



(51) International Patent Classification:

E21B 43/26 (2006.01) *E21B 43/27* (2006.01)
E21B 43/25 (2006.01) *E21B 43/28* (2006.01)

(21) International Application Number:

PCT/US2016/039793

(22) International Filing Date:

28 June 2016 (28.06.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

14/754,308 29 June 2015 (29.06.2015) US

(71) Applicant: CAMERON INTERNATIONAL CORPORATION [US/US]; 1333 West Loop South, Suite 1700, Houston, Texas 77027 (US).

(72) Inventors: ROESNER, Thomas G.; Cameron International Corporation, 3505 W. Sam Houston Parkway N., Houston, Texas 77043 (US). OPITZ, Joseph O.; Cameron International Corporation, 1660 Lincoln St., Ste 1400, Denver, Colorado 80264 (US). HOGG, Anthony L.; Cameron International Corporation, 3505 W. Sam Houston Parkway N., Houston, Texas 77043 (US). COTTON, Craig L.;

Cameron International Corporation, 3505 W. Sam Houston Parkway N., Houston, Texas 77043 (US).

(74) Agent: EUBANKS IV, L. Lee; Eubanks PLLC, 9720 Cypresswood Dr., Suite 242, Houston, Texas 77070 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR DISTRIBUTING FLUIDS TO A WELLBORE

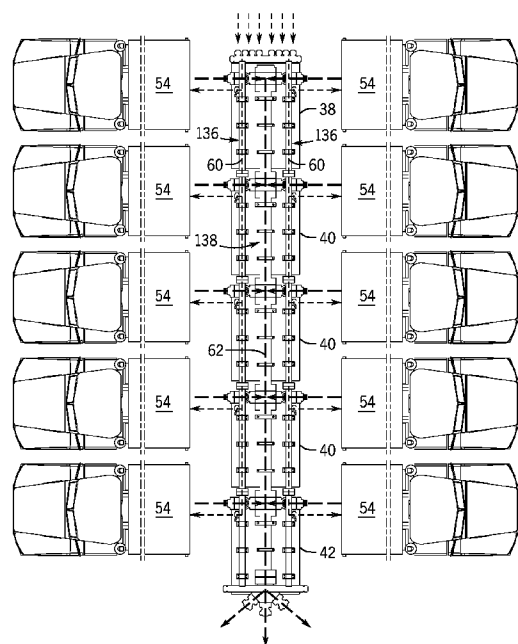


FIG. 10

(57) Abstract: An apparatus for distributing fluids to a well. In one embodiment, the apparatus includes a well stimulation fluid delivery system (10) having an intake connection (90) for receiving well stimulation fluid and a first conduit (136) configured to route the well stimulation fluid from the intake connection to multiple outlet connections (84) configured to be coupled to pumps (54) for increasing the pressure of the well stimulation fluid. A second conduit (138) of the apparatus is configured to receive the well stimulation fluid from the pumps, via multiple inlet connections (94) configured to be coupled to the pumps, and to route the well stimulation fluid to a discharge connection (124, 128). The apparatus also includes individual skids (38, 40, 42) including platforms (76, 104, 114) on which fluid conduit segments are mounted. The individual skids are coupled to one another via their mounted fluid conduit segments to form the first conduit and the second conduit.



SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG). **Published:**

— *with international search report (Art. 21(3))*

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

APPARATUS AND METHOD FOR DISTRIBUTING FLUIDS TO A WELLBORE

BACKGROUND

[0001] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the presently described embodiments. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present embodiments. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0002] In order to meet consumer and industrial demand for natural resources, companies often invest significant amounts of time and money in searching for and extracting oil, natural gas, and other subterranean resources from the earth. Particularly, once a desired subterranean resource is discovered, drilling and production systems are often employed to access and extract the resource. These systems may be located onshore or offshore depending on the location of a desired resource. Further, such systems generally include a wellhead assembly through which the resource is extracted. These wellhead assemblies may include a wide variety of components, such as various casings, valves, fluid conduits, and the like, that control drilling or extraction operations.

[0003] Additionally, such wellhead assemblies may use fracturing trees and other components to facilitate a fracturing process and enhance production from wells. As will be appreciated, resources such as oil and natural gas are generally extracted from fissures or other cavities formed in various subterranean rock formations or strata. To facilitate extraction of such a resource, a well may be subjected to a fracturing process that creates one or more man-made fractures in a rock formation. This facilitates, for example, coupling of pre-existing fissures and cavities, allowing oil, gas, or the like to flow into the wellbore. Fracturing processes typically use large pumps to inject a fracturing fluid—which is often a mixture including sand and water—into the well to increase the well's pressure and form the man-made fractures. A typical fracturing system includes a fracturing manifold trailer (also known as a missile trailer) with pipes

for routing fracturing fluid to and from the large pumps. Other pipes connected to the output of the manifold trailer carry the fracturing fluid to the well.

SUMMARY

[0004] Certain aspects of some embodiments disclosed herein are set forth below. It should be understood that these aspects are presented merely to provide the reader with a brief summary of certain forms the invention might take and that these aspects are not intended to limit the scope of the invention. Indeed, the invention may encompass a variety of aspects that may not be set forth below.

