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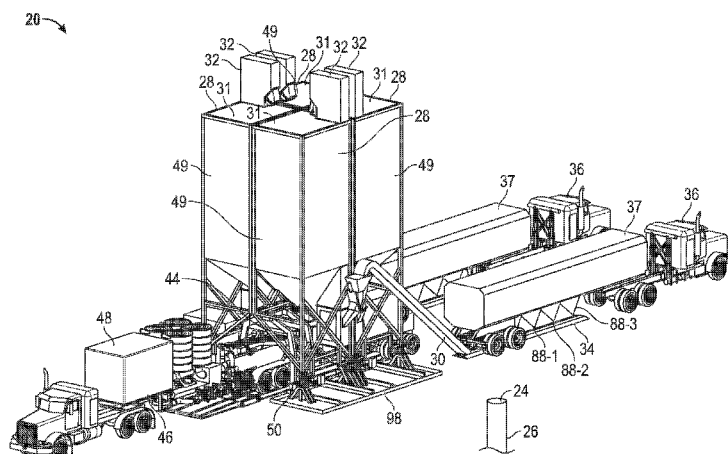


FIG. 1

(57) **Abstract**: A system and methodology facilitates the handling of oilfield materials in a space efficient manner. The oilfield materials are delivered without blowers to at least one modular silo. Each modular silo comprises an outer housing defining an enclosed interior. A vertical conveyor is positioned within the enclosed interior and is used to lift the oilfield material from a silo inlet to an upper portion of the modular silo without utilizing airflow to carry the oilfield materials. Once the oilfield materials are disposed within the upright modular silo, the outflow of oilfield materials through a silo outlet may be controlled so as to selectively release the desired amount of material into a blender or other suitable equipment.



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SYSTEM AND METHOD FOR DELIVERY OF OILFIELD MATERIALS

BACKGROUND

[0001] To facilitate the recovery of hydrocarbons from oil and gas wells, the subterranean formations surrounding such wells can be hydraulically fractured. Hydraulic fracturing may be used to create cracks in subsurface formations to allow oil and/or gas to move toward the well. The formation is fractured by introducing a specially engineered fluid, sometimes referred to as fracturing fluid or fracturing slurry, at high pressure and high flow rates into the formation through one or more wellbores. The fracturing fluids may be loaded with proppants which are sized particles that may be mixed with the liquids of the fracturing fluid to help form an efficient conduit for production of hydrocarbons from the formation to the wellbore. Proppant may comprise naturally occurring sand grains or gravel, man-made proppants, e.g. fibers or resin coated sand, high-strength ceramic materials, e.g. sintered bauxite, or other suitable materials. The proppant collects heterogeneously or homogeneously inside the fractures to prop open the fractures formed in the formation. Effectively, the proppant creates planes of permeable conduits through which production fluids can flow to the wellbore.

[0002] At the wellsite, proppant and other fracturing fluid components are blended at a low-pressure side of the system. Water-based liquid is added and the resulting fracturing fluid is delivered downhole under high pressure. However, handling of the proppant prior to blending tends to create substantial dust as the proppant is moved to wellsite storage and then to the blender via blowers and mechanical conveyors, respectively. As a result, dust control devices, e.g. vacuums, are employed in an effort to control the dust. The variety of equipment used in the process also tends to create a large footprint and reduced process reliability at the wellsite, and operating the equipment is generally a manually intensive process. Moreover, pneumatic transfer of proppant from haulers to storage is limited by low transfer rates, which lead to high demurrage costs and further increase in the footprint at the wellsite due to the need of multiple haulers to meet the job demand.

SUMMARY

[0003] In general, the present disclosure aims to provide a system and method which facilitate the handling of oilfield materials in a substantially automated and space efficient

manner. The present disclosure provides a plurality of modular silos, each modular silo being a modular unit sized for over-the-road transport by a trailer, and each modular silo having an enclosed interior for holding oilfield material. The modular silos have outer housings surrounding an enclosed interior for holding the oilfield material, and feeders which are oriented to deliver the oilfield material to a common area for blending. In one embodiment, the common area is located below and overlaps with the outer housings.

[0004] The present disclosure also aims to provide a system and method of handling oilfield materials in a manner that minimizes dust migration. The oilfield materials are delivered without blowers to at least one of the modular silos. A vertical conveyor, such as a bucket elevator, is positioned within the enclosed interior of the modular silo and is used to lift the oilfield material from a silo inlet to an upper portion of the modular silo without utilizing airflow to carry the oilfield materials. To increase storage capacity of the modular silos, the vertical conveyor extends from a top of the modular silo and is horizontally offset to avoid a gooseneck of a trailer which can be used to deliver the modular silo to the wellsite.

[0005] The present disclosure also aims to provide a system and method of handling oilfield materials in a time and cost efficient manner, while minimizing human intervention. For example, once the oilfield materials are disposed within the upright modular silo, the outflow of oilfield materials through a silo outlet may be controlled so as to selectively release the desired amount of material, by gravitational flow, directly into a blender or other suitable oilfield service equipment positioned underneath the modular silo.

[0006] The present disclosure also aims to reduce the time that it takes to unload a truck delivering oilfield material to the wellsite. This can be accomplished by a conveyor having a horizontal portion designed to be backed over by the trailer and positioned underneath multiple outlets on the underside of the trailer. Once the horizontal portion of the conveyor is positioned below the multiple outlets on the underside of the trailer, then oilfield material can be simultaneously delivered through the outlets of the trailer onto the horizontal portion of the conveyor and transferred by the conveyor into the silo inlet of one or more of the modular silos. A diverter having a single inlet and multiple outlets can be positioned between the conveyor and at least two of the silo inlets to utilize a single transfer conveyor to feed either of the two silos while maintaining a standard (fixed) setup.

[0007] The present disclosure further aims to provide a mobile oilfield material transfer unit. The unit has a chassis having a first end, a second end, a support beam extending

between the first end and the second end, and wheels operably coupled with the support beam for movably supporting the support beam. The unit also has an erecting mast assembly including a mast movably connected with the chassis proximate to the second end, and an actuator system coupled with the mast and with the chassis for moving the mast between a horizontal position and a vertical position. The unit further has a first conveyor assembly including a support frame coupled with the mast and moveable between the horizontal position and the vertical position, the first conveyor assembly including a first conveyor coupled with the support frame, an inlet, and an upper discharge portion, the first conveyor adapted to move a volume of oilfield material from the inlet to the upper discharge portion.

[0008] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0010] Figure 1 depicts an illustration of an example of a proppant delivery system positioned at a wellsite, according to an embodiment of the disclosure;

[0011] Figure 2 depicts an illustration of another embodiment of a proppant delivery system in which a plurality of closed, modular silos are used for holding oilfield materials, according to an embodiment of the disclosure;

[0012] Figure 3 depicts a schematic illustration of an example of a vertical conveyor system enclosed within a modular silo, according to an embodiment of the disclosure;

[0013] Figure 4 depicts an illustration of an example of an enclosed conveyor system for delivering oilfield materials from an unload area to inlets of modular silos for delivery to an upper portion of the modular silos via vertical conveyor systems, according to an embodiment of the disclosure;

[0014] Figure 5 depicts an illustration of a modular silo being transported by an over-the-road truck, according to an embodiment of the disclosure;

[0015] Figure 6 is a bottom perspective view of one of the modular silos, according to an embodiment of the disclosure;

[0016] Figure 7 is a partial bottom perspective view of four modular silos arranged in a group and connected together, according to an embodiment of the disclosure; and

[0017] Figure 8 is a bottom plan view of the four modular silos depicted in Figure 7, according to an embodiment of the disclosure;

[0018] Figure 9 is a perspective view of an example of a mobile oilfield material transfer unit according to an embodiment of the disclosure, with a first conveyor assembly shown in a horizontal position;

[0019] Figure 10 is a perspective view of the mobile oilfield material transfer unit of Figure 9 shown with the first conveyor assembly shown in a vertical position;

[0020] Figure 11 is a partial perspective view of an example of a support frame of a first conveyor assembly according to an embodiment of the disclosure;

[0021] Figure 12 is a perspective view of an example of a discharge chute of a first conveyor assembly according to an embodiment of the disclosure;

[0022] Figure 13 is a perspective view of a mobile oilfield material transfer unit shown coupled with a modular silo according to an embodiment of the disclosure;

[0023] Figure 14 is a perspective view of the mobile oilfield material transfer unit of Figure 13 shown with an oilfield material delivery trailer positioned thereon, according to an embodiment of the disclosure;

[0024] Figure 15 is a perspective view of an embodiment of a mobile oilfield material transfer unit shown coupled with a modular silo and an oilfield material delivery trailer positioned thereon, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0025] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0026] Unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by anyone of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0027] In addition, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of the inventive concept. This description should be read to include one or at least one and the singular also includes the plural unless otherwise stated.

[0028] The terminology and phraseology used herein is for descriptive purposes and should not be construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited.

[0029] Finally, as used herein any references to "one embodiment" or "an embodiment" means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily referring to the same embodiment.

[0030] The present disclosure generally involves a system and methodology to facilitate handling of oilfield materials in a space efficient manner. In one embodiment, the oilfield materials may be carried to a wellsite by suitable trucks and loaded into at least one modular silo without using air to carry the oilfield material. By way of example, the oilfield materials may be moved into a plurality of modular silos by using vertical conveyors to move the oilfield material without blowers. In some embodiments, each modular silo comprises an outer housing defining an enclosed interior for receiving the oilfield material. A

corresponding vertical conveyor is positioned within the enclosed interior and is used to lift the oilfield material from a silo inlet, e.g. a hopper, to an upper portion of the modular silo without utilizing airflow to carry the oilfield materials. Once the oilfield material is disposed within the upright modular silo, the outflow of oilfield material through a silo outlet may be gravity controlled so as to selectively release the desired amount of material into a blending system or other suitable equipment positioned underneath the modular silo.

[0031] According to a specific example, a vertical silo is designed as a modular silo which may be carried by an over-the-road truck. Truck refers to a transport vehicle, such as an articulated truck having a trailer pulled by a tractor. In this example, the modular silo is carried by the trailer of the truck. However, the truck also may comprise a straight truck or other suitable truck designed to carry the modular silo and to transport the modular silo over public roadways. In this example, the modular silo is erected from the truck to a vertical position at a wellsite to provide an efficient solution for proppant delivery that avoids bottlenecks associated with existing systems. However, it should be understood that in other embodiments, a crane may be used to lift the modular silo and place the modular silo onto a support structure.

[0032] In this embodiment, a conveyor, such as a mechanical belt conveyor, may be utilized to move oilfield material unloaded from a gravity dump transport into an intake hopper of a vertical conveyor enclosed within the modular silo. The mechanical belt conveyor can be backed-over by a trailer hauling the oilfield material with multiple nozzles overlapping the mechanical belt conveyor, or other types of haulers may also be used, such as tail dumps and live bottom trailers. By way of example, the vertical conveyor may comprise a bucket elevator or other type of vertical conveyor capable of conveying the oilfield material to an upper end of the modular silo a substantial distance, e.g. 30 (9.144 meters) to 70 (21.336 meters) feet, above the wellsite surface. The conveyor moving the oilfield material to the modular silo and the vertical conveyor may be enclosed to provide a dust free solution for handling oilfield material at much higher rates with greater energy efficiency and lower attrition than that achieved with existing pneumatic, e.g. blower, type conveyance systems. To increase storage capacity of the modular silo as compared to a cylindrical silo, the outer housing may have a substantially rectangular shape defining four corners (which may form pointed vertices or be rounded). The modular silo may be transported on a trailer having a gooseneck. As best shown in figure 5, to further increase the storage capacity of the modular silo while still being capable of being transported by a

truck, the vertical conveyor may extend beyond a top of the outer housing and be offset towards one of the corners so as to avoid the gooseneck of the trailer.

[0033] Depending on the parameters of a given fracturing process, a plurality of the modular silos may be grouped together so that feeders of the plurality of modular silos provide oilfield material to a common area, e.g. to a truck mounted blending system having a proppant metering/rate control system, or other portable blender or blending system positioned beneath the modular silos. In order to reduce the space required at the wellsite for the plurality of the modular silos, the common area may be located below and overlaps the outer housings of the modular silos. Additionally, some or all of the modular silos may be divided into compartments. In some applications, individual modular silos may have a plurality of internal compartments for holding different types of oilfield materials. Individual silos also may be divided into main storage compartments and secondary storage compartments located below the main storage compartments. In the latter example, the main storage compartment may be used to gravity feed oilfield material to an outlet feeder for distribution into the blender. Some systems may utilize a belt feeder or other type of feeder system instead of gravity feed. The secondary storage compartment may be exposed to the internal vertical conveyor and proppant from the secondary storage compartment may continually be lifted and discharged into the main storage compartment. In some applications, the secondary compartments or other compartments of the modular silo may have separate features which enable independent filling of those particular compartments. Additionally, outlet feeders may be designed with controllable mechanisms, e.g. gates, which are adjustable to control the outflow of oilfield material.

[0034] The modular silos may be designed in a variety of sizes and shapes, including cylindrical shapes or rectangular shapes, selected to enable transport via a suitable over-the-road truck. By way of example, the modular silos may vary in size according to the proppant delivery plan for a given fracturing operation, but an example of a suitable modular silo may hold 2000-4000 (609.6-1219.2 meters) cubic feet of oilfield material. In some systems, the modular silos are provided with sufficient clearance on the bottom side to form an unobstructed passage to enable a portable blender, such as a truck mounted blender, to be driven under a system of combined modular silos to receive oilfield material via gravity feed. For example, the portable blender may be mounted on a truck trailer which is backed into position under the outlet feeders of a plurality of modular silos. In some embodiments, the modular silos may be designed as standalone silos and in other embodiments, the

modular silos may be designed for placement on a framework/support structure which supports the modular silos at a desired height. In one embodiment the blending system may be skid mounted in order to be transported on a trailer to the wellsite and then placed under the silo system by a suitable mechanical device, such as a winch.

[0035] Each of these embodiments may utilize an enclosed, vertical conveyor to avoid blowing of the oilfield material, although in other embodiments a pneumatic fill tube can be used as a vertical conveyor. Each modular silo also may be filled by an integrated, oilfield material loading and delivery system utilizing an enclosed conveyor or other suitable system for moving oilfield material from an unload area to an inlet associated with the vertical conveyor at a lower portion of the modular silo. In some applications, the vertical conveyor may be powered by a belt or other device driven by the enclosed conveyor system used to move oilfield material from the unload area to the inlet of the modular silo. This allows the system to be substantially automated. However, the individual motive systems, e.g., vertical conveyor and enclosed conveyor extending from the unload area, may be powered individually or collectively by a variety of sources, including various motors, engines, or other devices.

