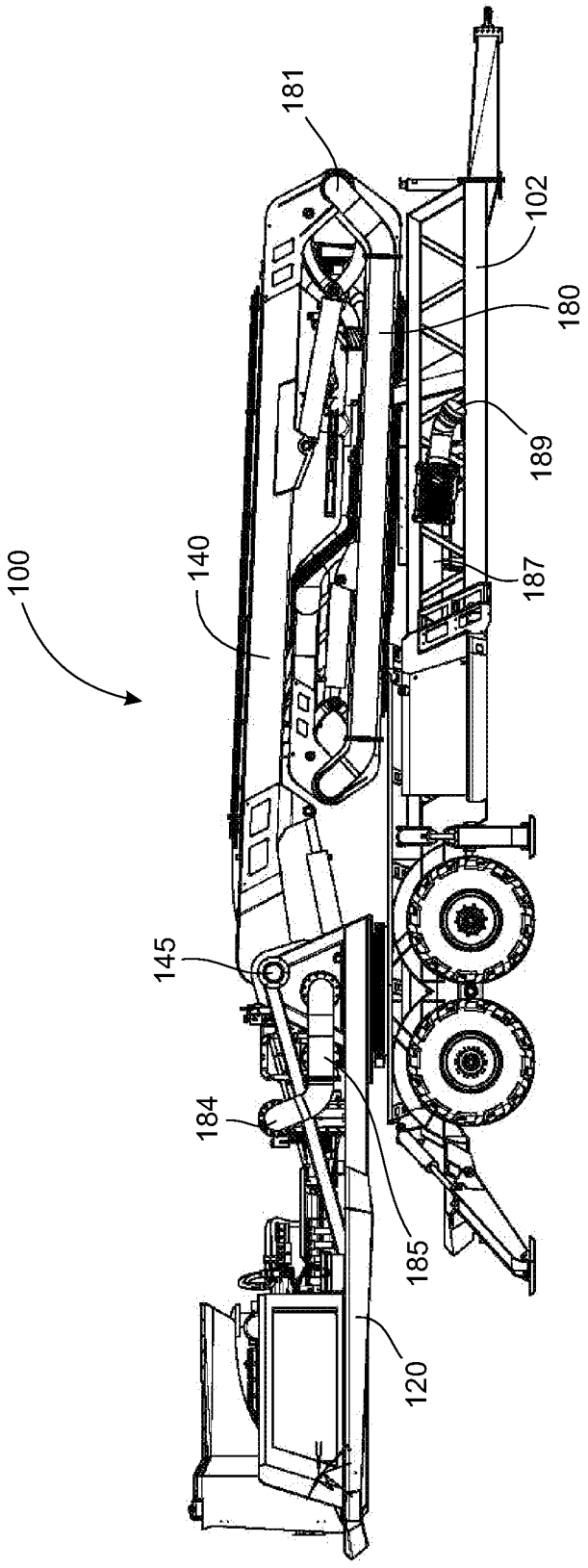

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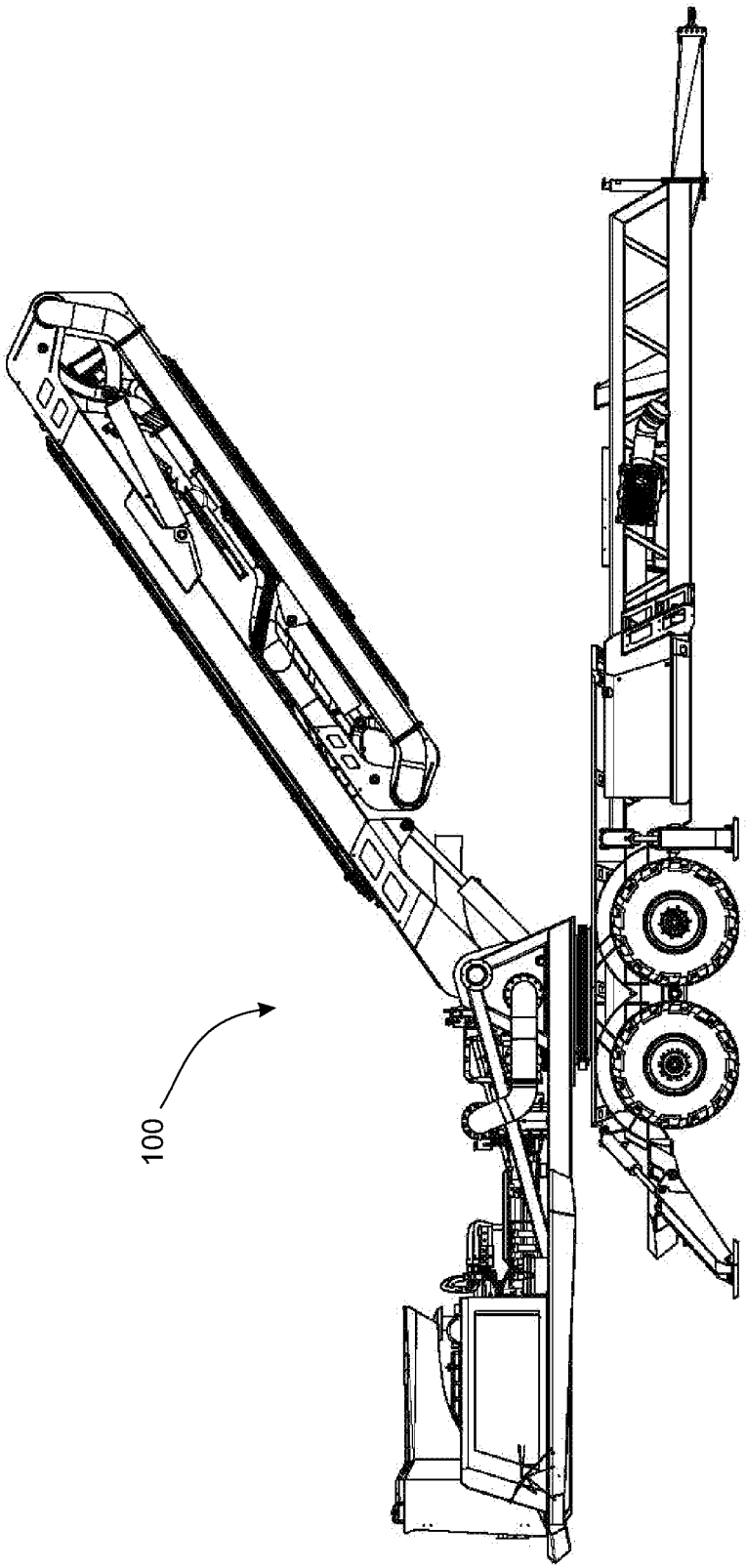