[0005] At least some embodiments of the present disclosure generally relate to modular systems for supplying fracturing fluid and other fluids to wells. In certain embodiments, multiple individual skids include fluid conduits mounted on platforms. The fluid conduits of the multiple skids are connected to form fluid lines spanning the multiple skids. These assembled, multi-skid fluid lines can be used for carrying fluid to and from pumps connected to the lines. For instance, one such fluid line can carry a low-pressure fracturing fluid. Pumps draw the low-pressure fracturing fluid from the fluid line and then pump the fracturing fluid, with a higher pressure, into a different one of the multi-skid fluid lines. The higher-pressure fracturing fluid can then be routed to a well for fracturing.

[0006] Various refinements of the features noted above may exist in relation to various aspects of the present embodiments. Further features may also be incorporated in these various aspects as well. These refinements and additional features may exist individually or in any combination. For instance, various features discussed below in relation to one or more of the illustrated embodiments may be incorporated into any of the above-described aspects of the present disclosure alone or in any combination. Again, the brief summary presented above is intended only to familiarize the reader with certain aspects and contexts of the some embodiments without limitation to the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features, aspects, and advantages of certain embodiments will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. 1 generally depicts a fracturing fluid delivery system in accordance with an embodiment of the present disclosure;

[0009] FIG. 2 is a block diagram of the fracturing fluid delivery system of FIG. 1 with a fracturing manifold coupled to multiple fracturing trees in accordance with one embodiment;

[0010] FIG. 3 is a block diagram of certain components of a modular fracturing fluid delivery system including individual skids coupled together to route fracturing fluid from a blending unit to pumps, and from the pumps to a fracturing manifold, in accordance with one embodiment;

[0011] FIG. 4 is a functional diagram generally depicting routing of low-pressure fracturing fluid to pump trucks via the individual skids of FIG. 3, as well as routing of high-pressure fracturing fluid away from the pump trucks via the individual skids, in accordance with one embodiment;

[0012] FIG. 5 is a plan view of a suction skid having an inlet for receiving fracturing fluid from a fluid source and conduits for routing the fracturing fluid to and from pump connections in accordance with one embodiment;

[0013] FIG. 6 is a plan view of a pump skid having conduits that can be coupled to the conduits of the suction skid of FIG. 5 to receive fracturing fluid and route the fracturing fluid to and from pump connections of the pump skid in accordance with one embodiment;

[0014] FIG. 7 is a plan view of a discharge skid having conduits that can be coupled to the conduits of the pump skid of FIG. 6 to receive fracturing fluid from the pump skid and route the fracturing fluid to and from pump connections of the discharge skid, the discharge skid also including a fluid distribution head with several discharge connections for coupling the discharge skid to a fracturing tree, in accordance with one embodiment;

[0015] FIG. 8 is a plan view of a discharge skid similar to that of FIG. 7, but having a spool with a single discharge connection in accordance with one embodiment;

[0016] FIG. 9 is an elevational view of a suction skid directly coupled to a pump skid in accordance with one embodiment;

[0017] FIG. 10 generally depicts a suction skid, three pump skids, and a discharge skid directly coupled together in series in accordance with one embodiment;

[0018] FIG. 11 generally depicts the same skids as in FIG. 10 instead coupled to one another via intervening fluid conduits in accordance with one embodiment;

[0019] FIG. 12 is similar to FIG. 10, but shows a single pump skid directly coupled to the suction skid and the discharge skid in accordance with one embodiment;

[0020] FIG. 13 generally depicts a suction skid coupled directly to a discharge skid without an intermediate pump skid in accordance with one embodiment;

[0021] FIG. 14 generally depicts a series of skids arranged with pump trucks coupled to just one side of the skids in accordance with one embodiment; and

[0022] FIG. 15 generally depicts a discharge skid coupled in series between other skids in accordance with one embodiment.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0023] One or more specific embodiments of the present disclosure will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0024] When introducing elements of various embodiments, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Moreover, any use of "top," "bottom," "above," "below," other directional terms, and variations of these terms is made for convenience, but does not require any particular orientation of the components.

[0025] Turning now to the present figures, an example of a fracturing fluid delivery system 10 is provided in FIGS. 1 and 2 in accordance with one embodiment. The fracturing fluid delivery system 10 facilitates extraction of natural resources (e.g., oil or natural gas) from a reservoir 12 via a well 14 and a wellhead 16. Particularly, by injecting a fracturing fluid down the well 14 into the reservoir 12, the system 10 increases the number or size of fractures in a formation to enhance recovery of natural resources present in the formation. In the presently illustrated embodiment, the well 14 is a surface well accessed through equipment of wellhead 16 installed at surface level (i.e., on ground 18). But it will be appreciated that natural resources may be extracted from other wells, such as platform or subsea wells.