[0036] Referring generally to Figure 1, an embodiment of a system, e.g. a system for fracturing formations, is illustrated in position at a wellsite. By way of example, the fracturing system may comprise many types of equipment, including vehicles, storage containers, material handling equipment, pumps, control systems, and other equipment designed to facilitate the fracturing process.

[0037] In the example of Figure 1, a formation fracturing system 20 is illustrated in position at a wellsite 22 having a well 24 with at least one wellbore 26 extending down into a reservoir/formation. The formation fracturing system 20 may comprise many types and arrangements of equipment, and the types or arrangements may vary from one fracturing operation to another. By way of example, the formation fracturing system 20 may comprise at least one modular silo 28, e.g. a plurality of modular silos that may be transported over-the-road by trucks able to operate on public roadways. The modular silos 28 are designed to store oilfield material such as a proppant used to prop open fractures upon fracturing of the subterranean formation, or guar used to increase the viscosity of a hydraulic fracturing fluid. In the example illustrated, several modular silos 28 receive oilfield material via conveyors 30, e.g. belt conveyors, and the oilfield material is lifted to an upper portion 31 of each

modular silo by corresponding vertical conveyors 32. The conveyors 30 and the vertical conveyors 32 may operate by carrying the oilfield material instead of blowing the oilfield material to avoid erosion of components and dusting of the area. Additionally, the conveyors 30 and vertical conveyors 32 may be enclosed to further reduce dust as the oilfield material is delivered from an unload area 34 and into the modular silos 28.

[0038] As illustrated, oilfield material transport trucks 36 may be used to deliver oilfield material to the unload area 34. In this example, the trucks 36 are tractor-trailer trucks having trailers 37 which may be backed over a portion of a selected conveyor 30. The trailers 37 can be gravity feed trailers or other types trailers capable of moving the oilfield material to the wellsite 22. The trailers may be operated to release the oilfield material onto a belt or other suitable carrier of the selected conveyor 30 for transfer to the associated modular silo or silos 28 along an enclosed pathway within the conveyor 30.

[0039] In this example, the formation fracturing system 20 may comprise a variety of other components including water tanks (not shown) for supplying water that is mixed with the oilfield material to form the hydraulic fracturing fluid, e.g. proppant slurry, that may be pumped downhole into wellbore 26 via a plurality of pumps (not shown). By way of example, pumps may be truck mounted pumps, e.g. pumping systems mounted on truck trailers designed for over-the-road transport. The multiple pumps may be coupled to a common manifold (not shown) designed to deliver the hydraulic fracturing fluid to the wellbore 26. The formation fracturing system 20 also may comprise a blending system 44 designed to blend oilfield material delivered from modular silos 28. By way of example, the blender 44 may be a portable blender, such as a truck mounted blender or a skid mounted blender. In the specific example illustrated, blending system 44 is mounted on a truck trailer 46 that may be driven, e.g. backed up, into a common area 47 (shown in figure 8) that is positioned underneath or proximate to the modular silos 28. The formation fracturing system 20 also may comprise a variety of other components, such as a control facility 48 and/or other components designed to facilitate a given fracturing operation. In one embodiment, the common area 47 is located below and overlaps with outer housings 49 of the modular silos 28.

[0040] Referring generally to Figure 2, an embodiment of modular silos 28 coupled together into a cooperating unit is illustrated. In this example, a plurality of the modular silos 28, e.g. four modular silos 28, is coupled together on a modular support structure, or

framework, 50 which may be mounted on a pad 52. For example, the modular silos 28 may be releasably mounted in a generally upright or vertical orientation on support structure 50. Support structure 50 is constructed with a plurality of silo receiving regions 54 on which the individual modular silos 28 may be mounted in a generally upright or vertical orientation. The support structure 50 and the silo receiving regions 54 may be designed to elevate the modular silos 28 to a sufficient height so as to allow movement of portable blending system 44 to a position sufficiently beneath the modular silos 28 within the common area 47 in order to receive a controlled outflow of oilfield material. For example, the support structure 50 may be designed to allow a truck mounted blending system 44 to be driven, e.g. backed up, into position beneath the modular silos 28, as illustrated. Additionally, pad 52 may be constructed in a variety of sizes and forms, including cement pads, compacted aggregate pads, pads constructed as portable structures, mixtures of these various structural elements, and/or other suitable pad types for supporting the plurality of modular silos 28.

[0041] In the example illustrated, modular silos 28 each may be constructed with a silo frame 56 supporting the outer housing 49 which defines an enclosed interior 60 for holding oilfield material 62 (see also Figure 3). Depending on the fracturing operation, oilfield material 62 may comprise naturally occurring sand grains or gravel, man-made proppants, resin coated sand, high-strength ceramic materials, e.g. sintered bauxite, other solids such as fibers, mica, mixtures of different sized oilfield materials, mixtures of different types of oilfield materials, and/or other suitable oilfield materials. In some applications, selected modular silos 28 or each of the modular silos 28 may be divided into the compartments 64 designed to hold different types of oilfield materials 62 that may be selectively released from the modular silo 28 and blended via the blending system 44. Each enclosed vertical conveyor 32 is designed to lift oilfield material (e.g., with or without blowing) from an inlet 66, e.g. an inlet hopper, disposed at a lower portion 68 to an upper discharge portion 70 for release into enclosed interior 60 through a vertical conveyor head 72. In some embodiments, the conveyor head 72 may have a pivotable or otherwise movable discharge which is selectively controllable to deliver the desired oilfield material to a corresponding desired compartment 64 within a given modular silo 28.

[0042] With further reference to Figure 3, the vertical conveyor 32 may be positioned within enclosed interior 60 in a manner which limits escape of dust while providing a uniform modular unit that may be readily transported via an over-the-road truck, such as truck 36 with a suitably designed trailer. Vertical conveyor 32 also may be constructed in a variety of

forms. For example, the vertical conveyor 32 may be constructed as a bucket elevator 74 having a plurality of buckets 75 conveyed in a continuous loop lifting oilfield material 62 from inlet 66 to upper discharge portion 70 for discharge into enclosed interior 60 via vertical conveyor head 72. The outflow of oilfield material 62 to the blending system 44 may be through an outlet, e.g. a feeder 76, and the amount of outflow through feeder 76 may be controlled by a suitable outflow control mechanism 78. For example, the blending system 44 may include a hopper 79-1 having an inlet 79-2 positioned below the feeder 76. In one embodiment, the outer housing 58 overlaps the inlet 79-2 of the hopper 79-1. The inlet 79-2 of the hopper 79-1 may have a width 79-3 up to 12 (3.6576 meters) feet, and desirably between 8 (2.4384 meters) feet to 8.5 (2.5908 meters) feet. The hopper 79-1 may also have an outflow control mechanism 79-4 which is similar to the outflow control mechanism 78. By way of example, outflow control mechanisms 78 and 79-4 may comprise a controllable gate, e.g. hydraulic gate, control valve, or other flow control mechanism which is operated via control facility 48 or via another suitable control system. In this example, oilfield material 62 is gravity fed through feeder 76 and the amount of outflow is governed by the outflow control mechanism 78. In one embodiment, the oilfield material 62 into a blender 79-5 of the blending system 44 may be regulated by both of the outflow control mechanisms 78 and 79-4. In this instance, the outflow control mechanism 79-4 may be maintained in a fixed open position while the outflow control mechanism 78 is regulated in real-time by the control facility 48 to control an amount of oilfield material 62 discharged into the blender 79-5. Because the feeder 76 is within the confines of the hopper 79-1, as the hopper 79-1 fills with oilfield material 62, the oilfield material 62 will bear against the feeder 76 and form a plug. In this manner, the outflow control mechanism 79-4 is self-regulating and the outflow control mechanism 78 and the control facility 48 may solely control the amount of oilfield material 62 discharged into the blender 79.

[0043] In some applications, the external conveyor or conveyors 30 have a horizontal portion 80 with an exposed belt 82, as illustrated in Figure 4 that the trailers 37 of the trucks 36 can be backed over. The oilfield material may be unloaded via gravity from one of the trailers 37 which is backed over the horizontal portion 80. The oilfield material dropped onto belt 82 is conveyed onto an inclined portion 84 of conveyor 30 which may be enclosed and transports the oilfield material along an incline for release into at least one inlet 66 of a corresponding modular silo 28. In the specific example illustrated, the inclined portion 84 delivers the oilfield material into a hopper 86 of a diverter 87. Diverter 87 splits and diverts

the oilfield material into downward flows which enter a plurality of inlets 66 of a plurality of modular silos 28. For example, the diverter 87 may be designed to deliver proppant from conveyor 30 into a pair of inlets 66 associated with adjacent modular silos 28. As described above, the oilfield material is then lifted by the vertical conveyor 32 of each modular silo 28. In this example, the oilfield material unloaded from truck 36 is immediately moved into an enclosed system and is automatically conveyed into the enclosed interiors 60 of adjacent modular silos 28 without releasing dust into the surrounding environment.

[0044] The horizontal portion 80 is designed to enhance the rate at which oilfield material can be transferred into the modular silos 28 from the trailer 37. In particular, as shown in FIG. 1, the trailer 37 may be provided with multiple outlets 88-1, 88-2 and 88-3 which are spaced apart on the underside of the trailer 37. Although three outlets 88-1, 88-2, and 88-3 are shown and described, more or less outlets can be provided on the underside of the trailer 37. The horizontal portion 80 is provided with a first end 89-1, a second end 89-2 and a length 89-3 extending between the first end 89-1 and the second end 89-2. The first end 89-1 overlaps the inclined portion 84 so as to transfer the oilfield material onto the inclined portion 84 from the trailer 37 of the truck 36. The horizontal portion 80 may have a height above the ground sufficient to permit the trailer 37 to be backed over the horizontal portion 80 and positioned underneath the outlets 88-1, 88-2, and 88-3 and between the wheels of the trailer 37. For example, the horizontal portion may have a height of less than 12 inches, and desirably between 6-8 inches. The length 89-3 of the horizontal portion 80 may be sufficient to be positioned in the unload area and simultaneously under all of the multiple outlets 88-1, 88-2 and 88-3. For example, the length 89-3 may be in a range from 8 (2.4384 meters) feet to 51 (15.5448 meters) feet. Once the trailer 37 is backed over the horizontal portion 80, the oilfield material may be simultaneously delivered through the outlets 88-1, 88-2 and 88-3 of the trailer 37 and onto the exposed belt 82 of the horizontal portion 80. The horizontal portion 80 also has a first side 90-1, a second side 90-2 extending substantially parallel to the first side 90-1, and a width 91 extending between the first side 90-1 and the second side 90-2. The width 91 is designed to fit in a space between the wheels of the trailer 37 so that the trailer 37 can be backed over the horizontal portion 80. For example, the width 91 can be approximately two (0.6096 meters) feet.

[0045] As discussed above, each modular silo 28 may be designed as a modular unit used alone or in cooperation with other silos 28. The modularity along with the design and sizing of the modular silos 28 enables transport of individual modular silos 28 over public

highways via trucks 36. As illustrated in Figure 5, a suitable truck 36 may comprise a tractor 92-1 pulling a gooseneck trailer 92-2 appropriately sized to receive one of the modular silos 28 in a lateral, e.g. horizontal, orientation. The gooseneck trailer 92-2 has a gooseneck 92-3 connecting the gooseneck trailer 92-2 to the tractor 92-1. In the example illustrated, the modular silo 28 is constructed such that the vertical conveyor head 72 of the vertical conveyor 32 is disposed along a side of the modular silo 28 and extends from a closed top 94 of the outer housing 58 of the modular silo 28 along a side 95-1 of the gooseneck 92-3. In this position, the vertical conveyor head 72 overlaps with the side 95 of the gooseneck 92-3, and may avoid overlapping with a top 95-2 of the gooseneck 92-3. The vertical conveyor 32 may extend between one inch and ten (3.048 meters) feet beyond the closed top 94 of the outer housing 58 in order to enable transport of the modular silo 28 on the gooseneck trailer 92-2, as illustrated. The gooseneck trailer 92-2 can be a conventionally styled gooseneck trailer, for example.

[0046] In the example illustrated in Figure 5, the modular silo 28 includes silo frame 56 which is designed for engagement with support structure 50 at one of the silo receiving regions 54. However, silos 28 may be constructed in other types of configurations. For example, each modular silo 28 may be constructed as a standalone silo. In this configuration, silo frame 56 may be designed to engage a silo support pad located at the base of the modular silo 28. A variety of outriggers may be used in cooperation with silo support pad and/or silo frame 56 to stabilize the modular silo 28 when pivoted into its upright position. By way of example, the outriggers may be hydraulically, electrically, pneumatically, manually, or otherwise actuatable between a retracted position and an extended position to support the modular silo 28 in the vertical position. In some embodiments, outriggers 98 may be mounted to the support structure 50 to stabilize the support structure 50 when the modular silos 28 are mounted in an upright position on the support structure 50, as shown in FIG. 1.

[0047] Referring to Figures 5 and 6, in one embodiment, the modular silos 28 have been constructed in a manner which goes against conventional wisdom. In particular, conventional wisdom would center the vertical conveyor 32 on a centerline of the modular silo in order to balance the modular silos 28 on the trailers 37. However, as shown in Figures 5 and 6, the vertical conveyor 32 and the feeder 76 of the modular silos 28 may be arranged on a same side of the outer housing 58 so as to facilitate the formation of the modular silos 28 into the cooperating unit shown and described above with respect to FIGs.

1 and 2, although the modular silos 28 may not be balanced on the trailers 37. In particular, as shown in FIG. 5, the outer housing 58 has a lower portion 68 and an upper portion 100. The outer housing 58 also has a first centerline 102 and second centerline 104 extending from the lower portion 68 to the upper portion 100 of the outer housing 58 and dividing the enclosed interior 60 generally into quadrants 106-1, 106-2, 106-3 and 106-4. In the example shown, the outer housing 58 has a substantially rectangular shape defining four corners 107-1, 107-2, 107-3 and 107-4 and each quadrant 106-1, 106-2, 106-3 and 106-4 encompasses one of the corners 107-1, 107-2, 107-3 and 107-4. The first centerline 102 also divides the outer housing 58 into a first half 108 and a second half 110 with the first quadrant 106-1 encompassed within the first half 108. The vertical conveyor 32 is mounted to the outer housing 58 and extends from the lower portion 68 to the upper portion 100 and may be within 5 degrees of parallel to the first centerline 102. The vertical conveyor 32 may be located within the second quadrant 106-2 of the quadrants 106-1, 106-2, 106-3 and 106-4 and positioned adjacent to the first quadrant 106-1, the corner 107-4 and within the first half 108.

[0048] In this example, the vertical conveyor 32 has third centerline 111 which is offset from the first centerline 102 such that the third centerline 111 is horizontally offset from and clears the side 95-1 of the gooseneck trailer 92-3. For example, the third centerline 111 can be offset between two (0.6096 meters) feet and seven (2.1336 meters) feet from the first centerline 102.