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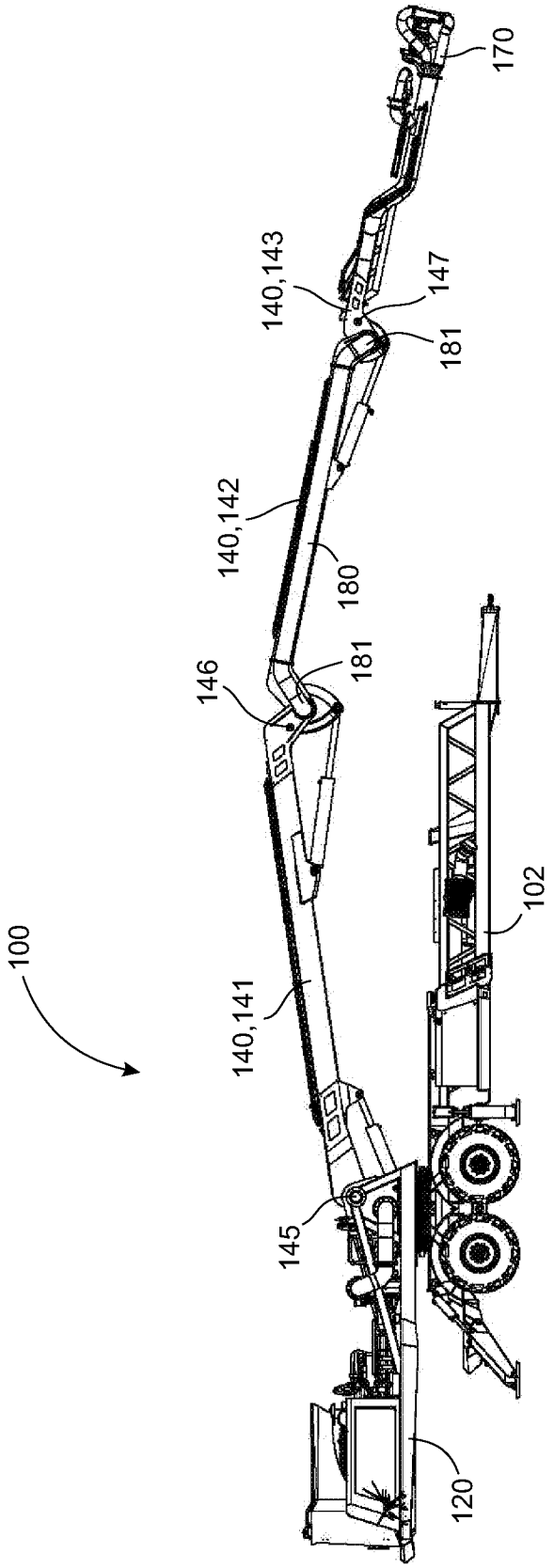

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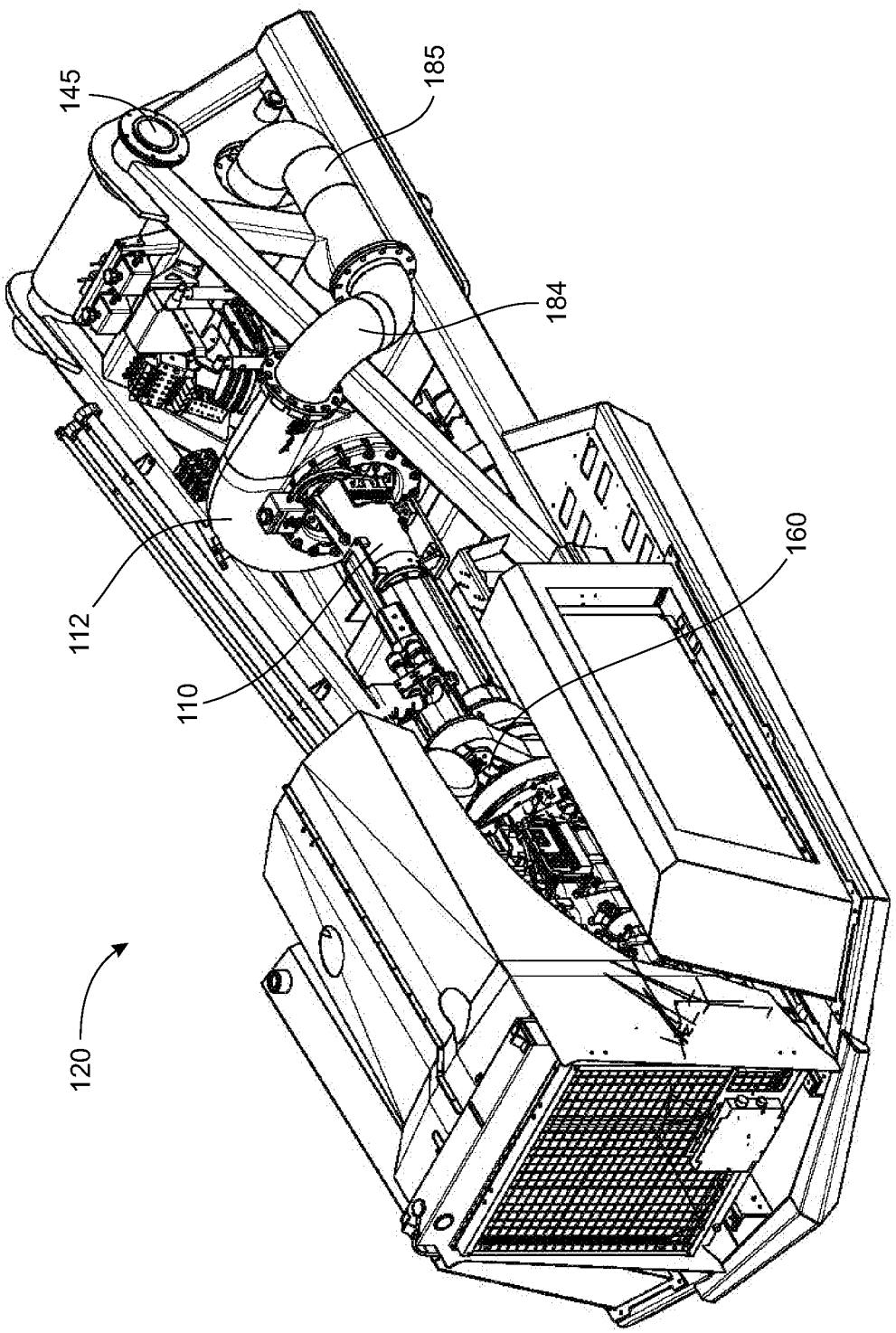