[0026] The fracturing fluid delivery system 10 includes various components to control flow of a fracturing fluid into the well 14. For instance, the depicted system 10 includes a fracturing tree 20 and a fracturing manifold 22. The fracturing tree 20 is coupled to the wellhead 16 and can be considered part of a wellhead assembly, which includes the wellhead 16 and other coupled components. The fracturing tree 20 can be a conventional fracturing tree positioned vertically above the wellhead 16 or can be a horizontal fracturing tree. Still further, the fracturing tree 20 can include at least one valve that controls flow of the fracturing fluid into the wellhead 16 and, subsequently, down the well 14 to the reservoir 12. Similarly, the fracturing manifold 22 can include at least one valve that controls flow of the fracturing fluid to the fracturing tree 20 by a conduit or fluid connection 26 (e.g., by one or multiple pipes). As depicted in FIG. 2, the fracturing manifold 22 is connected to provide fracturing fluid to multiple fracturing trees 20 and wellheads 16 (which may be located at one or multiple wellsites). But it is noted that the fracturing manifold 22 may instead be coupled to a single fracturing tree 20 in full accordance with the present techniques.

[0027] Fracturing fluid is provided to the fracturing manifold 22 from a supply system 28. In FIG. 1, a fluid connection 30 (e.g., pipes) receives fracturing fluid from the supply system 28 and then transmits the fluid to the fracturing manifold 22. The fluid connection 30 could be provided above the ground 18 or as a subterranean fluid connection.

[0028] The fracturing fluid supply system 28 can take many forms, but in at least some embodiments the system 28 is a modular system including pumps for pressurizing fracturing fluid and multiple skids coupled to one another for routing fracturing fluid to and from the pumps. An example of such a modular fracturing fluid supply system 28 coupled to a fracturing manifold 22 is generally depicted in FIG. 3. In this embodiment, the modular system 28 has a blending unit 36 coupled to provide a stimulation fluid (e.g., a fracturing fluid) to a series of modular skids, including a suction skid 38, several pump skids 40, and a discharge skid 42. Each of these skids can include various components (e.g., pipe segments, valves, and chokes) mounted on a platform to facilitate handling and placement of the skids. The skids may also include

adjustable feet or other alignment features to facilitate connection of the skids to one another.

[0029] In operation, one or more blenders 46 of the blending unit 36 can be used to produce the fracturing fluid by mixing fluid 48 (e.g., water) with various additives 50, such as sand (or another proppant) and chemicals. The blended fracturing fluid flows from the blending unit 36 to pumps 54 via the skids 38, 40, and 42. In at least some embodiments, the blending unit 36 is provided at a wellsite with the skids 38, 40, and 42. But in other instances, the blending unit 36 could be provided at a remote location, such as a fracturing factory that services multiple pads.

[0030] The blending unit 36 can also be used to provide other fluids 48, such as a different well stimulation fluid (e.g., an acid or solvent), through the skids 38, 40, and 42 to the pumps 54. Although the system 10 is described at times herein as a fracturing fluid delivery system, and components of the system 10 may be described as fracturing fluid components, it will be appreciated that the fracturing fluid delivery system 10 and its components can also or instead be used to deliver other stimulation fluids into the well. Thus, the fracturing fluid delivery system 10 can also be referred to as a well stimulation fluid delivery system. And while various conduits and operation of the system 10 are described with reference to fracturing fluid by way of example, the conduits and operations described could also be used with a different well stimulation fluid.

[0031] The pumps 54 can take any suitable form, and may include truck-mounted pumps or skid-mounted pumps. Regardless of their form, the pumps 54 increase the pressure of the fracturing fluid (or other fluid) received from the blending unit 36 via the skids and then route the fluid back into the depicted skids. The fracturing fluid pumped back into the skids by the pumps 54 can then be routed out through the discharge skid 42 to the fracturing manifold 22 for delivery to one or more fracturing trees 20 coupled to the manifold 22. In other instances, the manifold 22 may be omitted and the fracturing fluid can be routed from the discharge skid 42 directly to the one or more fracturing trees 20.

[0032] The flow of fracturing fluid between the pumps 54 and the various skids 38, 40, and 42 may be better understood with reference to FIG. 4. As described in greater detail below, the skids 38, 40, and 42 include fluid conduits coupled together to form multiple fluid lines. This allows low-pressure fracturing fluid flow (generally represented by dashed line 60) through the skids to the pumps 54 via at least one of the fluid lines, and high-pressure fracturing fluid flow (generally represented by dashed line 62) from the pumps 54 through the skids via another of the fluid lines.

[0033] The pumps 54, which are shown in this figure as truck-mounted pumps, are positioned along the skids and connected to the assembled fluid lines. Low-pressure fracturing fluid flows into at least one of the assembled fluid lines at the suction skid 38 (e.g., from the blending unit 36), as generally represented by reference numeral 66, and is routed to the connected pumps 54. The pumps 54 increase the pressure of the fracturing fluid and the resulting high-pressure fracturing fluid is pumped into a high-pressure line of the connected skids. The high-pressure fracturing fluid flows through the high-pressure line and out of the discharge skid 42, as generally represented by reference numeral 70. In the presently depicted embodiment, each of the pumps 54 draws low-pressure fluid from one of the skids 38, 40, and 42 and then reintroduces that fluid into the same skid as high-pressure fluid.