[0049] It should be noted that the corners 107-1, 107-2, 107-3 and 107-4 can either be shaped as a vertex, or rounded in order to provide a stronger outer housing 58. In addition, the sides of the outer housing 58 may be planar or concavely shaped in order to bulge outwardly in a predetermined manner when the oilfield material 62 is loaded into the enclosed interior 60 of the modular silo 28.

[0050] Figures 7 and 8 will now be described. FIG. 7 is a partial bottom perspective view of a cooperating unit 120 formed of four modular silos 28 arranged in a group and connected together, according to an embodiment of the disclosure. Figure 8 is a bottom plan view of the cooperating unit 120 having the four modular silos 28 depicted in Figure 7. The cooperating unit 120 is provided with a first group 124 of modular silos 28, and a second group 126 of modular silos 28. The first group 124 and the second group 126 are substantially identical and may be constructed to form mirror images of one another.

[0051] The first group 124 is provided with a first modular silo 28a and a second modular silo 28b. The second group 126 is provided with a third modular silo 28c and a fourth modular silo 28d. In general, the first modular silo 28a and the second modular silo 28b are similar in construction with the exception that the second modular silo 28b is a mirror image of the first modular silo 28a to permit feeders 76a and 76b to be positioned adjacent to each other and within the common area 47. The first and fourth modular silos 28a and 28d are similar to one another, and the second and third modular silos 28b and 28c are also similar to one another. The third and fourth modular silos 28c and 28d are similar in construction with the exception that the fourth modular silo 28d is constructed to be a mirror image of the third modular silo 28c.

[0052] For purposes of clarity, only the first group 124 will be described in detail. The first modular silo 28a is provided with a first housing side 134 positioned adjacent to a vertical conveyor 32a and the feeder 76a. The second modular silo 28b is provided with a first housing side 136 which is also positioned adjacent to a vertical conveyor 32b and the feeder 76b. The first housing sides 134 and 136 contact each other or are positioned in close proximity to neighbor each other. The feeders 76a and 76b are desirably positioned within 12 (3.6576 meters) feet of each other, and more desirably positioned within eight (2.4384 meters) feet of each other. In one embodiment, the feeders 76a and 76b are positioned adjacent to the first housing sides 134 and 136, e.g., desirably within six (1.8288 meters) feet of the first housing sides 134 and 136, and more desirably within four (1.2192 meters) feet of the first housing sides 134 and 136 such that the feeders 76a and 76b discharge the oilfield material into the hopper 79-1.

[0053] The first modular silo 28a is also provided with a second housing side 140 positioned adjacent to the vertical conveyor 32a and extending generally normal to the first housing side 134. The second modular silo 28b is also provided with a second housing side 142 which is also positioned adjacent to the vertical conveyor 32b and extending generally normal to the first housing side 136. When the first modular silo 28a and the second modular silo 28b are interconnected, as shown in Figures 7 and 8, the second housing sides 140 and 142 are in a co-planar relationship. The feeders 76a and 76b may be positioned adjacent to the second housing sides 140 and 142, e.g., within twelve inches of the second housing sides 134 and 136.

[0054] When the first group 124 of modular silos 28a and 28b are connected to the second group 126 of modular silos 28c and 28d, the second housing sides 140 and 142 extend parallel to the second housing sides 144 and 146 of the modular silos 28c and 28d.

[0055] The arrangement and components of formation fracturing system 20 may vary substantially depending on the parameters of a given fracturing operation. The modular silos 28 may be used individually or in groups of standalone silos or silos securely mounted on a support structure. The modular silos may be mounted at a sufficient height to direct outflowing oilfield material through an outflow feeder positioned at the bottom of the enclosed interior. In other applications, the feeders may be positioned to direct outflow of oilfield material from a higher compartment within the modular silo. In some applications, the modular silos may comprise an enclosed interior divided into a plurality of compartments for holding different types of oilfield material that may be selectively metered to a blender for blending into a desired mixture which is then pumped downhole into the wellbore.

[0056] Additionally, various belt conveyors or other types of conveyors may be enclosed to deliver oilfield material from the unload area to the upright, modular silos. The modular silos also may incorporate a variety of vertical conveyors for lifting the oilfield material to an upper discharge region of the modular silos. Various arrangements of upright silos enable storage of a substantial quantity of oilfield materials that may be readily supplied for use in a fracturing operation. The upright arrangement of modular silos also provides for an efficient use of wellsite space. In addition to the space efficiency, the enclosed system for storing and delivering oilfield material provides a clean wellsite substantially free of dust production. However, depending on the specifics of a given fracturing operation, various numbers and arrangements of modular silos, conveyors, blenders, and other wellsite equipment may be employed.

[0057] Referring now to Figures 9-10, shown therein is an embodiment of a mobile oilfield material transfer unit 450 constructed in accordance with the present disclosure. The mobile oilfield material transfer unit 450 may include a chassis 452, a horizontal conveyor system 454 that may be referred to herein as a "second conveyor system 454", an erecting mast assembly 456, and a first conveyor assembly 458.

[0058] The chassis 452 includes a support base 460 and a gooseneck portion 462. The chassis 452 may be configured to support the first conveyor assembly 458 and to be pulled by a truck 36 to transport the first conveyor assembly 458 to any desired location such as a

well site. The chassis 452 is coupled to the erecting mast assembly 456 and may further be configured to erect the first conveyor assembly 458 to an upright or vertical operational position for conveying oilfield material into a silo (which may be a modular silo), as discussed in more detail with reference to Figure 13. The chassis 452 may cooperate with the erecting mast assembly 456 to move the first conveyor assembly 458 from a horizontal or transport position on the chassis 452 to an upright or vertical operational position. In some embodiments the chassis 452 may also be configured to be docked or otherwise aligned with a modular silo as will be described below.

[0059] The chassis 452 is provided with a support base 460 having a first end 464 (e.g., a front end) and a second end 466 (e.g., a rear end). The chassis 452 may also be provided with a support beam 468 extending between the first end 464 and the second end 466 of the support base 460, and a plurality of wheels 470 located at least partially underneath the support beam 468 (e.g., proximate to the second end 466) and operably connected to the support beam 468. The wheels 470 may be connected to one or more axles, and may include collapsible suspensions in some embodiments of the instant disclosure, such that the support base 460 may be positioned onto the ground when the suspension of the wheels 470 is collapsed.

[0060] In the embodiment shown in Figures 9-10, the chassis 452 is provided with two support beams, e.g., 468-1 and 468-2, which are separated from one another by a gap 472 and may be connected together to collectively form a support base 460 via one or more transverse support members 474 (Figure 10). The gap 472 extends longitudinally along the support base 460 between the first end 464 and the second end 466. The support beams 468-1 and 468-2 may be implemented as a steel beam, channel, I-beam, H-beam, wide flange, universal beam, rolled steel joist, or any other structure. In some embodiments of the present disclosure a plurality of transverse support members 474 may be spaced a distance apart from one another between the first end 464 and the second end 466 of the support base 460, while extending between the support beams 468-1 and 468-2.

[0061] The gooseneck portion 462 extends from the first end 464 of support base 460 and is configured to connect the chassis 452 to a truck such as the truck 36, such as via a suitable trailer hitch, for example. Once the truck 36 has been disconnected from the gooseneck portion 462, the gooseneck portion 462 may be manipulated to lie on the ground and be generally co-planar with the support base 460 as shown in Figure 14. In this

configuration, the gooseneck portion 462 may form a ramp to allow an oilfield material delivery truck or trailer to be driven over or backed onto the support base 460. For example, the gooseneck portion 462 may be provided with a first section 476 and a second section 478. The first section 476 may extend from the first end 464 of the support base 460. The first section 476 has a first end 480 and a second end 482. The first end 480 of the first section 476 is movably connected to the support base 460, such as by the use of a set of hinges, voids and pins or other types of connectors which may be locked at more than one position. The second section 478 is movably connected to the second end 482 of the first section 476. For example, the first section 476 may be a four bar linkage which can be locked in an elevated position to form the gooseneck portion 462, or a lowered position to form a ramp. Any desired trailer hitch such as a gooseneck hitch having a structure known in the art as a "kingpin", for example, may be implemented to connect the gooseneck portion 462 to the truck 36 as will be appreciated by persons of ordinary skill in the art having the benefit of the instant disclosure.

[0062] The second conveyor system 454 can be implemented as any suitable conveyor-belt type transloader or auger, and may be associated with the support base 460 so that the second conveyor system 454 is positioned at least partially in the gap 472 between the support beams 468-1 and 468-2. In another embodiment, the second conveyor system 454 may be pivotably connected to the chassis 452 so as to move oilfield material towards the second end 466 of the chassis 452. In one embodiment, at least a portion of the second conveyor system 454 extends along a centerline of the support base 460 as shown in Figures 9-10. The second conveyor system 454 has a second conveyor 484 and a third conveyor 486. The second conveyor 484 may be recessed in the gap 472 and positioned substantially horizontally such that a top surface of the second conveyor 484 is positioned level with or below a top surface of the support beams 468-1 and 468-2, and is configured to allow an oilfield material transport truck or trailer positioned on the support base 460 to discharge, dump, or otherwise deposit a volume of oilfield material onto the second conveyor 484 and to transport the volume of oilfield material from the first end 464 toward the second end 466 of the support base 460. In some embodiments, the second conveyor 484 may be positioned at a centerline of the support base 460. The third conveyor 486 is positioned between the second conveyor 484 and the second end 466 of the chassis 452 and is configured to receive a volume of oilfield material from the second conveyor 484 and to transport the oilfield material towards the second end 466. As will be appreciated by

persons of ordinary skill in the art, the second conveyor system 454 may include an auger, a conveyor belt with a smooth surface, or with cleated features for oilfield material transfer (e.g., in the third conveyor 486). Further, in some embodiments the second conveyor 484 may be open, and the third conveyor 486 may be enclosed, as will be appreciated by a person of ordinary skill in the art having the benefit of the instant disclosure. The third conveyor 486 may be positioned at an upwardly inclined (non-zero, positive angle) with respect to the second conveyor 484.

[0063] In some embodiments of the present disclosure, second conveyor system 454 may be pivotably connected with the support base 460 and/or the chassis 452 such that the second conveyor system 454 can be pivoted laterally from the support base 460 at any desired angle as shown in Figure 13.

[0064] The erecting mast assembly 456 may include a mast 488 supported by the chassis 452, and an actuator system 490 engaging the mast 488 and the chassis 452. The erecting mast assembly 456 is configured to lay flat onto the support base 460 (e.g., onto the support beams 468-1 and 468-2) when the chassis 452 is transported, and to clear the second conveyor system 454 when the erecting mast assembly 456 is deployed to the upright or vertical operational position. The range of motion of the erecting mast assembly 456 may extend from horizontal to slightly past vertical (e.g., more than a 90 degree range of motion) when deployed to account for angular misalignment due to ground height differences. The erecting mast assembly 456 may be formed from steel tubing, beam, channel, I-beam, H-beam, wide flange, universal beam, rolled steel joist, or any other material.

[0065] The mast 488 may be supported by the support beams 468-1 and 468-2 of the chassis 452 proximate to the second end 466 of the chassis 452. The mast 488 is configured to support the first conveyor assembly 458 and to be moved between a horizontal position (Figure 9) and a vertical position (Figure 10) by the actuator system 490 to raise the first conveyor assembly 458 to the vertical position and to associate the first conveyor assembly 458 with a modular silo as will be described with reference to Figure 13 below.

[0066] The mast 488 may be provided with a frame 492 including a first end 494, a second end 496, a first support beam 498-1 extending between the first end 494 and the second end 496, and a second support beam 498-2 extending between the first end 494

and the second end 496. The first and second support beams 498-1 and 498-2 may be spaced apart in a parallel orientation and configured to jointly support the first conveyor assembly 458 as will be described below.

[0067] The actuator system 490 engages the mast 488 and at least one of the support beams 468-1 and 486-2 of the chassis 452 to move the mast 488 in an arc-shaped path for moving the first conveyor assembly 458 between the horizontal and vertical positions. As shown in Figures 9 and 10, the actuator system 490 may include a plurality of actuators 500-1 and 500-2 working in concert to move the mast 488 from the lateral position to the vertical position. However, it will be understood that the actuator system 490 may be implemented as a single actuator 500 or any number of actuators 500. The actuator(s) 500 may be implemented as hydraulic actuators, pneumatic actuators, electrical actuators, mechanical actuators, or any suitable mechanism capable of moving the mast 488 into the vertical position.

[0068] The first conveyor assembly 458 may be implemented as an enclosed vertical bucket elevator or an auger (e.g., not using airflow to carry the oilfield material), and may include a first conveyor 502 and a support frame 504 which is movably connected to the mast 488 of the erecting mast assembly 456 so that the first conveyor 502 is movable between a horizontal position where the first conveyor 502 lies flat onto the support base 460 during transport, and a vertical position where the first conveyor 502 is oriented vertically for transporting a volume or oilfield material into one or more modular silos. In some embodiments, the first conveyor 502 may be implemented and may function similarly to the vertical conveyor 32 described above.

[0069] As shown in Figure 11, the support frame 504 may be movably connected to the mast 488 via one or more mechanical linkages 506 attached to the mast 488 and one or more actuators 508 configured to slide, or otherwise move the support frame 504 relative to the first end 494 of the mast 488 within a predetermined range. In some embodiments the actuators 508 may be implemented as hydraulic or pneumatic actuators. It is to be understood that the mechanical linkages 506 may be implemented in a variety of manners, such as rails (as shown in Figure 11) hydraulic or pneumatic arms, gears, worm gear jacks, cables, or combinations thereof.

[0070] Referring now to Figures 12-13, the first conveyor 502 may include an inlet 510 and an upper discharge portion 512. The inlet 510 may be positioned proximate to and/or

below the third conveyor 486 of the second conveyor system 454 such that a volume of oilfield material transported via the third conveyor 486 of the second conveyor system 454 enters the first conveyor 502 via the inlet 510.

[0071] The upper discharge portion 512 may include a discharge chute 514 which may be a dual-discharge chute configured to fill two or more modular silos 516 simultaneously, such as by having two or more outlets 517 operably coupled with two or more receiving chutes 518 of the modular silos 516, for example. In some embodiments, the discharge chute 514 may include a built-in diverter valve 520 (e.g., a three-position diverter valve) to allow the discharge chute 514 to fill one, two, or more than two modular silos 516 as will be appreciated by persons of ordinary skill in the art. The discharge chute 514 can interface, or otherwise be coupled with the receiving chutes 518 of the modular silos 516 in any desired manner protected from rain and/or moisture, for example, by including one or more rain-covers or shields.