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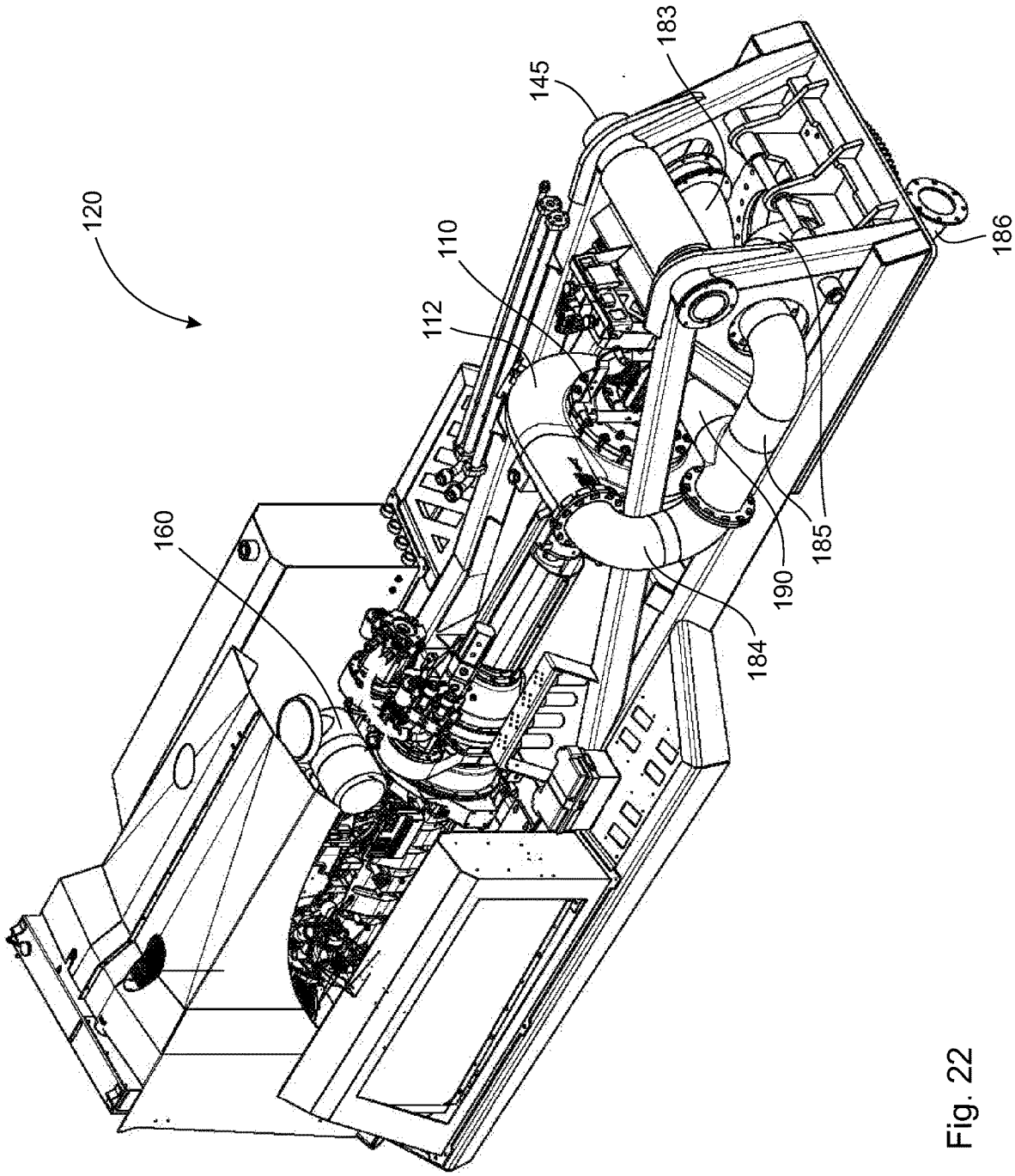

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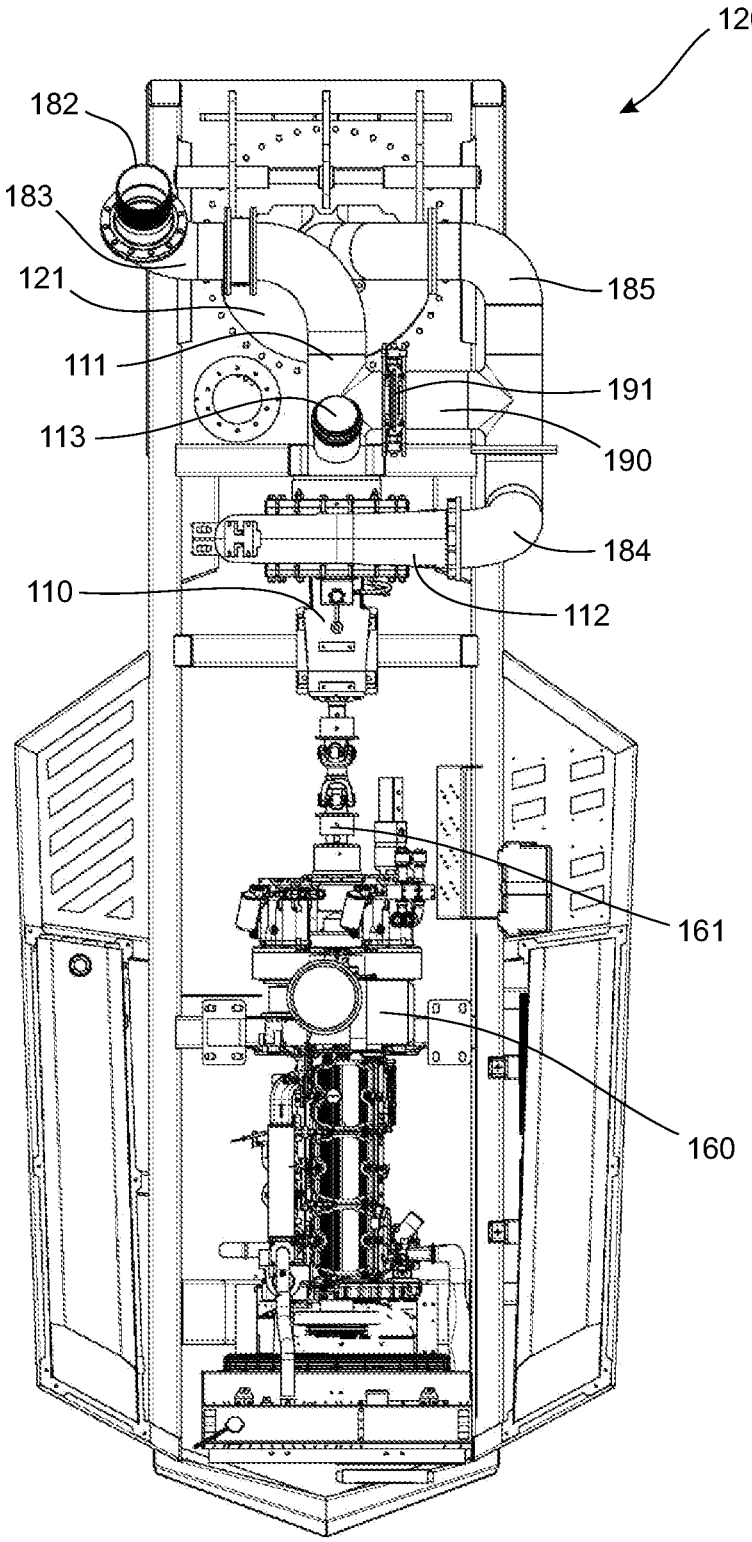

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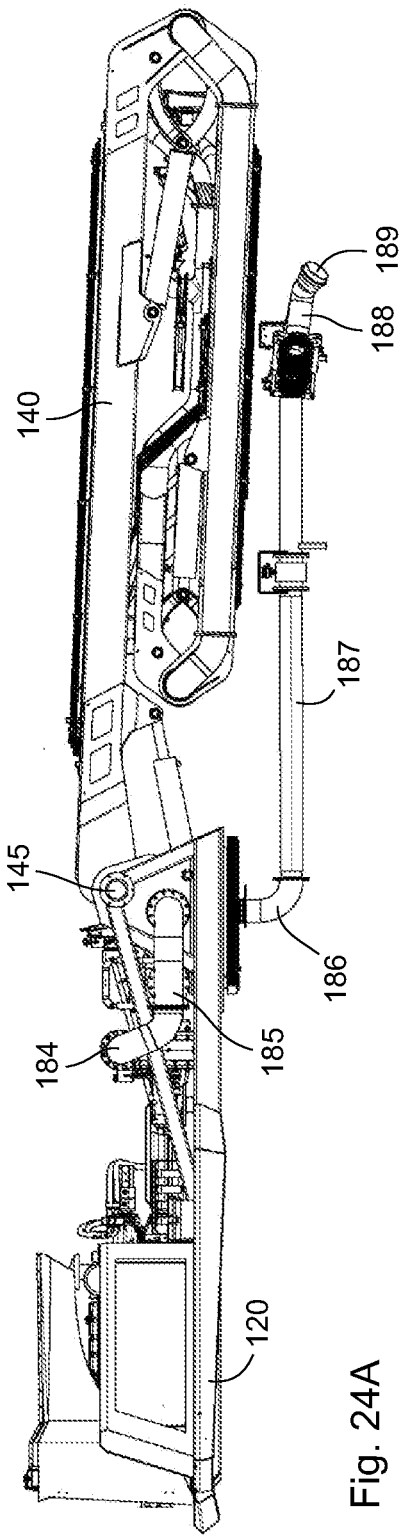