[0034] In some instances, the high-pressure fluid has a pressure of at least one order of magnitude greater than the low-pressure fluid. For example, the low-pressure fluid can have a pressure below 300 psi (e.g., 200 psi) and the high-pressure fluid can have a pressure of thousands of psi (e.g., between 5,000 and 15,000 psi). But as used herein, the terms low-pressure fluid and high-pressure fluid (whether fracturing fluid or another fluid) are used as relative terms with respect to the state of the fluid before and after its pressure is increased to a desired level by a pump (e.g., pump 54) of the system 10—these terms do not denote specific pressures or pressure ranges. Similarly, low-pressure and high-pressure are also used to describe different fluid conduits or fluid lines in the system 10 for conveying the low-pressure and high-pressure fluids, respectively, and do not require any specific pressure ratings.

[0035] Certain embodiments of the skids 38, 40, and 42 are shown in FIGS. 5–9 for the sake of explanation. It will be appreciated, however, that the skids 38, 40, and 42 can be provided in any other suitable form. In FIG. 5, a suction skid 38 is depicted as having various components mounted on a skid platform 76. The mounted components include fluid conduits 78 and a fluid conduit 80. As described further below, the fluid conduits 78 can be connected as portions of low-pressure fluid lines spanning multiple skids for conveying fracturing fluid to the pumps 54; thus, these conduits 78 may be considered low-pressure fluid conduit segments. The fluid conduit 80 may be connected as a portion of a high-pressure fluid line spanning multiple skids for receiving fracturing fluid from the pumps 54 and can be considered a high-pressure fluid conduit segment.

[0036] The suction skid 38 includes outlet connections 84 for coupling pumps 54 to receive fluid from the conduits 78. Valves 86 (e.g., butterfly valves) can be used to control flow from the conduits 78 through the connections 84 to the pumps 54. The suction skid 38 of FIG. 5 also includes an intake header 88 for receiving fracturing fluid entering the suction skid 38 (e.g., from the blending unit 36) through intake connections or inlets 90. Some of the fracturing fluid received in the intake header 88 flows through the conduits 78 to pumps 54 connected to the outlet connections 84 of the suction skid 38, while some of the fracturing fluid instead flows through the conduits 78 to another skid (e.g., a pump skid 40).

[0037] The suction skid 38 also includes inlet connections 94 for coupling the pumps 54 to the fluid conduit 80. Pumps 54 connected across the outlet connections 84 and the inlet connections 94 can draw fracturing fluid from the suction skid 38 (via the outlet connections 84) and then pump the fracturing fluid back into the suction skid 38 (via the inlet connections 94) at a higher pressure. The suction skid 38 also includes valves 96 (e.g., gate valves) coupled to the conduit 80 (more specifically, to a connection block 98 of the conduit 80) for controlling flow of the high-pressure fracturing fluid from the pumps 54 into the conduit 80. This high-pressure fracturing fluid is then routed through the conduit 80 to a pump skid 40 or some other downstream skid.

[0038] An example of a pump skid 40 is shown in FIG. 6. The depicted pump skid 40 includes a skid platform 104, on which fluid conduits 106 and 108 are mounted. Like the fluid conduits 78 of the suction skid 38, the fluid conduits 106 of the pump skid 40 can be connected as portions of the low-pressure fluid lines extending across multiple skids and may also be referred to as low-pressure fluid conduit segments. The fluid conduits 106 can be coupled to receive fracturing fluid from the upstream fluid conduits 78 of the suction skid 38. The fluid conduit 108 can be connected (like the conduit 80) as a portion of the high-pressure fluid line extending across the multiple skids and may be referred to as a high-pressure fluid conduit segment.

[0039] The pump skid 40 also includes outlet connections 84 and inlet connections 94 for coupling the skid 40 to pumps 54, and valves 86 and 96 for controlling flow to and from those pumps 54, as described above with respect to the suction skid 38. Pumps 54 coupled to the connections 84 and 94 of the pump skid 40 can draw low-pressure fracturing fluid from the skid 40 out of the conduits 106 and then return the fracturing fluid with a high pressure into the skid 40 (i.e., into the conduit 108). The conduit 108 includes a pipe segment and a connection block 98 mounted on the platform 104. The connection block 98 is shown as a studded connection block that can be coupled to an end of the conduit 80 of the suction skid 38. The conduit 108 receives high-pressure fracturing fluid from the pumps 54 connected to the connections 84 and 94 of the pump skid 40, as well as from the upstream conduit 80 of the suction skid 38.

[0040] In some embodiments, a fracturing fluid delivery system includes multiple pump skids 40 connected in series with the suction skid 38 and the discharge skid 42. In such cases, a first pump skid 40 can be coupled to the suction skid 38, as described above, and each additional pump skid 40 can be coupled to a previous pump skid 40 in a similar manner. The fluid conduits 106 and 108 of the additional pump skids 40 receive fracturing fluid from the upstream skids, and pumps 54 can be coupled across connections 84 and 94 to draw fluid from and inject the fluid back into the additional pump skids 40.