[0072] As shown in Figure 12, the support frame 504 may include one or more optional silo-engaging members 522, which may be implemented as hooks, L-shaped protrusions, flanges, or combinations thereof, for example. The silo-engaging members 522 may be configured to engage corresponding frame-attachment members 524 formed in the modular silo(s) 516, such that the support frame 504 and the first conveyor 502 may be securely attached, or otherwise associated with the modular silo(s) 516. As will be appreciated by persons of ordinary skill in the art, the silo-engaging members 522 and/or the frame-attachment members 524 may be omitted in some embodiments of the present disclosure.

[0073] Referring back to Figure 9, in some embodiments an optional power supply system 526 may be implemented with the mobile oilfield material transfer unit 450, and may be configured to power the actuator system 490, the first conveyor 502, and the actuators 508. However, in some embodiments the power supply system 526 may be omitted, and the actuator system 490, the first conveyor assembly 458, and the actuators 508 may be powered by any desired power source, such as a power source associated with the modular silos 516, a separate generator, an electrical line connected to a grid or to a local power source, and combinations thereof. In some embodiments where the power supply system 526 is provided with the mobile oilfield material transfer unit 450, the power supply system 526 is desirably sized and positioned onto the support base 460 so as to not interfere with

the operation and movement of the erecting mast assembly 456 and the second conveyor system 454.

[0074] Referring now to Figure 14, in operation a mobile oilfield material transfer unit 450 may function as follows: the truck 36 backs up the chassis 452 proximate to one or more modular silo 516 (e.g., a cooperating unit of two or more modular silos 516). When the truck 36 has been disconnected from chassis 452, the gooseneck portion 462 may be manipulated to lie on the ground and be generally co-planar with the support base 460 to form a ramp to allow an oilfield material transport trailer 528 to be driven over or backed onto the support base 460. The erecting mast assembly 456 is raised to the vertical position so as to raise the first conveyor assembly 458 to the vertical position as well. The actuators 508 may be operated to raise the first conveyor 502 to the upper limit of the predetermined range of movement of the actuators 508, by moving the support frame 504 relative to the first end 494 of the mast 488 (e.g., along the mechanical linkage 506). The position of the chassis 452 relative to the modular silo(s) 516 may be adjusted as needed (e.g., in three-dimensions, such as by moving the chassis 452, by docking or otherwise aligning the second end 466 of the chassis 452 with the modular silo(s) 516, and/or by collapsing a suspension of the chassis 452 to position the discharge chute 514 to engage with the receiving chutes 518. The actuators 508 may be operated to lower the first conveyor 502 over the modular silo(s) 516 such that the discharge chute 514 engages the receiving chutes 518. Optionally, lowering the first conveyor 502 may also cause the silo-engaging members 522 to engage with the corresponding frame-attachment members 524, such that the support frame 504 of the first conveyor assembly 458 is securely attached, or otherwise associated with the modular silo(s) 516 causing the discharge chutes 514 to be aligned with the receiving chutes 518 of the modular silo(s).

[0075] The oilfield material transport trailer 528 may be backed over the chassis 452, such that discharge openings (not shown) of the oilfield material transport trailer 528 are positioned over and vertically aligned with the second conveyor 484 of the second conveyor system 454. As a volume of oilfield material is dumped, discharged, or otherwise deposited (e.g., under gravity) on the second conveyor system 454, the oilfield material is moved by the second conveyor 484 towards the third conveyor 486. The third conveyor 486 is optional in that the second conveyor 484 may convey the oilfield material directly to the first conveyor 502. The third conveyor 486 continues moving the volume of oilfield material towards the second end 466 of the chassis 452. Once the volume of oilfield material reaches the first

conveyor 502, the oilfield material enters the inlet 510 of the first conveyor 502. The volume of oilfield material is carried upward by the first conveyor 502 and is deposited into the modular silos 516 via the discharge chute 514 and the receiving chutes 518.

[0076] In some embodiments of the present disclosure, the second conveyor system 454 may be pivoted laterally from the support base 460 at any desired angle, and the oilfield material transport trailer 528 may be positioned over the second conveyor system 454 without being backed over the chassis 452 as shown in Figure 13, as will be appreciated by persons of ordinary skill in the art having the benefit of the present disclosure.

[0077] Referring now to Figure 15, in another embodiment, the second conveyor system 454 includes a pivoting conveyor assembly 530 rather than the discharge chute 514. The pivoting conveyor assembly 530 includes a conveyor 532 that may be attached to a housing and/or support frame extending around the first conveyor 502 with a horizontal adjustment assembly and a vertical adjustment assembly. The horizontal adjustment assembly may include a mechanical linkage with one pivot connection or multiple pivot connections working in concert to provide a range of motion of the conveyor 532 in a horizontal path that may be approximately within a range from 0 degrees to 180 degrees as shown by an arrow 534. The conveyor assembly 530 may also include a vertical adjustment assembly (not shown) including a mechanical linkage to provide a range of motion of the conveyor 532 in a horizontal path that may be within a range from 0 degrees to 120 degrees as shown by an arrow 536. The horizontal and vertical adjustment assemblies may include one or more actuators to effect controlled motion in the horizontal and vertical paths discussed above.

[0078] The horizontal and vertical adjustment assemblies provides movement between a stowed position where the conveyor 532 extends substantially parallel to the first conveyor 502, and an extended position where the conveyor 532 extends laterally away from the first conveyor 502. The conveyor 532 may be implemented as an auger, or an enclosed two-way conveyor belt in some embodiments of the present disclosure, and may be pivoted by one or more actuators (not shown). The conveyor 532 may function similarly to the discharge chute 514, and may be coupled with one or more receiving chutes 518 of the modular silo(s) 516 similarly to the discharge chute 514. For example, the conveyor 532 may be coupled with one or more of the receiving chutes 518 in a manner protecting the receiving chutes 518 from rain or moisture, such as via one or more rain covers or shields, for example. As will be appreciated by persons of ordinary skill in the art, the pivoting conveyor assembly

530 allows the chassis 452 to be positioned at any desired angle, orientation, or position relative to the modular silo(s) 516, such as parallel, angled, or perpendicular, for example. Further, when the pivoting conveyor assembly 530 is implemented, the support frame 504 may or may not be attached to the silo(s) via the silo-engaging members 522.

[0079] As will be appreciated by persons of ordinary skill in the art having the benefit of the present disclosure, a mobile oilfield material transfer unit 450 according to embodiments of the present disclosure utilizes a first conveyor which is external from the silos, and is transported to any desired location and coupled with one or more silos in situ. Further, the chassis 452 or a mobile oilfield material transfer unit 450 according to the inventive concepts disclosed herein forms a ramp allowing oilfield material transport trailers 528 to be backed onto the chassis 452 and deposit oilfield material onto the second conveyor system 454 of the mobile oilfield material transfer unit 450. The mobile oilfield material transfer unit 450 may allow for flexible positioning and for quick and efficient transfer of oilfield material into modular silos 516 on location. Further, removing the vertical conveyor from the silo (e.g., the first conveyor being external to the silo) increases available silo volume. It is to be understood, however, that in some embodiments, an external first conveyor as disclosed herein may be used with modular silos including internal vertical elevators, for example.

[0080] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

CLAIMS

What is claimed is:

1. A system for handling oilfield materials, comprising:
a plurality of modular silos, each modular silo being sized for over-the-road transport by a trailer, each modular silo having an outer housing surrounding an enclosed interior for holding an oilfield material and a feeder through which the oilfield material is discharged from the enclosed interior, the feeders of at least two of the modular silos of the plurality of modular silos being oriented to deliver the oilfield material to a common area for blending, the common area located below the outer housings, and the outer housings overlapping the common area, each modular silo further comprising a vertical conveyor system to deliver the oilfield material into the enclosed interior.
2. The system as recited in claim 1, wherein the vertical conveyor system comprises at least one of a bucket elevator and a screw auger.
3. The system as recited in claim 1, wherein the vertical conveyor system includes a pneumatic fill tube.
4. The system as recited in claim 1, wherein at least one of the modular silos has a plurality of compartments within the enclosed interior for holding different types of oilfield materials.
5. The system as recited in claim 1, wherein each of the modular silos has a plurality of compartments within the enclosed interior for holding different types of oilfield materials.
6. The system as recited in claim 1, wherein the plurality of modular silos comprises four silos coupled together.
7. The system as recited in claim 1, further comprising a support structure, the plurality of modular silos being releasably mounted to the support structure.

8. The system as recited in claim 7, wherein the support structure supports the feeders at a sufficient height above the common area to allow a truck mounted portable blending system to be moved under the feeders.
9. The system as recited in claim 1, further comprising a belt conveyor positioned to deliver the oilfield material to the lower end hopper from an unload area, the belt conveyor having a horizontal portion overlapping with an inclined portion, the horizontal portion positioned in the unload area and having a length in a range from 8 (2.4384 meters) feet to 51 (15.5448 meters) feet, and a height above the ground less than 12 inches and sufficient to permit a truck to back over the horizontal portion.
10. The system of claim 9, wherein the horizontal portion has a height in a range from 6 inches to 8 inches.
11. The system as recited in claim 9, wherein the inclined portion of the belt conveyor is enclosed from the unload area to the lower end hopper.
12. The system as recited in claim 1, wherein the plurality of modular silos include a first modular silo and a second modular silo, the outer housing of the first modular silo having a first housing side, and the outer housing of the second modular silo having a first housing side, the first housing sides of the first and second modular silos being adjacent to one another, and wherein the feeders of the first and second modular silos are adjacent to the first housing sides of the first and second modular silos.
13. The system as recited in claim 12, wherein the feeder of the first modular silo is spaced a first distance less than six (1.8288 meters) feet from the first housing side of the first modular silo.
14. The system as recited in claim 12, wherein the outer housing has a substantially rectangular configuration defining four corners, and wherein the feeder of the first modular silo is adjacent to one of the corners and within a quadrant defined by the outer housing.

15. The system as recited in claim 1, wherein the vertical conveyor system of the first silo has a first centerline extending from a lower portion of the outer housing to an upper portion of the outer housing, and the first housing side of the first modular silo has a second centerline extending from the lower portion to the upper portion of the housing, and wherein the first centerline is horizontally offset from the second centerline at the upper portion of the outer housing.
16. The system as recited in claim 15, wherein the first centerline is canted at an angle less than 5 degrees to parallel with the second centerline.
17. The system as recited in claim 15, wherein the first centerline is horizontally offset from the second centerline between two (0.6096 meters) feet and seven (2.1336 meters) feet at the upper portion of the outer housing.
18. A method for handling oilfield material, comprising:
 - providing a plurality of modular silos, each modular silo having an outer housing surrounding an enclosed interior for holding the oilfield material;
 - connecting the plurality of modular silos to a support structure;
 - loading the oilfield material into the enclosed interiors of the plurality of modular silos with at least one vertical conveyor; and
 - delivering the oilfield material from at least two of the plurality of modular silos to a common area for blending, the common area located below the outer housings and the outer housings overlapping the common area.
19. The method as recited in claim 18, wherein providing comprises providing at least one of the modular silos with a compartmentalized, enclosed interior to hold different types of oilfield materials.
20. The method as recited in claim 18, further comprising placing a hopper of a blending system within the common area and below feeders of the at least two of the plurality of modular silos, the blending system having a blender located below an outlet of the hopper, and wherein the step of delivering the oilfield material includes metering the oilfield material into the blender by maintaining gates of the feeders in a fixed open

condition while regulating a metering gate of the hopper in real-time to control an amount of oilfield material to be blended by the blender..

21. The method as recited in claim 18, wherein loading the plurality of modular silos comprises loading each modular silo with a corresponding vertical conveyor located in that silo.
22. The method as recited in claim 18, wherein loading comprises using a bucket elevator.
23. The method as recited in claim 18, wherein delivering comprises delivering the oilfield material into a truck mounted blending system via gravity feed.
24. A system for handling oilfield materials, comprising:
 - a modular silo, comprising:
 - an outer housing defining an enclosed interior, the outer housing have a lower portion and an upper portion, the outer housing having first and second centerlines extending from the lower portion to the upper portion of the housing and dividing the enclosed interior generally into quadrants, the outer housing also having an inlet located at the upper portion of the outer housing; and
 - a feeder located at the lower portion and being encompassed within a first quadrant of the quadrants.
25. The system as recited in claim 24, wherein the outer housing has a bottom located at the lower portion thereof, the bottom having an outlet encompassed within the first quadrant, and wherein the feeder is connected to the bottom of the modular silo and communicates with the outlet.
26. The system as recited in claim 24, wherein the first centerline divides the outer housing into a first half and a second half with the first quadrant encompassed within the first half, and further comprising a vertical conveyor mounted to the outer housing and extending from the lower portion to the upper portion, the vertical conveyor within a second quadrant of the quadrants positioned adjacent to the first quadrant and within the first half.

27. The system as recited in claim 26, wherein the vertical conveyor has a lower end hopper, and further comprising a belt conveyor positioned to deliver the oilfield material to the lower end hopper from an unload area, the belt conveyor having a horizontal portion overlapping with an inclined portion, the horizontal portion positioned in the unload area and having a length in a range from 8 (2.4384 meters) feet to 51 (15.5448 meters) feet, and a height above the ground less than 12 inches sufficient to permit a truck to back over the horizontal portion.
28. A system for handling oilfield materials, comprising:
a modular silo, comprising:
an outer housing defining an enclosed interior, the outer housing have a lower portion and an upper portion, the outer housing having a first vertical centerline extending from the lower portion to the upper portion of the housing, the outer housing also having an inlet located at the upper portion of the outer housing; and
a bucket elevator extending from the lower portion of the outer housing to the upper portion of the outer housing, the bucket elevator having a second vertical centerline that is offset from the first centerline.
29. The system of claim 28, wherein the outer housing has a top, and wherein the bucket elevator extends between one inch and fifteen (4.572 meters) feet beyond the top of the outer housing.
30. The system of claim 28, wherein the second vertical centerline extends non-parallel with the first vertical centerline and within 5 degrees of parallel to the first centerline to provide the offset from the first centerline.
31. The system of claim 28, wherein the second vertical centerline is horizontally offset between two (0.6096 meters) feet and seven (2.1336 meters) feet from the first centerline.
32. The system of claim 28, wherein the outer housing has a substantially rectangular shape defining four corners, and wherein the outer housing has a third vertical centerline extending from the lower portion to the upper portion of the housing such that the first and third vertical

centerlines divide the housing into quadrants, and wherein the bucket elevator is adjacent to one of the corners and encompassed within one of the quadrants.