Fig. 24A

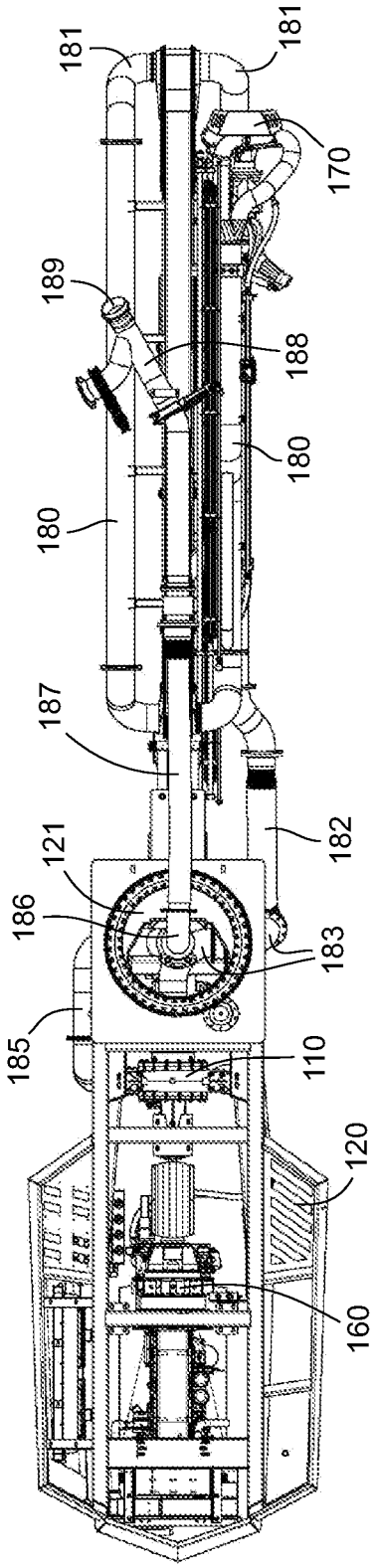

Fig. 24B

BOOM MOUNTED PUMP

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 17/859,479 filed Jul. 7, 2022, which claims the benefit of U.S. patent application 63/219,621 filed Jul. 8, 2021, both of which are incorporated herein by reference.

FIELD

[0002] This application relates to liquid pumps and vehicles equipped for pumping. In particular, this application relates to boom mounted pumps.

BACKGROUND

[0003] Liquid manure comprises a suspension of solid manure in a liquid medium (i.e., water). Liquid manure is often stored in a large lagoon for use later for fertilizing fields. When use of the stored liquid manure is desired, a pump immersed in the liquid manure lagoon is used to pump the liquid manure out of the lagoon into a tank of a liquid manure spreader.

[0004] Liquid manure lagoons are often very large and/or surrounded by a high wall or berm. Boom mounted pumps have been developed to assist in pumping liquid manure out of the lagoon into a tank of a liquid manure spreader. However, the ground around the liquid manure lagoons is usually unstable and/or sloped, therefore the vehicles on which the boom mounted pumps are supported are generally parked relatively far from the lagoon necessitating long booms, which severely destabilizes the vehicle. To better stabilize the vehicle, very long stabilizer legs must be used, which also limits the space in which the vehicle may be parked.

[0005] There remains a need for a boom mounted pump arrangement that has a smaller vehicle footprint and/or is more stable on unstable ground.

SUMMARY

[0006] In an embodiment, a liquid pumping vehicle comprises: a frame; rotatable ground-engaging elements mounted on the frame to permit driving the vehicle on ground; a platform rotatably mounted on the frame, the platform rotatable about a vertically oriented rotation axis relative to the ground; an articulated boom mounted on the platform proximate a first end of the boom; a liquid pump mounted on the boom proximate a second end of the boom, the liquid pump immersible in a liquid reservoir for pumping liquid out of the reservoir; an engine mounted on the platform, the engine operably connected to the liquid pump for operating the liquid pump, the engine situated so that the rotation axis of the platform is between the boom and the engine and so that a first turning moment created on a first moment arm relative to the rotation axis by weight of the engine and other components on an engine-side of the platform is balanced under operational conditions of the pumping vehicle by a second turning moment created on a second moment arm relative to the rotation axis by weight of the boom and other components on a boom-side of the platform; and, a flow discharge outlet mounted on the frame, the flow discharge outlet connected to the liquid pump by a fluid conduit through which the liquid is pumped by the liquid pump from the liquid reservoir to the flow discharge outlet.

[0007] In another embodiment, a liquid pumping vehicle comprises: a frame; rotatable ground-engaging elements mounted on the frame to permit driving the vehicle on ground; a platform rotatably mounted on the frame, the platform rotatable about a vertically oriented rotation axis relative to the ground; an articulated boom mounted on the platform proximate a first end of the boom; a first liquid pump mounted on the boom proximate a second end of the boom, the liquid pump immersible in a liquid reservoir for pumping liquid out of the reservoir; a second liquid pump mounted on the platform, the second liquid pump in fluid connection with a fluid conduit through which the first liquid pump pumps the liquid; an engine mounted on the platform, the engine operably connected to the liquid pump for operating the liquid pump, the engine situated so that the rotation axis of the platform is between the boom and the engine and so that a weight of the engine, second liquid pump and other components on an engine-side of the platform acts as a counterbalance to a weight of the boom and other components on a boom-side of the platform; and, a flow discharge outlet, the flow discharge outlet connected to the second liquid pump by the fluid conduit through which the liquid is pumped by the first and second liquid pumps from the liquid reservoir to the flow discharge outlet.

[0008] The vehicle is better balanced for greater stability on unstable ground when in use for pumping a liquid. The balance is a major factor, since less weight is placed on stabilizer legs. The greater stability thereby permits the use of shorter stabilizer legs, resulting in the vehicle having a smaller footprint, which is especially useful in areas where there is not much space. The presence of a second liquid pump mounted on the engine-side of the platform provides more counterweight for the boom thereby permitting the use of longer booms. The second liquid pump cooperates with the first liquid pump for more efficient pumping of the liquid.