[0041] A discharge skid 42 is depicted in FIG. 7 in accordance with one embodiment. The presently depicted discharge skid 42 includes a skid platform 114, and fluid conduits 116 and 118 are mounted on the platform 114. Like the similar conduits of the skids 38 and 40, the fluid conduits 116 can be connected as portions (i.e., segments) of the low-pressure fluid lines running across multiple skids and the fluid conduit 118 can be connected as a portion (i.e., segment) of the high-pressure fluid line across the multiple skids. An additional conduit 120 may also be included to couple the fluid conduit 116 together.

[0042] The discharge skid 42 includes connections 84 and 94 for connecting pumps 54 to the skid 42, and valves 86 and 96 for controlling flow to and from the pumps 54. These pumps 54 draw low-pressure fluid from the discharge skid 42 (from the fluid conduits 116, which can receive the fluid from upstream conduits 78 and 106) and reintroduce that fluid to the discharge skid 42 (into the conduit 118) as a high-pressure fluid. A connection block 98 of the conduit 118 facilitates connection to an output end of an upstream high-pressure fluid conduit segment (e.g., the conduit 108 of a pump skid 40). In operation, the conduit 118 receives high-pressure fluid from pumps coupled across the connections 84 and 94 of the skid 42, and also from upstream high-pressure fluid conduit segments of other skids.

[0043] The fluid flowing in the high-pressure fluid line can be output to a fracturing tree 20 or manifold 22 through a distribution head 122 of the discharge skid 42. As depicted in FIG. 7, the distribution head 122 includes multiple outlets in the form of discharge connections 124. In another embodiment, such as that shown in FIG. 8, the discharge skid 42 can instead include just a single outlet 128 (e.g., provided by a spool connected to the conduit 118) for discharging the high-pressure fluid.

[0044] The various skids 38, 40, and 42 can be coupled directly to one another or coupled together with intervening fluid conduit segments. By way of example, a suction skid 38 is shown coupled directly to a pump skid 40 in FIG. 9. That is, the conduits 80 and 108 of the skids are connected together without any additional conduits between them. Likewise, conduits 78 of the suction skid 38 are connected to conduits 106 of

the pump skid 40 without any intervening conduits. Valves 132 can be provided to control flow through the conduits 106.

[0045] While FIG. 9 shows a pair of conduits 78 on the depicted side of the skid 38 and a pair of conduits 106 on the same side of the skid 40, the skids 38, 40, and 42 can include any desired number of low-pressure fluid conduits 78, 106, and 116. For instance, the skids 38, 40, and 42 can each include two such low-pressure fluid conduits on opposite sides of the skid (that is, one on each side). Also, while the skids 38, 40, and 42 can include just a single high-pressure conduit in some embodiments, the skids could include multiple high-pressure conduits in others.

[0046] In at least some embodiments, the high-pressure fluid conduit segments of the skids 38, 40, and 42 include or are connected to valves and chokes to regulate the pressurized fluid flow from the pumps 54 for isolation and to reduce pulsation of the conduits. In one embodiment, high-pressure lines from the pumps 54 are connected to the inlet connections 94 via a choke and one or more valves. Further, the fluid conduit segments of the skids 38, 40, and 42 may include heavy-walled pipe to reduce vibration from operation of the system 10.

[0047] Each of the skids 38, 40, and 42 can be considered a module of the fracturing fluid delivery system 10, and these modular skids can be arranged and connected in any suitable fashion. Several examples of different modular arrangements are generally depicted in FIGS. 10–15. In FIG. 10, three pump skids 40 are coupled in series with a suction skid 38 and a discharge skid 42 to form low-pressure fluid lines 136 and a high-pressure fluid line 138. The low-pressure fluid lines 136 include fluid conduits 78, 106, and 116 of the skids, while the high-pressure fluid line 138 includes the fluid conduits 80, 108, and 118 of the skids. The low-pressure fluid conduit segments of the fluid line 136 can be provided as rigid or flexible segments. Further, in this embodiment, the skids 38, 40, and 42 are coupled directly to one another (in series) without additional fluid conduits interposed between the mounted conduits of adjacent skids.

[0048] In another embodiment generally depicted in FIG. 11, however, the skids 38, 40, and 42 are coupled to one another with additional fluid conduits interposed between the conduits mounted on the skids. More specifically, additional fluid conduit segments 140 (which may be rigid or flexible) are provided as portions of the low-pressure fluid lines 136 and are interposed between skid-mounted conduit segments 78, 106, and 116. Similarly, additional fluid conduit segments 142 are provided as portions of the high-pressure fluid line 138 and are interposed between skid-mounted conduit segments 80, 108, and 118. The number and length of the additional fluid conduit segments 140 and 142 can be varied in any desired manner. For example, multiple fluid conduit segments 140 or 142 could be used in connecting two skids to one another. In certain embodiments, some of the skids are coupled directly together while others are coupled via additional fluid conduit segments 140 and 142. Still further, the fluid conduit segments 140 and 142 could be provided with various features (e.g., ball joints, elbow joints, or pipe bends) to facilitate connection of skids whose respective conduits are not aligned with each other.