33. A method for delivering oilfield material to a wellsite, comprising the steps of:
backing a trailer containing the oilfield material over a horizontal portion of a conveyor such that multiple outlets of the trailer are positioned over the horizontal portion of the conveyor; and
simultaneously delivering the oilfield material through the outlets of the trailer onto the horizontal portion of the conveyor.
34. The method of claim 33, wherein the oilfield material is a proppant material.
35. A mobile oilfield material transfer unit, comprising:
a chassis having a first end, a second end, at least one support beam extending between the first end and the second end, and two or more wheels operably coupled with the at least one support beam for movably supporting the at least one support beam;
an erecting mast assembly including a mast movably connected with the chassis proximate to the second end, and an actuator system coupled with the mast and with the chassis for moving the mast between a horizontal position and a vertical position; and
a first conveyor assembly including a support frame coupled with the mast and moveable between the horizontal position and the vertical position, the first conveyor assembly including a first conveyor coupled with the support frame, an inlet, and an upper discharge portion, the first conveyor adapted to move a volume of oilfield material from the inlet to the upper discharge portion.
36. The mobile oilfield material transfer unit of claim 35, wherein the at least one support beam further comprises a first support beam and a second support beam extending between the first end and the second end and being separated by a gap.
37. The mobile oilfield material transfer unit of claim 36, further comprising a second conveyor system including a second conveyor configured to move oilfield material toward the second end of the chassis, the second conveyor system at least partially positioned in the gap.

38. The mobile oilfield material transfer unit of claim 37, wherein the second conveyor system further comprises a third conveyor positioned between the first and second conveyors, and wherein the inlet of the first conveyor is below and proximate to a discharge of the third conveyor of the second conveyor system.

39. The mobile oilfield material transfer unit of claim 35, wherein the first conveyor assembly further comprises a discharge chute coupled with the upper discharge portion of the first conveyor.

40. The mobile oilfield material transfer unit of claim 39, wherein the discharge chute comprises a first outlet and a second outlet and a diverter valve for selectively directing the volume of oilfield material through at least one of the first and second outlet.

41. The mobile oilfield material transfer unit of claim 35, wherein the first conveyor assembly further comprises a pivoting conveyor assembly movably associated with the upper discharge portion.

42. The mobile oilfield material transfer unit of claim 41, wherein the support frame is movably coupled with the mast and further comprises at least one actuator for moving the support frame relative to the mast.

43. The mobile oilfield material transfer unit of claim 35, wherein the support frame further comprises one or more silo-engaging members shaped to connect with a predetermined portion of a silo.

44. The mobile oilfield material transfer unit of claim 35, further comprising a second conveyor system pivotably connected to the chassis so as to move oilfield material towards the second end of the chassis.

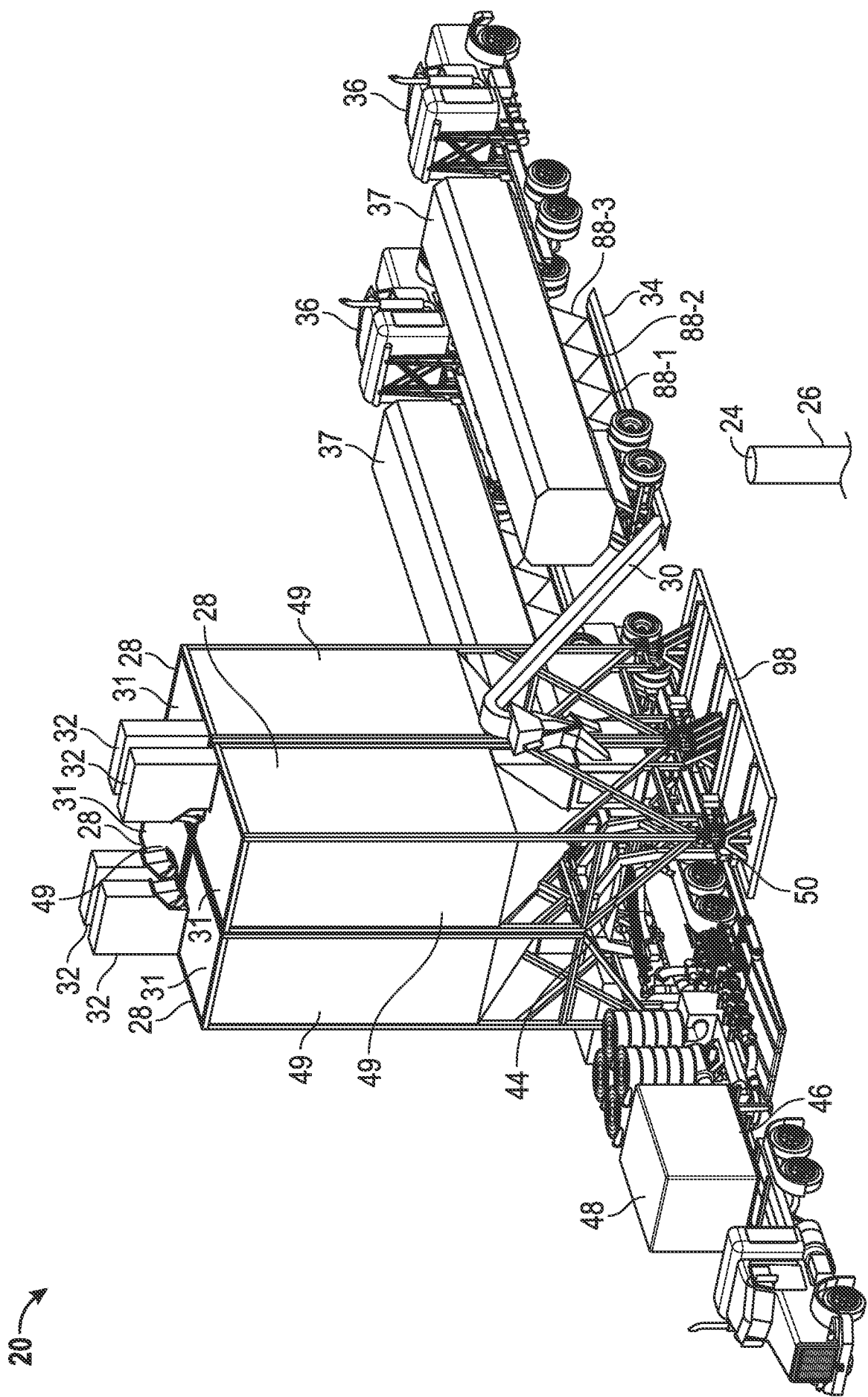
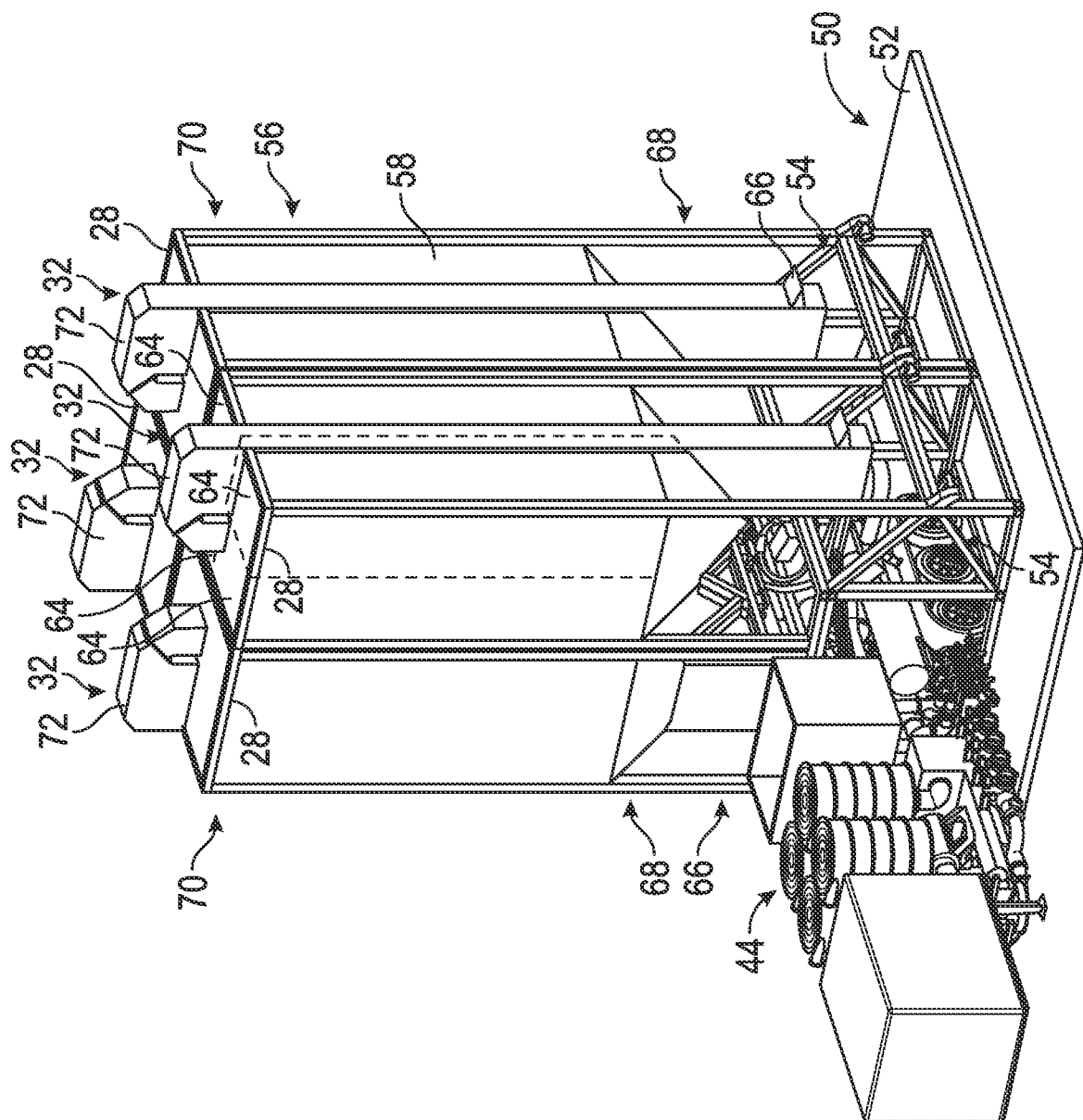
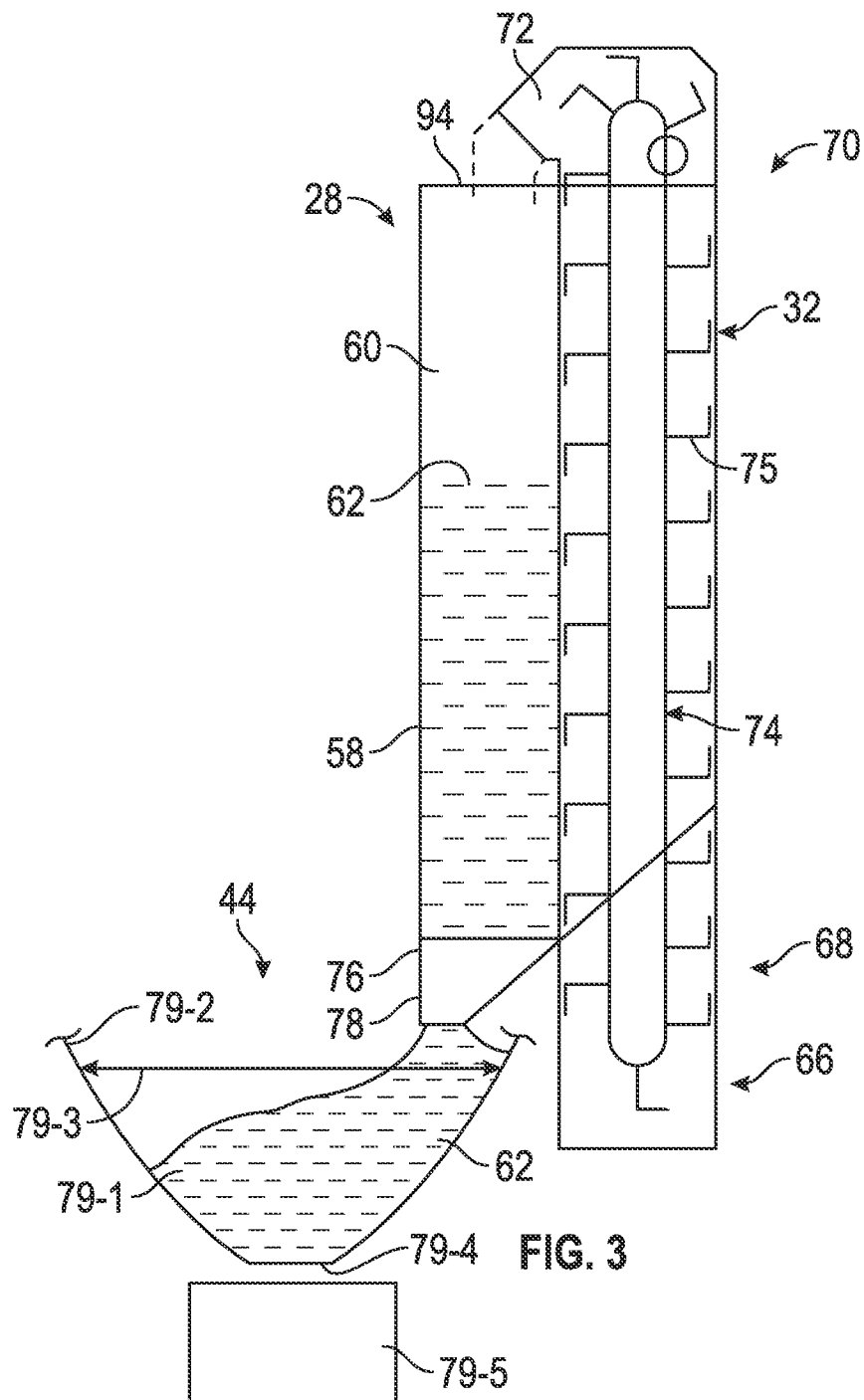
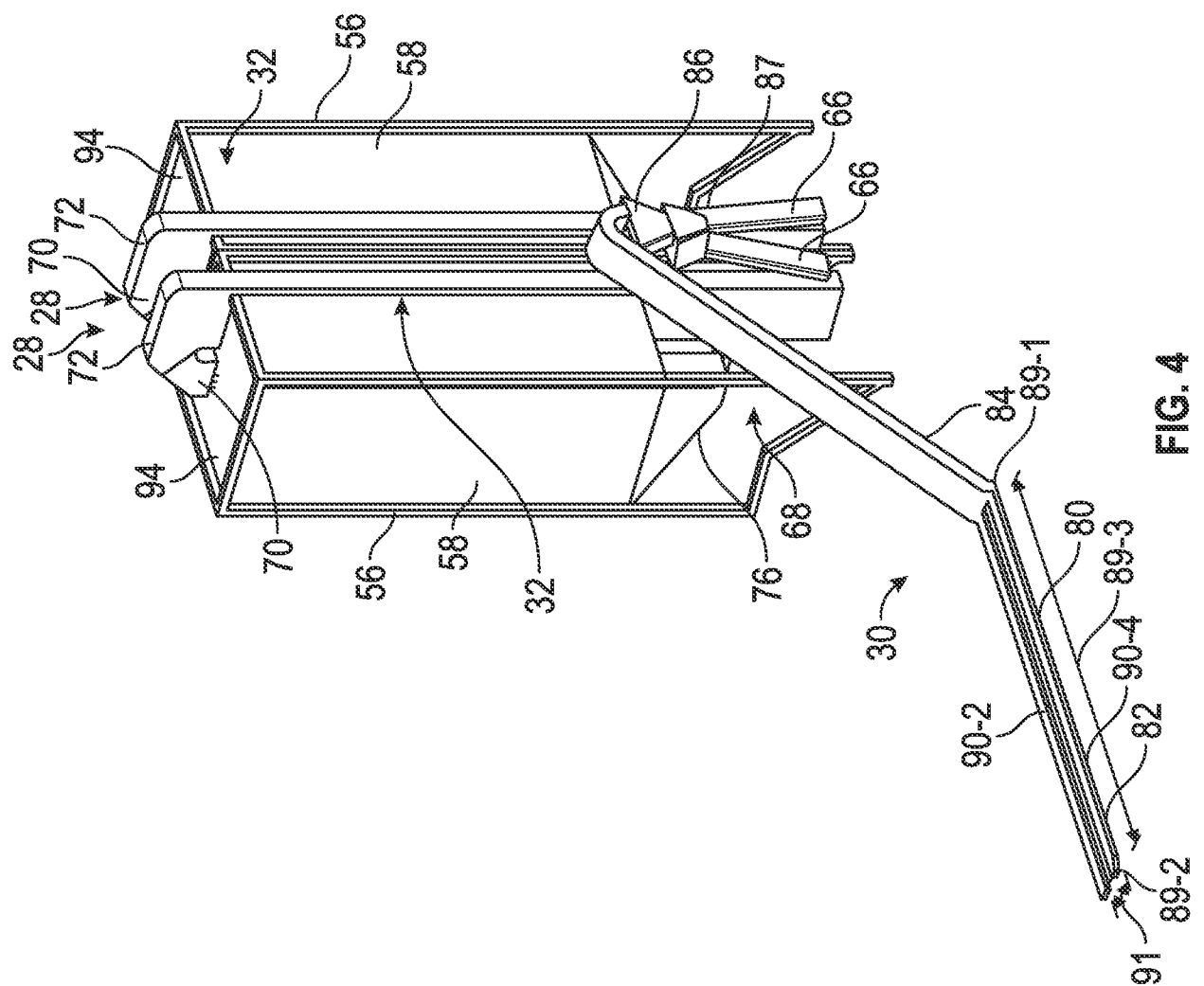