[0009] In some embodiments, the platform is continuously rotatable through 360°, preferably in both rotational directions. In some embodiments, the engine and the boom are fixedly mounted on the platform to be carried by the platform as the platform is being rotated while maintaining the balance of the first turning moment and the second turning moment. Maintaining the balance of the first turning moment and the second turning moment ensures that the center of gravity of the trailer remains over the frame of the trailer, preferably on or close to the rotation axis of the platform. Thus, the engine, and a hydraulic fluid pump when present, acts as a counterbalance to the boom, which permits the use of a shorter overall boom length because there is more useable boom length in the present arrangement, while the inclusion of the second liquid pump permits the use of a longer boom while maximizing efficiency of the overall boom length. To further maximize efficiency of the overall boom length, articulation points of the boom permit pivoting of boom arm sections through 180°. Balance is maintained under operation conditions of the pumping vehicle, which may comprise one or more of, preferably all of, the hydraulic fluid lines being full of hydraulic fluid, the boom being extended and the fluid conduit containing liquid being pumped by the liquid pump.

[0010] Such an arrangement further permits continuous positioning of the boom and the liquid pump at the end of the boom without the necessity of pivoting hydraulic fluid lines through a swivel. The only swivel (i.e., rotation) point is where the platform is mounted on the trailer. The entire platform swivels. The engine, and a hydraulic fluid pump when present, are on an engine-side of the rotation axis of the platform. The hydraulic pump, when present, is driven by the engine, the hydraulic pump operatively connected to the first liquid pump for operating the first liquid pump. The first liquid pump preferably comprises a hydraulic motor for operating the first liquid pump, in which case the hydraulic motor may be operatively connected to the hydraulic pump by hydraulic fluid lines extending between the hydraulic fluid pump and the hydraulic motor along the boom. The second liquid pump is preferably driven by a drive shaft of the engine, for example driven directly or through a clutching mechanism. The second liquid pump preferably operates at higher pressure than the first liquid pump.

[0011] The boom is connected to the platform on a boom-side of the rotation axis, preferably directly opposite the engine and the second liquid pump, and opposite the hydraulic fluid pump when present. When the platform pivots about the rotation axis, the boom, with the first liquid pump thereon, the second liquid pump on the platform and the engine, with the hydraulic fluid pump connected thereto, all swivel at the same time in the same direction at the same rate, eliminating the need for swiveling of hydraulic fluid lines connected to the hydraulic pump and the first liquid pump. The hydraulic fluid lines themselves are only required to flex about the joints of the boom, not individually and/or separately swivel (i.e., not individually and/or separately rotate about a longitudinal axis of the hydraulic fluid line). High pressure hydraulic swivels are very difficult to make and a main failure point of hydraulically powered equipment. The arrangement described herein eliminates the need for such swivels, increasing reliability and reducing the likelihood of an environmental disaster in the event of a hydraulic swivel failure.

[0012] In some embodiments, the vehicle may further comprise stabilizer legs mounted on the frame. The stabilizer legs are preferably moveable between a ground-disengaging position and a ground-engaging position. The stabilizer legs assist with stabilizing the vehicle on the ground when the stabilizer legs are in the ground-engaging position. Preferably, the stabilizer legs are pivotable on the frame between a lowered the ground-engaging position and a raised ground-disengaging position. Because of the stability provided by the platform arrangement, the stabilizer legs can be shorter thereby providing a smaller footprint for the vehicle, which permits use in space-restricted areas.

[0013] In some embodiments, the fluid conduit is at least partially housed in the boom between the first liquid pump and the flow discharge outlet. Also, in some embodiments, the fluid conduit is at least partially housed in the frame between the boom and the flow discharge outlet. Housing the fluid conduit in the boom and/or the frame protects the fluid conduit from damage, such as punctures and tears, which could occur when exposed portions of the fluid conduit get caught on obstacles or protruding parts of the vehicle. In other embodiment, the fluid conduit is situated exterior to the boom and passes from one side of the boom to another side of the boom at articulation points on the boom, thereby permitting the use of hard, difficult to puncture conduit materials such as hard steel.

[0014] In some embodiments, the articulated boom comprises at least two boom sections. The at least two boom sections are pivotable relative to each other by one or more hydraulic cylinders connected between adjacent boom sections. The boom may comprise two, three, four, five or more boom sections. Hydraulic cylinders connecting adjacent boom sections may be provided with hydraulic fluid from the same hydraulic pump that operates the first liquid pump, or by one or more dedicated hydraulic pumps. Hydraulic fluid may be provided from one or more hydraulic fluid reservoirs, which hold hydraulic fluid to be used to operate any or all of the hydraulic devices on the trailer. Preferably, there is one hydraulic fluid reservoir and one hydraulic fluid pump to provide hydraulic fluid to all hydraulic devices on the trailer. The hydraulic fluid pump is preferably a direct-drive hydraulic fluid pump. The hydraulic fluid pump is preferably a high-pressure pump instead of a high-volume pump. Appropriate valving may be provided to ensure proper operation of all of the hydraulic devices.

[0015] The vehicle can be used to pump any liquid (e.g., water, liquid manure, chemical solutions) from a reservoir (e.g., fire hydrants connected to water mains, rivers, lakes, ponds, liquid manure lagoons, storage tanks or the like). The vehicle can therefore be used in a variety of applications such as liquid manure transfer, fire-fighting, de-watering, chemical solution transfer and the like.

[0016] The vehicle may be a self-propelled vehicle or a trailer. The rotatable ground-engaging elements may comprise wheels, tracks or the like or combinations thereof.

[0017] Further features will be described or will become apparent in the course of the following detailed description. It should be understood that each feature described herein may be utilized in any combination with any one or more of the other described features, and that each feature does not necessarily rely on the presence of another feature except where evident to one of skill in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] For clearer understanding, preferred embodiments will now be described in detail by way of example, with reference to the accompanying drawings, in which:

[0019] FIG. **1** depicts a front perspective view of a liquid pumping trailer with a boom extended in a first direction.

[0020] FIG. **2** depicts a rear perspective view of the trailer in FIG. **1**.

[0021] FIG. **3** depicts a front perspective view of the trailer of FIG. **1** with the boom extended in a second direction.

[0022] FIG. **4** depicts a side view of the trailer in FIG. **3**.

[0023] FIG. **5** depicts a front view of the trailer in FIG. **3**.

[0024] FIG. **6** depicts a rear view of the trailer in FIG. **3**.

[0025] FIG. **7** depicts a top view of the trailer in FIG. **3**.

[0026] FIG. **8** depicts the trailer in FIG. **7** with the boom extended further.

[0027] FIG. **9** depicts a top view of the trailer of FIG. **1** with the boom extended in a third direction.

[0028] FIG. **10** depicts a top view of the trailer of FIG. **1** with the boom extended in a fourth direction.

[0029] FIG. **11** depicts a top view of the trailer of FIG. **1** with the boom extended in a fifth direction.

[0030] FIG. **12** depicts a magnified top perspective view of the trailer of FIG. **1** showing a location of a hydraulic pump on the trailer.

[0031] FIG. **13** depicts a side view of the trailer of FIG. **1** with the boom folded into a transport configuration.

[0032] FIG. **14** depicts a top view of the trailer of FIG. **1** with the boom removed.

[0033] FIG. **15** depicts a magnified view of a liquid pump that is mounted at a distal end of the boom of the trailer of FIG. **1**.

[0034] FIG. **16** depicts a front perspective view of another embodiment of a liquid pumping trailer with a boom partially folded.

[0035] FIG. **17** depicts the trailer of FIG. **16** with the boom fully folded.