[0049] In other embodiments, the quantity of the modular skids can be varied. For example, the number of pump skids 40 can be selected based on the pumping capacity needed for a given application. While the arrangements shown in FIGS. 10 and 11 each include five modular skids for a total of ten connected pumps 54, in other cases it may be desirable to have a different number of pumps 54. In FIG. 12, for instance, a single pump skid 40 is connected in series with a suction skid 38 and a discharge skid 42 (for a total of six connected pumps 54), while the modular arrangement in FIG. 13 includes only two skids—a suction skid 38 coupled to a discharge skid 42 without any pump skids 40 (for a total of four connected pumps 54). The skids in FIGS. 12 and 13 are shown directly coupled to one another, but in other instances fluid conduit segments 140 and 142 could be used to couple the skids together when spaced further apart from one another. Although not presently depicted, it will be appreciated that another arrangement may have two pump skids 40 connected in series with a suction skid 38 and a discharge skid 42 (for a total of eight connected pumps 54), and still other arrangements may have four or more pump skids 40 coupled between a suction skid 38 and a discharge skid 42.

[0050] Various embodiments have been described above as having multiple low-pressure fluid lines extending across multiple skids with pumps connected to opposite sides of each skid. But in at least one embodiment, a series of skids may include just one low-pressure fluid line. An example of this is depicted in FIG. 14, which shows a single low-pressure fluid line 136 connected to pumps 54 along just one side of the series of skids. In at least some instances, having all of the pumps 54 on a common side may reduce the amount of space needed to connect the pumps 54 to the skids. For example, in the case of truck-mounted pumps, limiting connection of the pumps 54 to a single side of the skid reduces the area needed for pump trucks to drive up to and align with the pump connections on the skids and allows the elimination of a driving lane and turning radius for trucks along one side of the skids.

[0051] Further, while certain embodiments have been depicted in which fluid enters one end of a series of skids and is discharged at the opposite end, other arrangements may also be used in full accordance with the present techniques. For instance, FIG. 15 shows a series of skids in which a discharge skid 42 is positioned as an intermediate skid between two pump skids 40. A suction skid 38 in FIG. 15 also includes an intake header provided in-line with other conduits of the low-pressure fluid line 136. Fluid (e.g., from a blending unit 36) can be pumped into the low-pressure fluid line 136 through this intake of the suction skid 38 for distribution to the pumps 54, high-pressure fluid can be pumped from the pumps 54 into the high-pressure line 138, and the high-pressure fluid in the line 138 can be discharged through an outlet (e.g., of a distribution head 122 or spool) of the discharge skid 42. Additionally, in other embodiments, the fluid intake for the low-pressure fluid line 136 is provided on an intermediate skid of the series of skids rather than at an end of the series. In one embodiment, the intake for the low-pressure fluid line 136 is provided on the same skid as the discharge outlet of the high-pressure line 138 (e.g., on the discharge skid 42 of FIG. 15), with one skid functioning as both a suction skid and a discharge skid.

[0052] The modularity of the fluid distribution systems described herein may allow greater flexibility in designing and deploying a fluid delivery apparatus at a wellsite. Particularly, whereas a conventional missile trailer has connections for eight or ten pumps, the presently disclosed modular systems are configurable to the number of

pumps needed for a particular fluid injection operation. These modular systems can also be positioned at a wellsite, connected to fracturing trees on wellheads at the wellsite, and pressure tested before arrival of pumping trucks and crews. The individual skids can each be smaller than a traditional missile trailer. This facilitates positioning and handling of the system during installation or removal. In at least some cases, a crane can be used to lift and position different skid modules in desired locations. The flexibility in positioning offered by the modular design may also facilitate the use of the present system in remote areas (e.g., in mountainous terrain or jungles), urban spaces (e.g., near buildings or utilities), or environmentally-sensitive areas. The modules can also be more easily positioned on a previously existing multi-well pad to avoid existing structures and obstructions (e.g., production equipment).

[0053] Further still, missile trailers are typically pulled by a truck on public roadways and may have size and weight constraints due to government regulations. For example, missile trailers typically range between 14.6 and 16.2 meters to comply with certain government regulations. But the individual skids of the presently disclosed system can be delivered to a wellsite and then connected to have a total length greater than that of a conventional missile trailer. For example, in one embodiment, the distance between the intake connection 90 and the discharge connections 124 or 128 is greater than seventeen meters. The greater total length allows pump trucks connected to the skids 38, 40, and 42 to be spaced further apart from one another, which makes it easier to position the pump trucks and increases access to the connected trucks and the skids. Further, with increased spacing, fire-resistant barriers can be installed between the pump trucks. The modularity also allows the use of heavier components compared to a conventional missile trailer, such as thicker-walled piping, larger-diameter flow bores, and larger valves that are more resistant to wear from abrasive and corrosive fluids to which they are exposed, which may result in lower operating expenses compared to missile trailers.