FIG. 1



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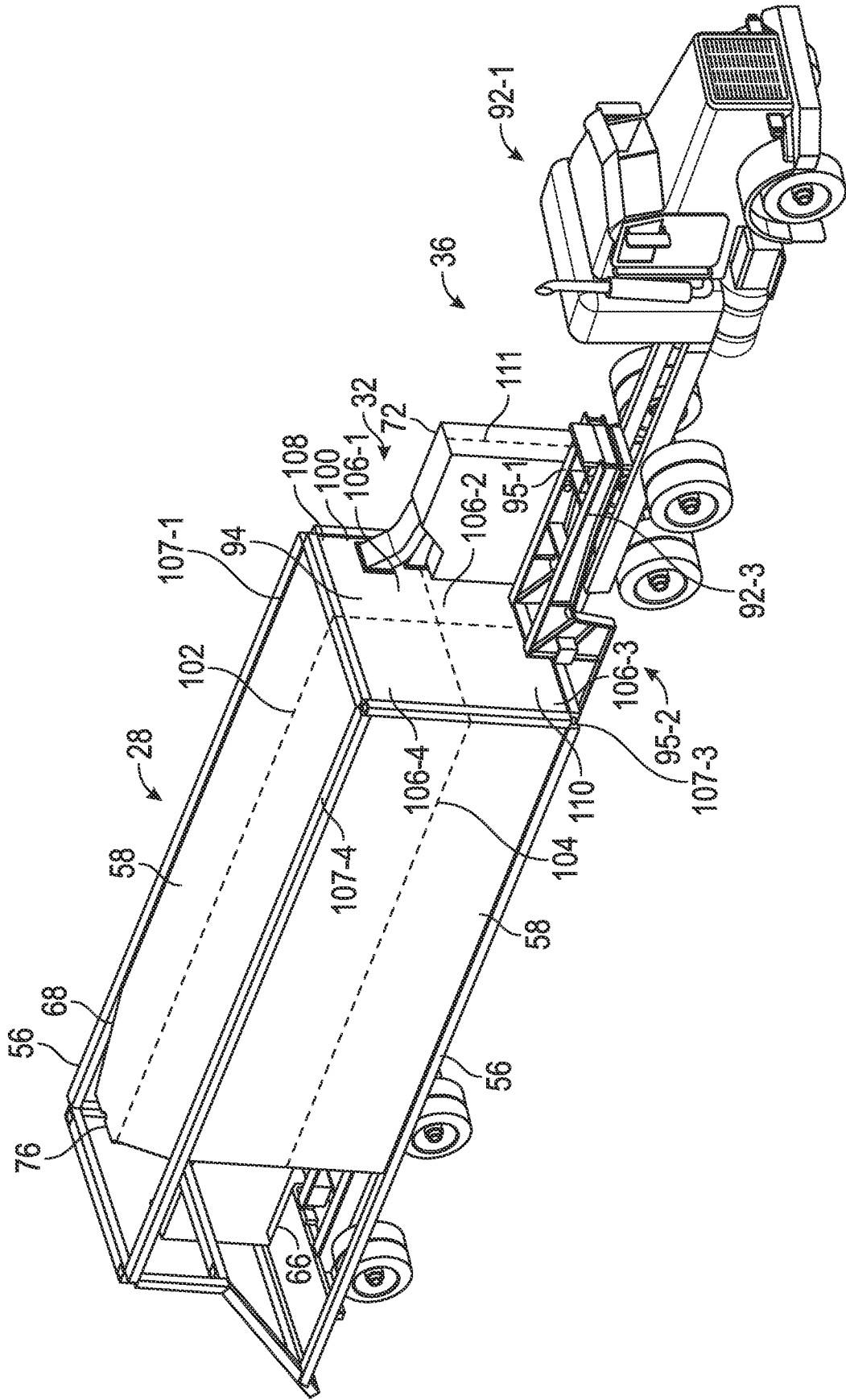