[0036] FIG. **18** depicts the trailer of FIG. **16** with the boom fully folded and in a transport configuration.

[0037] FIG. **19** depicts the trailer of FIG. **16** with the boom folded and raised out of the transport configuration.

[0038] FIG. **20** depicts the trailer of FIG. **16** with the boom fully extended horizontally forward.

[0039] FIG. **21** depicts a top perspective view of a platform of the trailer of FIG. **16**.

[0040] FIG. **22** depicts another top perspective view of the platform of the trailer of FIG. **16**.

[0041] FIG. **23** depicts a top view of the platform of the trailer of FIG. **16** with various components removed to better illustrate a high-pressure pump and piping mounted on the platform.

[0042] FIG. **24**A depicts a side view of the platform of FIG. **23** in context with a frame of the trailer of FIG. **16**.

[0043] FIG. **24**B depicts a bottom view of FIG. **24**A.

DETAILED DESCRIPTION

[0044] With reference to FIG. **1** to FIG. **15**, an embodiment of a liquid pumping vehicle in the form of a liquid pumping trailer **1** is shown. The trailer **1** comprises a frame **2** on which are rotatably mounted four wheel **3** (only one labeled), two on each transverse side of the trailer **1** in a tandem axle configuration. The wheels may be other rotatable ground-engaging elements such as tracks or combinations of tracks and wheels. For example, two tracks, one on each transverse side of the trailer may be used instead of four wheels. Extending longitudinally forward from the frame **2** is a tongue **4** terminating in a hitch **5**, which can be coupled to a prime mover (not shown) such as a truck, a tractor or other motorized vehicle. The trailer **1** further comprises four stabilizer legs **6** coupled to the frame **2**, the stabilizer legs **6** moveable between raised stowed positions and lowered ground-engaging positions. The stabilizer legs **6** in the lowered ground-engaging positions serve to take some of the weight of the trailer **1** thereby stabilizing the trailer **1** during a pumping operation. The stabilizer legs **6** are pivotally connected to the frame **2** and are raised and lowered by operation of stabilizer leg actuators **7**. The stabilizer leg actuators **7** may be any suitable actuator, for example hydraulic cylinders, pneumatic cylinders or linear actuators, but hydraulic cylinders are preferred.

[0045] A hydraulic swivel **10** (see FIG. **14**) is supported on the frame **2** over the axles of the wheels **3** so that most of the load placed on the swivel **10** is supported over the axles. The swivel **10** comprises a slewing bearing that is capable of continuous rotation in both rotational directions about a vertical rotation axis R through successive 360° rotations. Mounted on the swivel **10** is a platform **20**. The platform **20** is mounted on the swivel **10** proximate a proximal end of the platform **20** so that as the platform **20** rotates with the swivel **10**, a distal end of the platform **20** moves through an outer circular path. An articulated boom **40** having a first boom section **41**, a second boom section **42** and third boom section **43** is mounted on the platform **20** through a boom mount **44**. The boom mount **44** is rigidly secured to the platform **20** directly over the swivel **10**. A proximal end of the first boom section **41** is pivotally connected to the boom mount **44** at pivot **45**. A proximal end of the second boom section **42** is pivotally connected to a distal end of the first boom section **41** at pivot **46**. A proximal end of the third boom section **43** is pivotally connected to a distal end of the second boom section at **42** at pivot **47**. Pivoting of the boom sections **41**, **42**, **43** relative to each other is accomplished by actuating first, second and third boom section hydraulic cylinders **48**, **49**, **50**. Actuation of the first boom section hydraulic cylinder **48** connected between the boom mount **44** and the first boom section **41** permits rotation of the first boom section **41** about pivot **45**. Actuation of the second boom section hydraulic cylinder **49** connected between the first boom section **41** and the second boom section **42** permits rotation of the second boom section **42** about pivot **46**. Actuation of the third boom section hydraulic cylinder **50** connected between the second boom section **42** and the third boom section **43** permits rotation of the third boom section **43** about pivot **47**. Independent operation of the boom section hydraulic cylinders **48**, **49**, **50** permits extension and retraction of the boom **40** into a variety of configurations as evidenced by comparing the Figures, including folding the boom **40** into a folded transport configuration as seen in FIG. **13**.

[0046] In operation, the boom **40** extends away from the platform **20** in a fixed direction relative to the platform **20**. The length and height to which the boom **40** can reach is adjustable by operating the boom section hydraulic cylinders **48**, **49**, **50**, but the radial orientation of the boom **40** relative to the frame **2** of the trailer **1** is only adjustable by rotating the entire platform **20**.

[0047] To balance the weight of the boom **40** so that the center of gravity of the trailer **1** remains over the frame **2**, an engine **60** and a hydraulic pump **61** (see FIG. **12**), preferably a high-pressure direct-drive hydraulic pump, are fixedly mounted on the platform **20** on an engine-side of the platform **20** at or proximate the distal end of the platform **20** in a position opposite the boom **40** through the rotation axis R. Therefore, as the platform **20** is rotated, the boom **40** remains on a boom-side of the platform **20** opposite the engine **60** and the hydraulic pump **61** so that the engine **60** and the hydraulic pump **61** always act as a counterbalance to the boom **40** irrespective of the radial orientation of the boom **40**. Such an opposed configuration is maintained at all times as the platform **20** is rotated through a full circle. Also mounted on the engine-side of the platform **20** are hydraulic fluid reservoirs **62** and a hydraulic fluid cooler **63**, which are respectively used to supply hydraulic fluid to the hydraulic pump **61** and to cool the hydraulic fluid heated by operation of the hydraulic pump **61**. The weights of the hydraulic fluid reservoir **62** and the hydraulic fluid cooler **63** also serve to counterbalance the boom **40**. The hydraulic pump **61** drives a hydraulic motor of the hydraulic swivel **10**, as well as driving other hydraulic components of the trailer **1**.

[0048] With specific reference to FIG. **15**, a liquid pump **70**, for example a liquid manure pump as described in U.S. Pat. No. 8,944,758 issued Feb. 3, 2015, the entire contents of which is herein incorporated by reference, is mounted on the boom **40** at a distal end of the boom **40**. The liquid pump

70 is mounted on a pump mount **51** connected to the third boom section **43**. The liquid pump **70** comprises a main pipe **73** and a pump head **71** mounted at a distal end of the main pipe **73**, the pump head **71** immersible in a liquid reservoir such as a liquid manure lagoon. The pump head **71** is equipped with an impeller (not shown) driven by a hydraulic motor **72** in hydraulic communication through hydraulic fluid lines with the hydraulic pump **61**. The main pipe **73** is in fluid communication with a fluid conduit **80** connected to a proximal end of the main pipe **73**. Operation of the impeller in the pump head **71** forces liquid to flow into the main pipe **73** and thence into the fluid conduit **80**. Some of the liquid flow may be diverted from the main pipe **73** through a knife valve **75** into an agitator nozzle **74**. Pressurized liquid flow through the agitator nozzle **74** is used to mix the liquid in the liquid reservoir, which is especially useful for liquid manure lagoons, which have a high solids content. The agitator nozzle **74** can be swiveled around the main pipe **73** by virtue of swiveling mechanism **76** in order to change the direction of the pressurized liquid flow so that an area in the liquid reservoir entirely around the liquid pump **70** can be mixed.