[0054] While the aspects of the present disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. But it should be understood that the invention is not intended to be limited to the particular forms

disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

CLAIMS

1. An apparatus comprising:
a well stimulation fluid delivery system including:
an intake connection for receiving well stimulation fluid;
a first conduit configured to route the well stimulation fluid from the intake connection to multiple outlet connections configured to be coupled to pumps for increasing the pressure of the well stimulation fluid;
a second conduit configured to receive the well stimulation fluid from the pumps, via multiple inlet connections configured to be coupled to the pumps, and to route the well stimulation fluid to a discharge connection; and
a plurality of individual skids including platforms on which fluid conduit segments are mounted, wherein the individual skids are coupled to one another via their mounted fluid conduit segments to form the first conduit and the second conduit.
2. The apparatus of claim 1, wherein the plurality of individual skids includes a first skid having the intake connection and a second skid having the discharge connection.
3. The apparatus of claim 2, wherein the plurality of individual skids includes at least one additional skid coupled between the first skid and the second skid.
4. The apparatus of claim 1, wherein:
the well stimulation fluid delivery system includes an additional conduit configured to route the well stimulation fluid from the intake connection to multiple additional outlet connections configured to be coupled to additional pumps for increasing the pressure of the well stimulation fluid;
the second conduit is configured to receive the well stimulation fluid from the additional pumps, via multiple additional inlet connections configured to be coupled to

the additional pumps, and to route the well stimulation fluid to the discharge connection; and

additional fluid conduit segments are mounted on the platforms of the plurality of individual skids, and the additional fluid conduit segments are coupled to one another to form the additional conduit.

5. The apparatus of claim 1, wherein the fluid conduit segments of at least two individual skids of the plurality of individual skids are coupled directly together.

6. The apparatus of claim 1, wherein the fluid conduit segments of at least two individual skids of the plurality of individual skids are coupled together via additional fluid conduit segments that are not mounted on any of the plurality of individual skids.

7. The apparatus of claim 1, wherein the individual skids of the plurality of individual skids are coupled in series such that the distance between the intake connection and the discharge connection is greater than seventeen meters.

8. The apparatus of claim 1, comprising a fracturing tree connected to receive the well stimulation fluid from the second conduit.

9. The apparatus of claim 8, wherein the fracturing tree is connected to receive the well stimulation fluid from the second conduit via a fracturing manifold.

10. The apparatus of claim 1, comprising the pumps, wherein the pumps are coupled to the multiple outlet connections and to the multiple inlet connections.

11. An apparatus comprising:

a modular fracturing fluid delivery system including a plurality of skids coupled to one another to route low-pressure fracturing fluid to pumps connected to the plurality of skids and to route high-pressure fracturing fluid from the pumps to a well via the plurality of skids, the plurality of skids including:

a suction skid including a low-pressure fracturing fluid conduit and a high-pressure fracturing fluid conduit, the low-pressure fracturing fluid conduit of the suction skid including an inlet for receiving the low-pressure fracturing fluid;

a pump skid including a low-pressure fracturing fluid conduit coupled to the low-pressure fracturing fluid conduit of the suction skid and a high-pressure fracturing fluid conduit coupled to the high-pressure fracturing fluid conduit of the suction skid; and

a discharge skid including a low-pressure fracturing fluid conduit coupled to the low-pressure fracturing fluid conduit of the pump skid and a high-pressure fracturing fluid conduit coupled to the high-pressure fracturing fluid conduit of the pump skid, the high-pressure fracturing fluid conduit of the discharge skid including an outlet for routing the high-pressure fracturing fluid to the well;

wherein the modular fracturing fluid delivery system further includes: a low-pressure fracturing fluid line having the low-pressure fracturing fluid conduits of the suction skid, the pump skid, and the discharge skid; a high-pressure fracturing fluid line having the high-pressure fracturing fluid conduits of the suction skid, the pump skid, and the discharge skid; a first plurality of pump connections on the low-pressure fracturing fluid line for routing the low-pressure fracturing fluid out of the low-pressure fracturing fluid line into pumps; and a second plurality of pump connections on the high-pressure fracturing fluid line for receiving the high-pressure fracturing fluid from the pumps into the high-pressure fracturing fluid line.

12. The apparatus of claim 11, comprising a blender coupled to provide the low-pressure fracturing fluid to the low-pressure fracturing fluid line of the modular

fracturing fluid delivery system via the inlet of the low-pressure fracturing fluid conduit of the suction skid.

13. The apparatus of claim 11, comprising a plurality of pumps coupled to the first plurality of pump connections to receive the low-pressure fracturing fluid from the low-pressure fracturing fluid line and coupled to the second plurality of pump connections to provide the high-pressure fracturing fluid to the high-pressure fracturing fluid line.

14. The apparatus of claim 13, wherein the plurality of pumps includes a plurality of truck-mounted pumps.

15. The apparatus of claim 11, wherein the pump skid includes a plurality of pump skids coupled in series to one another.

16. The apparatus of claim 11, comprising a fracturing fluid manifold coupled between the outlet of the discharge skid and a plurality of fracturing trees connected to wellheads.