FIG. 5

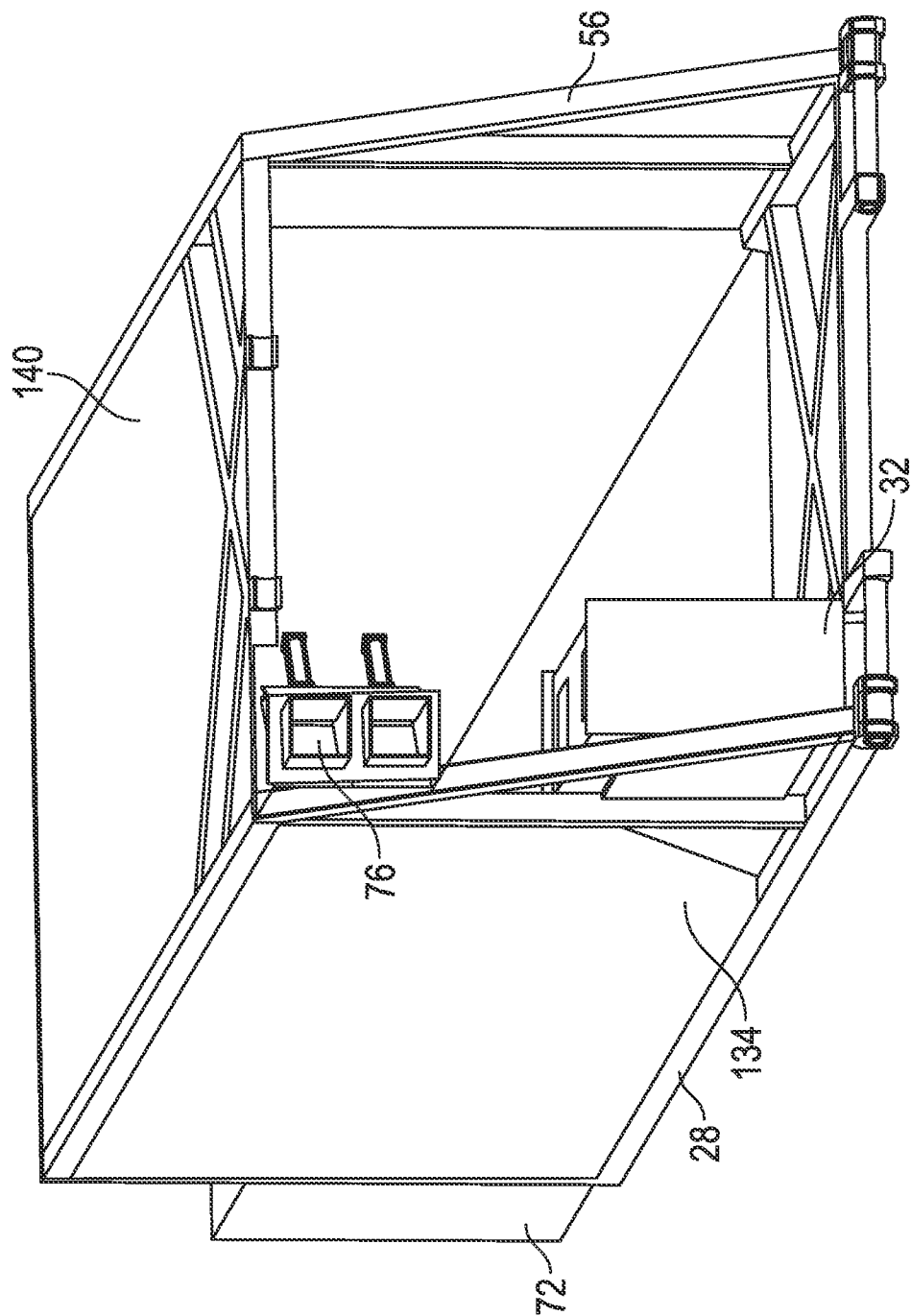


FIG. 6

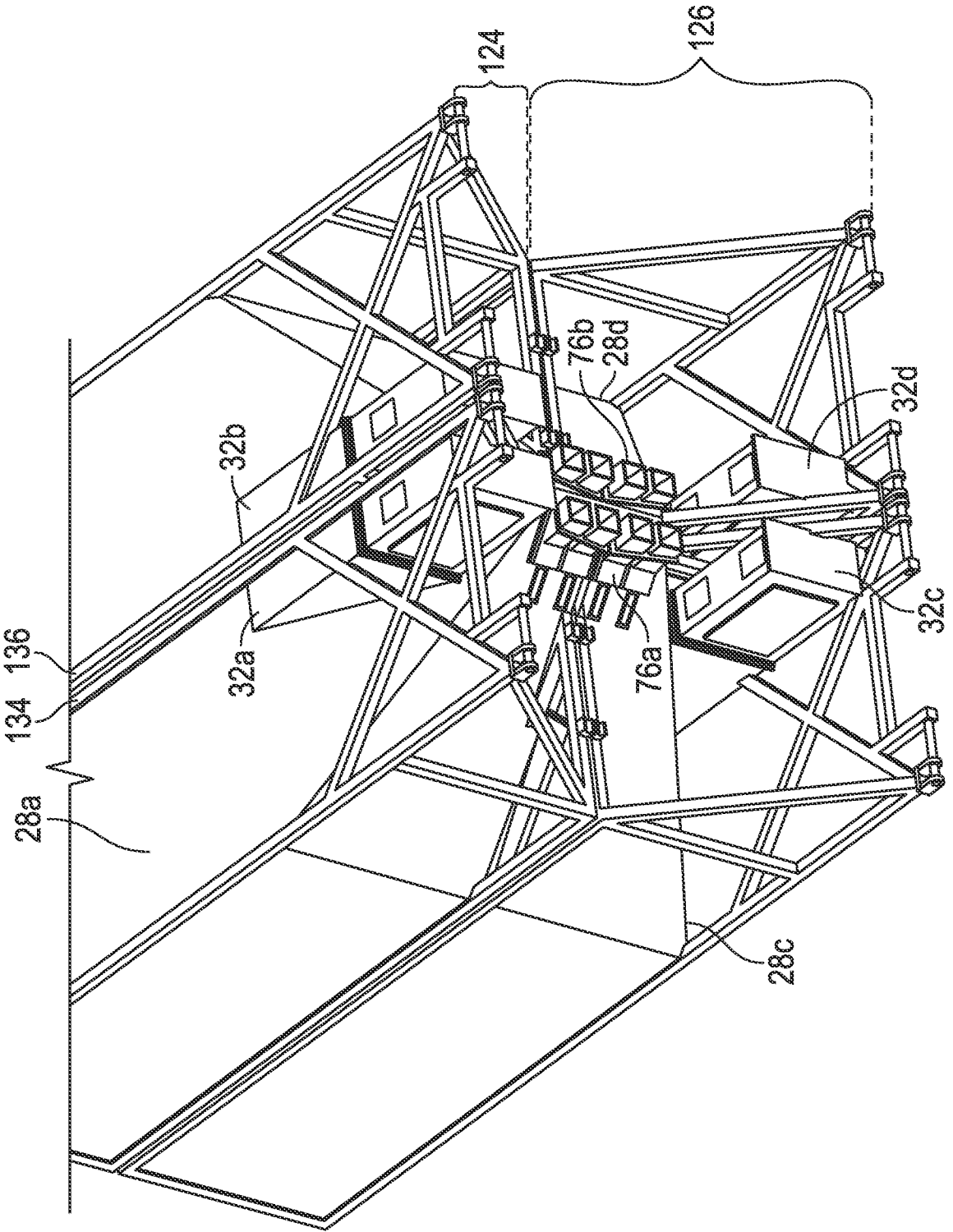


FIG. 7

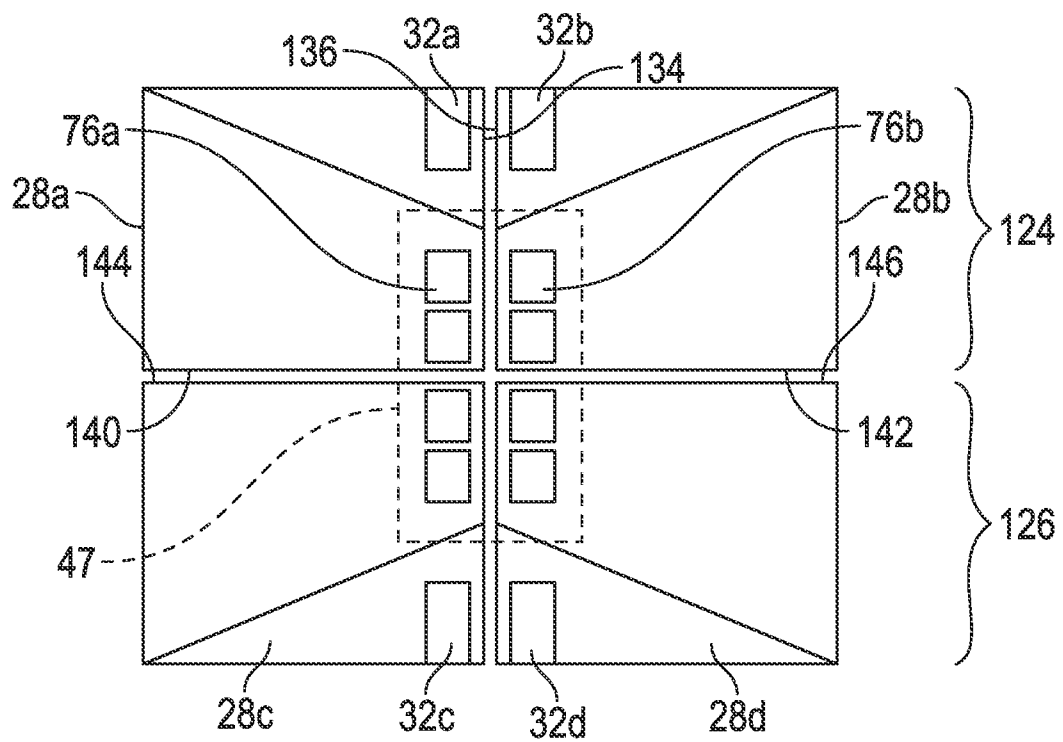
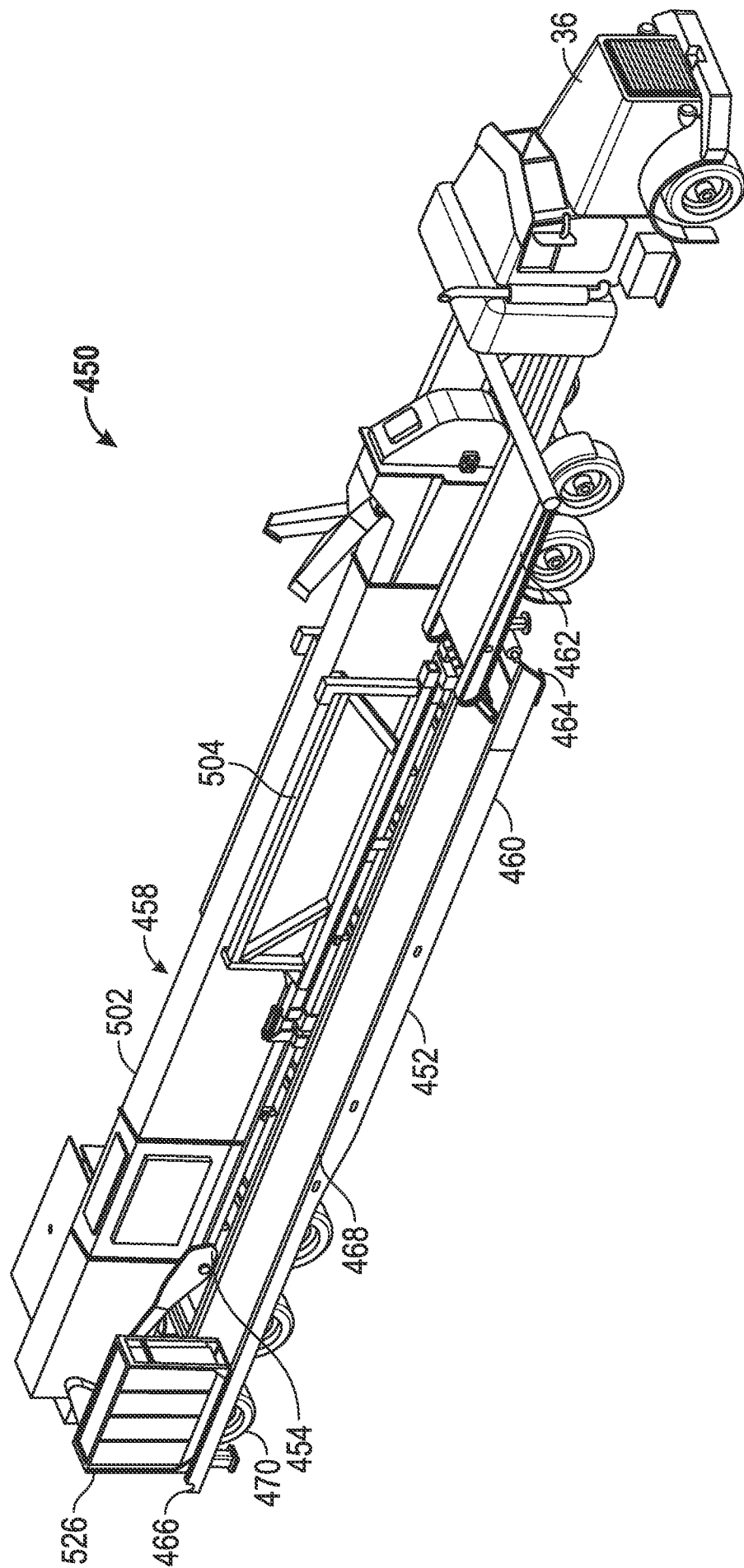