[0049] The fluid conduit **80** is connected to the main pipe **73** at a distal end of the fluid conduit **80**. A proximal end of the fluid conduit **80** is connected to a flow discharge outlet **81** situated on the frame **2** of the trailer **1**. The fluid conduit **80** therefore extends between the main pipe **73** of the liquid pump **70** at the distal end of the boom **40** and the flow discharge outlet **81** on the frame **2**. To protect the fluid conduit **80** from damage over the long length of the fluid conduit **80**, the fluid conduit **80** is at least partially housed in the boom **40** nestled between the walls of the boom **40**. Further, once the fluid conduit **80** reaches the proximal end of the boom **40**, the fluid conduit **80** is routed between frame elements of the frame **2** so that the fluid conduit **80** is at least partially housed in the frame **2** before reaching the flow discharge outlet **81**. In order for the fluid conduit **80** to continue from the boom **40** into the frame **2**, the fluid conduit **80** passes through a central aperture **11** in the swivel **10** (see FIG. **14**).

[0050] The hydraulic pump **61** is driven by a drive shaft of the engine **60**. The engine **60** is preferably a combustion engine, more preferably a diesel engine. Fuel of the engine is stored in one or more fuel tanks **65** and supplied to the engine by fuel lines (not shown). The hydraulic pump **61** is used to operate all hydraulic components of the trailer **1** including the liquid pump **70**, the first, second and third boom section hydraulic cylinders **48**, **49**, **50**, the hydraulic swivel **10** and the stabilizer leg actuators **7**. Hydraulic fluid lines (not shown) and hydraulic fluid valves (not shown) are used to complete hydraulic circuits that supply and control hydraulic fluid flow between the hydraulic pump **61** and the other hydraulic components of the trailer **1**. Because the hydraulic pump **61**, the liquid pump **70**, the first, second and third boom section hydraulic cylinders **48**, **49**, **50** and the hydraulic swivel **10** are ultimately connected to the platform **20**, rotation of the swivel **10** and therefore the platform **20** does not cause wrapping of the hydraulic fluid lines connecting the hydraulic pump **61** to the above-mentioned hydraulic components. The hydraulic fluid lines move with the platform **20** in synchronicity with the both the hydraulic pump **61** and the hydraulic components, therefore the hydraulic fluid lines do not need to be coiled through the swivel **10**. However, because the stabilizer legs **6** are not mounted on the platform **20**, the hydraulic fluid lines connecting the stabilizer leg actuators **7** to the hydraulic pump **61** should be disconnected once the stabilizer legs **6** are locked in the ground-engaging position, or a separate dedicated hydraulic pump could be used to power the stabilizer leg actuators **7**.

[0051] FIG. **16** to FIG. **24**B depict another embodiment of a liquid pumping trailer **100**, which has many components in common with the liquid pumping trailer **1**. There are three primary differences between the trailer **100** and the trailer **1**.

[0052] First, the trailer **100** has an articulated boom **140** with first, second and third boom sections **141**, **142** and **143**, respectively, each of the boom sections **141**, **142**, **143** connected to respective neighboring boom sections through one or both of pivots **146** and **147** such that pivoting of the second and third boom sections **142** and **143**, respectively, can be accomplished through an angle of 180°. The boom sections **141**, **142** and **143** are therefore capable of extending further while being able to fold up completely on each other into a compact transport configuration. The first boom section **141** is pivotally connected to a platform **120** of the trailer **100** at pivot **145**.

[0053] Second, the trailer **100** has a rigid fluid conduit **180** extending along an exterior of the boom **140** from a distal end of the fluid conduit **180** where the fluid conduit **180** is connected to a liquid pump **170** all the way to a proximal end of the fluid conduit **180** proximate a frame **102** of the trailer **100** where fluid in the fluid conduit **180** is ejected through a discharge outlet **189**. The rigid fluid conduit **180** is made of hard steel or other strong material and is therefore more robust and less prone to damage than a flexible conduit made of rubber or another polymer. Thus, the fluid conduit does not need to be protected over its long length by housing the fluid conduit in the boom nestled between the walls of the boom. To run the fluid conduit **180** along the exterior of the boom **140** while permitting the boom sections **141**, **142** and **143** to articulate, the fluid conduit **180** is passed from one side of the boom **140** through to the other side of the boom **140** at each articulation point proximate pivot **146** and pivot **147**, as best seen in regions A and B in FIG. **16**. Elbows **181** in the fluid conduit **180** are employed to redirect the fluid conduit **180** through an aperture in the boom **140** at the articulation points and then back along the exterior of the boom **140**. When the boom sections **141**, **142** and **143** articulate. The boom sections **141**, **142** and **143** rotate about the fluid conduit **180** without twisting the fluid conduit **180**.

[0054] Third, the trailer **100** has an additional liquid pump **110** that is mounted on the platform **120**, as best seen in FIG. **21** to FIG. **24**B. The additional fluid pump **110** is fluidically in-line with the fluid conduit **180** and is used to complement the pumping action of the liquid pump **170**. The liquid pump **170** is at the distal end of the fluid conduit **180** beyond a distal end of the boom **140**, while the additional fluid pump **110** is close to the discharge outlet **189** at a proximal end of the fluid conduit **180**. The additional liquid pump **110** is preferably a high-pressure pump relative to the liquid pump **170**. The additional liquid pump **110** provides extra pumping power for efficient transport of the liquid through the fluid conduit **180**.

[0055] The additional fluid pump **110** is driven by an engine **160** either directly through a drive shaft **161** of the engine or through a clutch connecting the additional liquid pump **110** to the drive shaft **161** of the engine **160**. The engine **160** and the additional fluid pump **110** are both

mounted on the platform **120** on an opposite side of an axis of rotation of the platform **120** in relation to the boom **140**. The additional liquid pump **110** therefore also provides extra weight on the platform **120** to help counterbalance the boom **140** allowing the boom **140** on the trailer **100** to be longer than the boom **40** on the trailer **1**.

[0056] FIG. **21** to FIG. **24**B shows details of how the additional fluid pump **110** is plumbed into the fluid conduit **180**. Reference is made herein to conduit sections, which are sections of the fluid conduit **180**. Liquid flowing through the fluid conduit **180** from the liquid pump **170** enters conduit section **182** between the boom **140** and the platform **120** to be delivered into conduit section **183** mounted on the platform **120**. The conduit section **183** has an elbow that directs the liquid flow into an inlet **111** of the additional liquid pump **110**. The additional liquid pump **110** pumps the liquid into conduit section **184** connected to an outlet **112** of the additional liquid pump **110**, the outlet **112** having an elbow to direct the liquid flow to an opposite lateral side of the platform **120** where the fluid flows into the conduit section **184**. The conduit section **184** has an elbow to redirect the liquid flow parallel to the lateral edge of the platform **120** where the liquid flows into conduit section **185**. The conduit section **185** has elbows to redirect the liquid flow laterally back toward a centerline of the platform **120** and then down vertically through a central aperture **121** in the platform **120** where the liquid flows into conduit section **186**. The conduit section **186** has an elbow to redirect the liquid flow longitudinally parallel to a longitudinal axis of the trailer **100** into conduit section **187** that delivers the liquid flow to conduit section **188** and finally out through the discharge outlet **189**.