FIG. 8





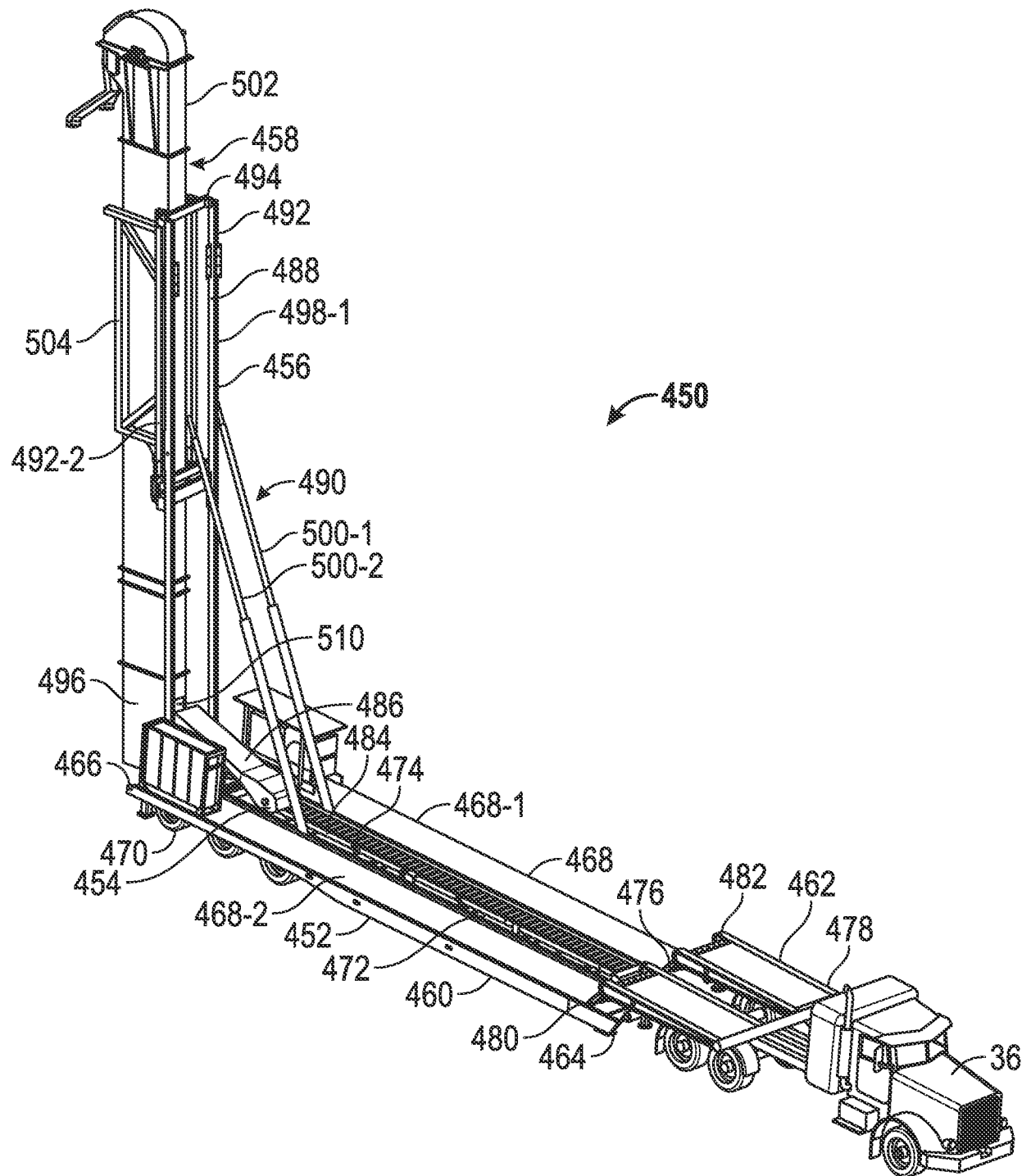


FIG. 10

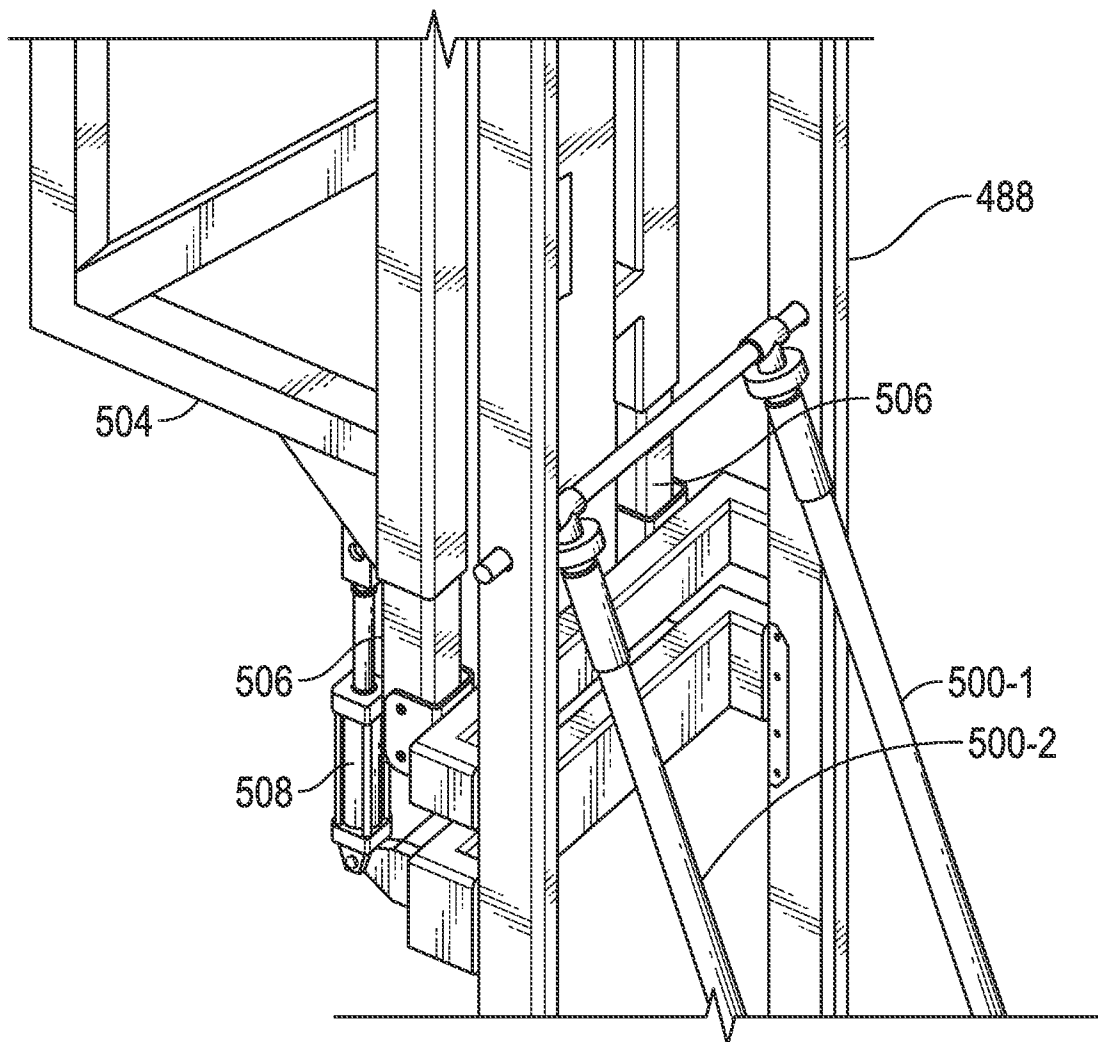


FIG. 11

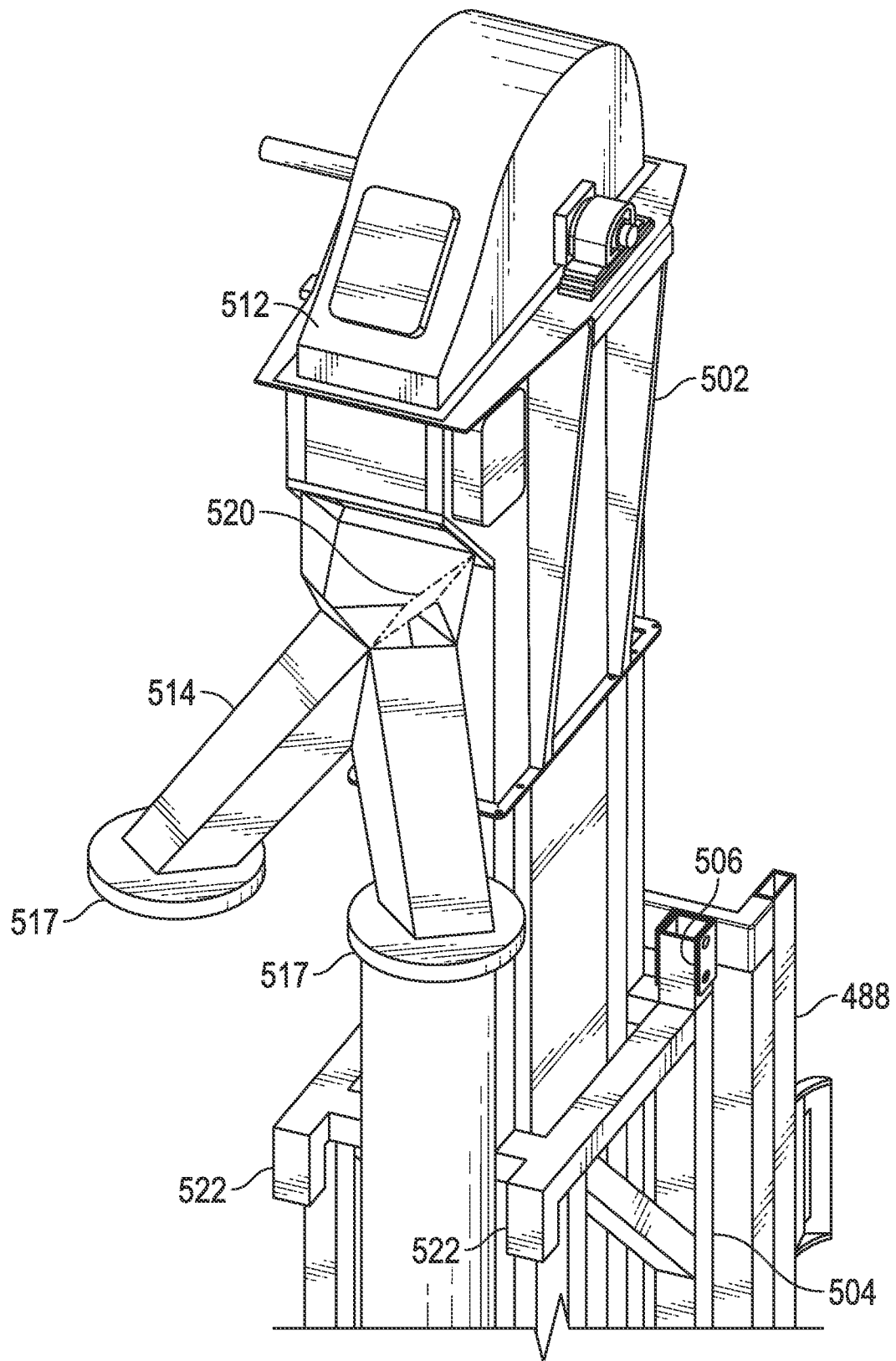


FIG. 12

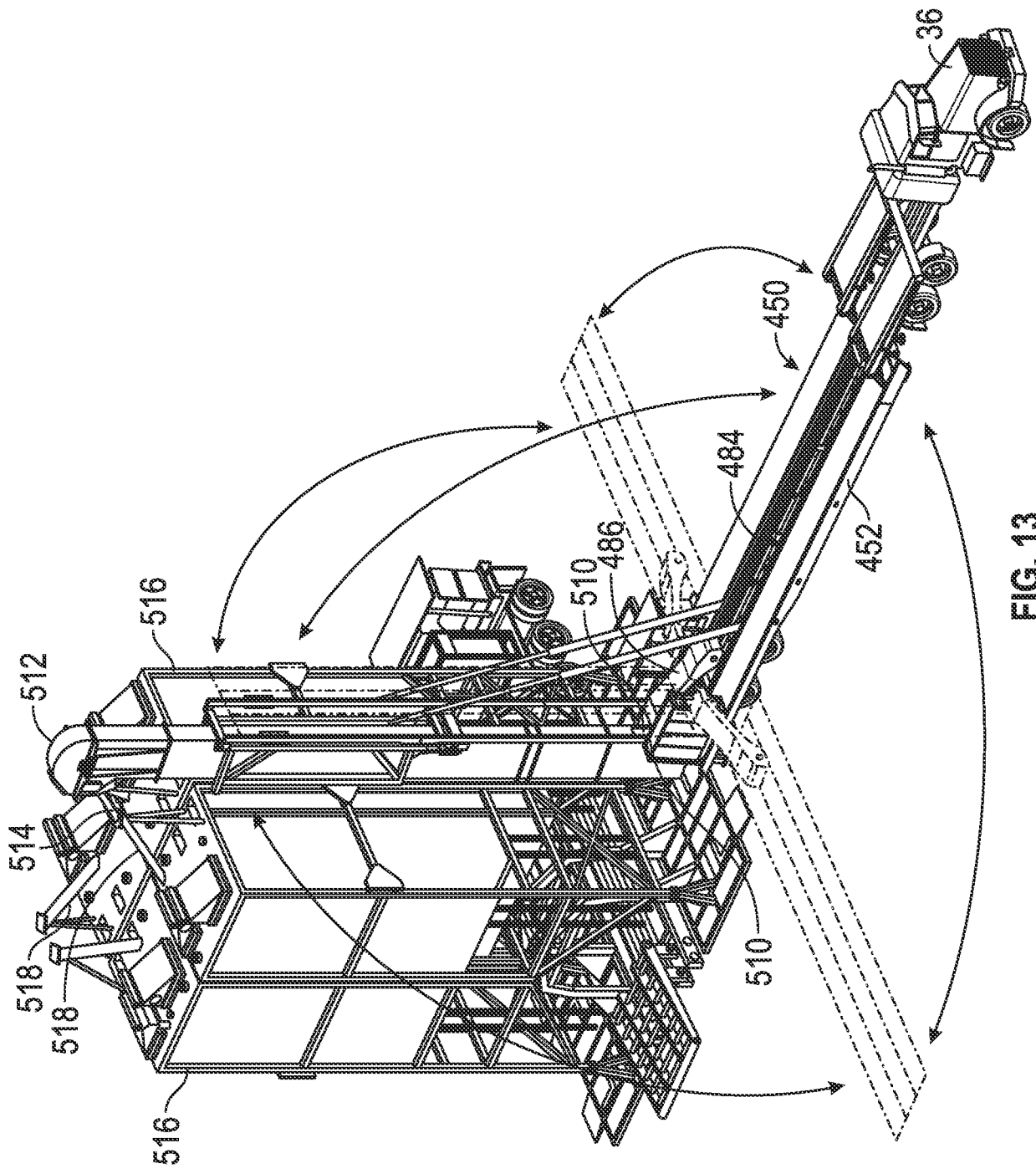


FIG. 13

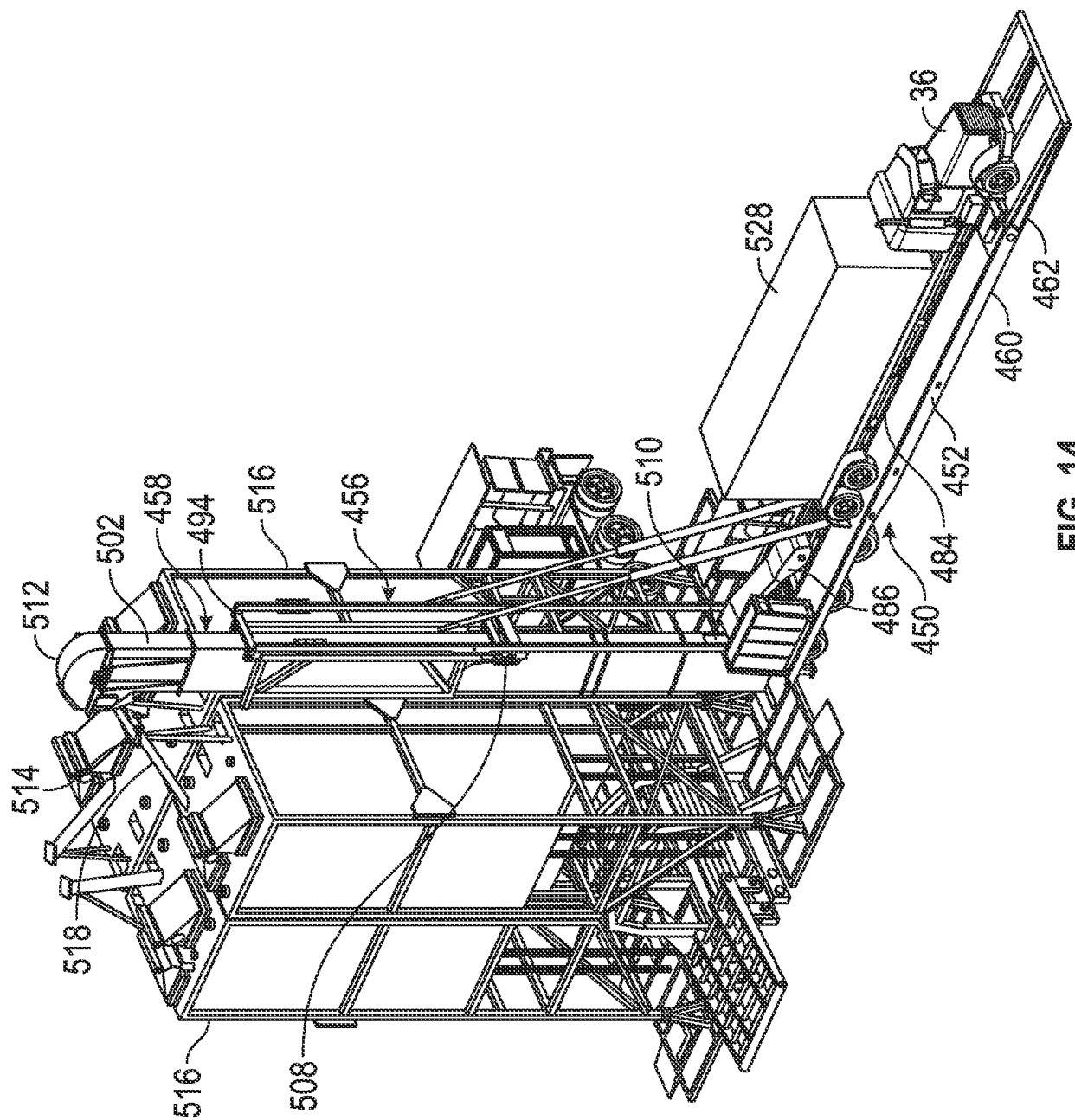
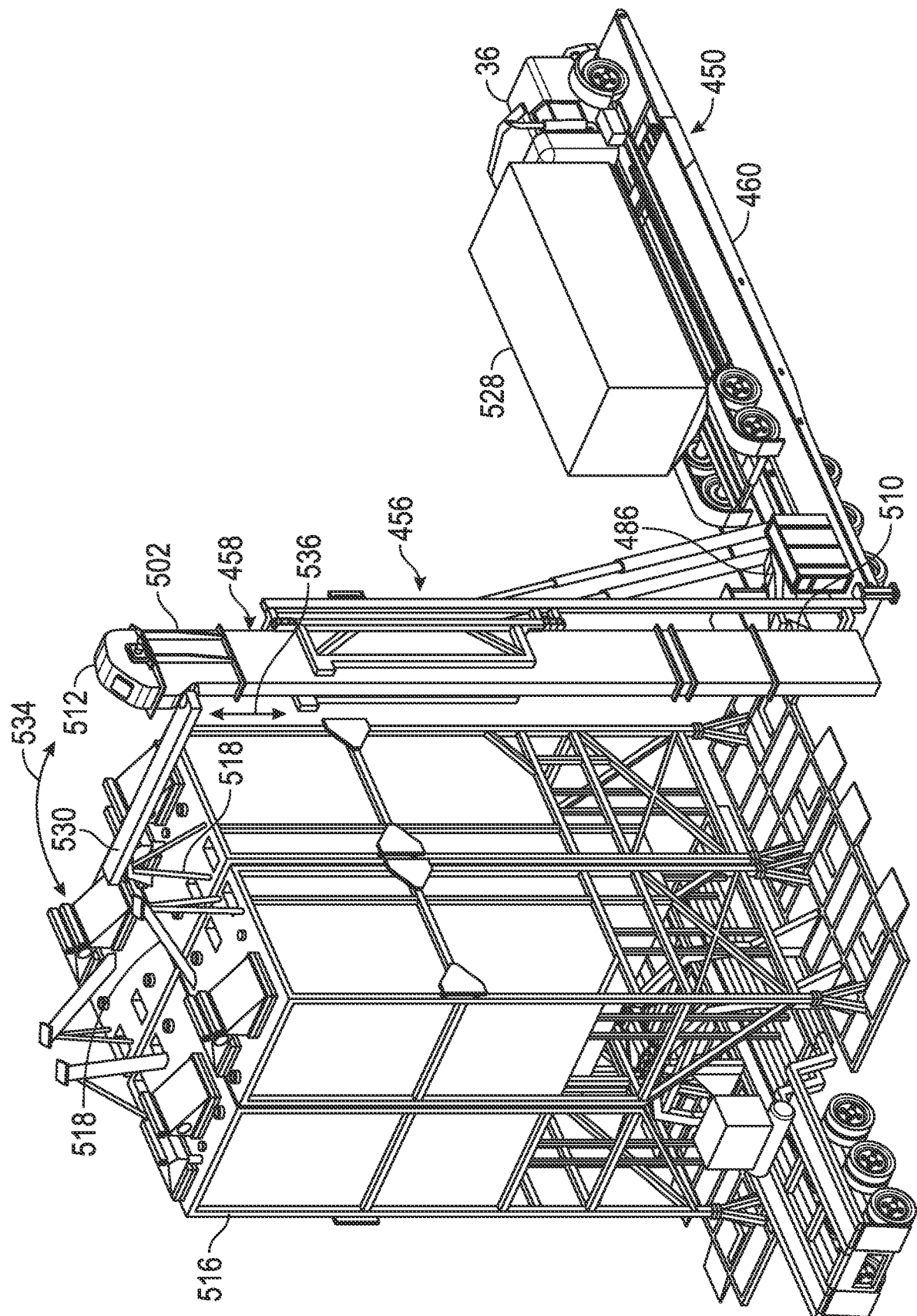


FIG. 14



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/054283**A. CLASSIFICATION OF SUBJECT MATTER****E21B 43/17(2006.01)i, E21B 7/02(2006.01)i, E21B 43/14(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 43/17; B65G 57/14; B65D 88/32; F17D 1/00; E21B 43/267; E21B 21/01; E21B 43/26; G05D 11/02; E21B 7/02; E21B 43/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: delivery, oilfield, silo, trailer, and conveyor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0243255 A1 (LUHARUKA et al.) 30 September 2010 See paragraphs [0014]-[0020], [0049]-[0058], [0080]-[0085] and figures 2, 8.	1-44
A	US 2008-0008562 A1 (BECKEL et al.) 10 January 2008 See paragraphs [0013]-[0027] and figures 2-3.	1-44
A	US 2010-0243251 A1 (LUHARUKA et al.) 30 September 2010 See paragraphs [0018]-[0027] and figures 8-9.	1-44
A	US 2011-0063942 A1 (HAGAN et al.) 17 March 2011 See paragraphs [0015]-[0018] and figure 3.	1-44
A	WO 2011-088493 A1 (TYCO FLOW SERVICES AG.) 28 July 2011 See page 2, line 10 - page 5, line 15 and figure 1.	1-44



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

25 October 2013 (25.10.2013)

Date of mailing of the international search report

25 October 2013 (25.10.2013)

Name and mailing address of the ISA/KR

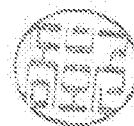
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