[0057] With specific reference to FIG. **23**, the fluid conduit **180** at the inlet **111** of the additional liquid pump **110** is equipped with a by-pass conduit **190** fluidly connecting the conduit section **185** to the inlet **111** of the additional liquid pump **110** through a valve **191**. Operation of the valve **191** permits fluid leaving the additional liquid pump **110** to be recycled back into the additional liquid pump **110** to help regulate the liquid flow through the additional liquid pump **110**. In addition, the inlet **111** is equipped with a clean-out port **113** to assist with maintenance of the additional liquid pump **110**.

[0058] The novel features will become apparent to those of skill in the art upon examination of the description. It should be understood, however, that the scope of the claims should not be limited by the embodiments, but should be given the broadest interpretation consistent with the wording of the claims and the specification as a whole.

1. A liquid pumping vehicle comprising:

a frame;

rotatable ground-engaging elements mounted on the frame to permit driving the vehicle on ground;

a platform rotatably mounted on the frame, the platform rotatable about a vertically oriented rotation axis relative to the ground;

an articulated boom mounted on the platform proximate a first end of the boom;

a first liquid pump mounted on the boom proximate a second end of the boom, the liquid pump immersible in a liquid reservoir for pumping liquid out of the reservoir;

a second liquid pump mounted on the platform, the second liquid pump in fluid connection with a fluid conduit through which the first liquid pump pumps the liquid;

an engine mounted on the platform, the engine operably connected to the liquid pump for operating the liquid pump, the engine situated

so that the rotation axis of the platform is between the boom and the engine and

so that a first turning moment created on a first moment arm relative to the rotation axis by weight of the engine and other components on an engine-side of the platform is balanced under operational conditions of the pumping vehicle by a second turning moment created on a second moment arm relative to the rotation axis by weight of the boom and other components on a boom-side of the platform;

and,

a flow discharge outlet, the flow discharge outlet connected to the second liquid pump by the fluid conduit through which the liquid is pumped by the first and second liquid pumps from the liquid reservoir to the flow discharge outlet.

2. The vehicle of claim **1**, wherein the second liquid pump operates at higher pressure than the first liquid pump.

3. The vehicle of claim **1**, wherein the second liquid pump is driven by a drive shaft of the engine.

4. The vehicle of claim **1**, wherein the fluid conduit is situated exterior to the boom and passes from one side of the boom to another side of the boom at articulation points on the boom.

5. The vehicle of claim **4**, wherein the articulation points permit pivoting of boom arm sections through 180°.

6. The vehicle of claim **1**, wherein the platform is continuously rotatable through 360°, and the engine, the second liquid pump and the boom are fixedly mounted on the platform to be carried by the platform as the platform is being rotated while maintaining the balance of the first turning moment and the second turning moment.

7. The vehicle according to claim **1**, further comprising a direct-drive hydraulic pump mounted on the engine-side of the platform, the hydraulic pump driven by the engine, the hydraulic pump operatively connected to the first liquid pump for operating the first liquid pump.

8. The vehicle according to claim **7**, wherein the first liquid pump comprises a hydraulic motor for operating the first liquid pump, the hydraulic motor operatively connected to the hydraulic pump by hydraulic fluid lines extending between the hydraulic pump and the hydraulic motor along the boom.

9. The vehicle of claim **8**, wherein the operational conditions of the pumping vehicle comprise the hydraulic fluid lines being full of hydraulic fluid, the boom being extended and the fluid conduit containing liquid being pumped by the first and second liquid pumps.

10. The vehicle according to claim **1**, further comprising stabilizer legs mounted on the frame, the stabilizer legs moveable between a ground-disengaging position and a ground-engaging position, the stabilizer legs assisting with stabilizing the vehicle on the ground when the stabilizer legs are in the ground-engaging position.

11. The vehicle according to claim **1**, wherein the boom comprises at least two boom sections, the at least two boom

sections pivotable relative to each other by one or more hydraulic cylinders connected between adjacent boom sections.

12. The vehicle according to claim **1**, wherein the rotatable ground-engaging elements comprise wheels.

13. The vehicle according to claim **1**, wherein the vehicle is a trailer.

14. The vehicle according to claim **1**, wherein the liquid is liquid manure.

15. A liquid pumping vehicle comprising:

a frame;

rotatable ground-engaging elements mounted on the frame to permit driving the vehicle on ground;

a platform rotatably mounted on the frame, the platform rotatable about a vertically oriented rotation axis relative to the ground;

an articulated boom mounted on the platform proximate a first end of the boom;

a first liquid pump mounted on the boom proximate a second end of the boom, the liquid pump immersible in a liquid reservoir for pumping liquid out of the reservoir;

a second liquid pump mounted on the platform, the second liquid pump in fluid connection with a fluid conduit through which the first liquid pump pumps the liquid;

an engine mounted on the platform, the engine operably connected to the liquid pump for operating the liquid pump, the engine situated

so that the rotation axis of the platform is between the boom and the engine and

so that a weight of the engine, second liquid pump and other components on an engine-side of the platform acts as a counterbalance to a weight of the boom and other components on a boom-side of the platform;

and,

a flow discharge outlet, the flow discharge outlet connected to the second liquid pump by the fluid conduit through which the liquid is pumped by the first and second liquid pumps from the liquid reservoir to the flow discharge outlet.

16. The vehicle of claim **15**, wherein the second liquid pump operates at higher pressure than the first liquid pump.

17. The vehicle of claim **15**, wherein the second liquid pump is driven by a drive shaft of the engine.

18. The vehicle of claim **15**, wherein the fluid conduit is situated exterior to the boom and passes from one side of the boom to another side of the boom at articulation points on the boom.

19. The vehicle of claim **18**, wherein the articulation points permit pivoting of boom arm sections through 180°.

20. The vehicle of claim **15**, wherein the platform is continuously rotatable through 360°, and the engine, the second liquid pump and the boom are fixedly mounted on the platform to be carried by the platform as the platform is being rotated while maintaining the balance of the first turning moment and the second turning moment.

21. The vehicle according to claim **15**, further comprising a direct-drive hydraulic pump mounted on the engine-side of the platform, the hydraulic pump driven by the engine, the hydraulic pump operatively connected to the first liquid pump for operating the first liquid pump.

22. The vehicle according to claim **21**, wherein the first liquid pump comprises a hydraulic motor for operating the first liquid pump, the hydraulic motor operatively connected to the hydraulic pump by hydraulic fluid lines extending between the hydraulic pump and the hydraulic motor along the boom.

23. The vehicle of claim **22**, wherein the operational conditions of the pumping vehicle comprise the hydraulic fluid lines being full of hydraulic fluid, the boom being extended and the fluid conduit containing liquid being pumped by the first and second liquid pumps.

24. The vehicle according to claim **15**, further comprising stabilizer legs mounted on the frame, the stabilizer legs moveable between a ground-disengaging position and a ground-engaging position, the stabilizer legs assisting with stabilizing the vehicle on the ground when the stabilizer legs are in the ground-engaging position.

25. The vehicle according to claim **15**, wherein the boom comprises at least two boom sections, the at least two boom sections pivotable relative to each other by one or more hydraulic cylinders connected between adjacent boom sections.

26. The vehicle according to claim **15**, wherein the rotatable ground-engaging elements comprise wheels.

27. The vehicle according to claim **15**, wherein the vehicle is a trailer.

28. The vehicle according to claim **15**, wherein the liquid is liquid manure.

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