17. A method comprising:

positioning a plurality of fluid routing skids at a wellsite, the plurality of fluid routing skids including skid platforms, a first plurality of fluid conduit segments mounted on the skid platforms, and a second plurality of fluid conduit segments mounted on the skid platforms;

coupling the first plurality of fluid conduit segments together to form a first fluid conduit for routing fluid to pumps;

coupling the second plurality of fluid conduit segments together to form a second fluid conduit for receiving the fluid from the pumps; and

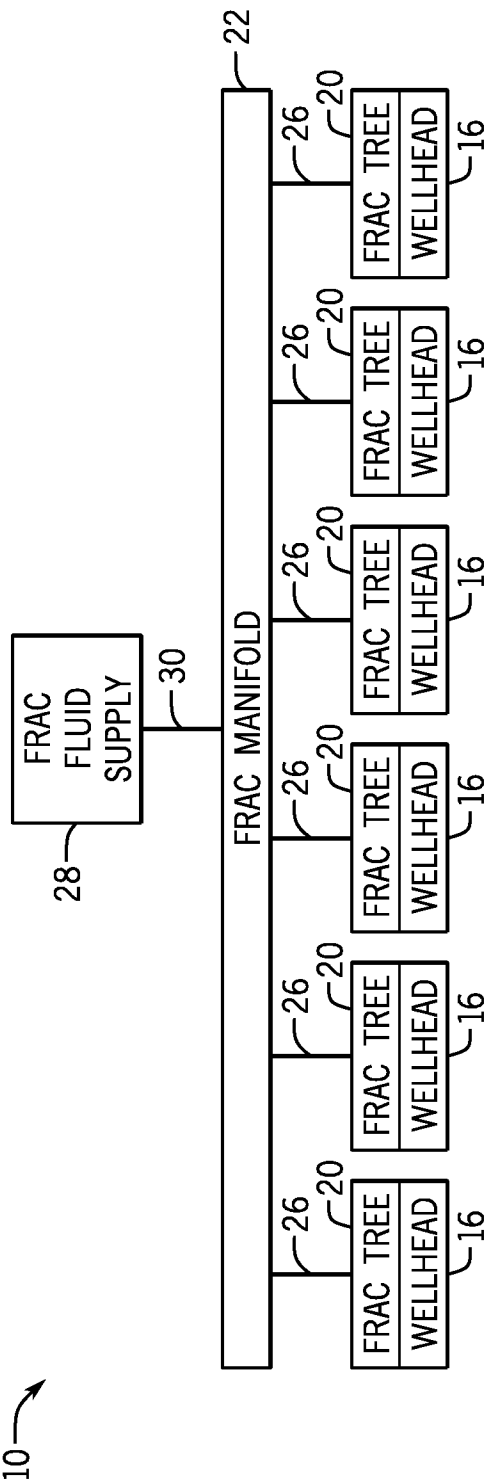
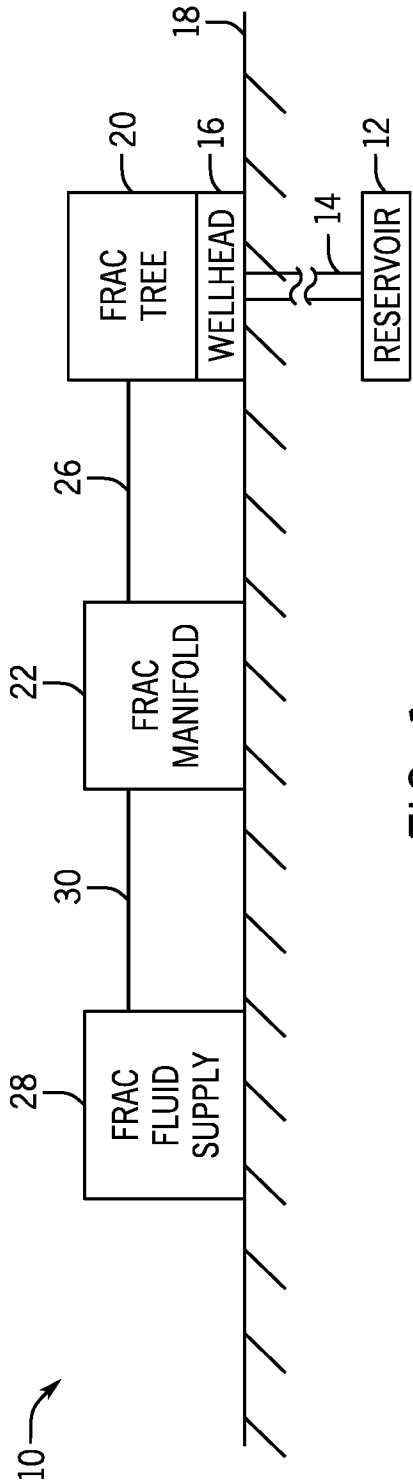
coupling the second fluid conduit to a wellhead assembly.

18. The method of claim 17, wherein coupling the second fluid conduit to the wellhead assembly includes comprising coupling the second fluid conduit to at least one fracturing tree of the wellhead assembly.

19. The method of claim 17, comprising coupling the pumps to the first and second fluid conduits.

20. The method of claim 17, comprising:

- receiving a fracturing fluid in the first fluid conduit;
- routing the fracturing fluid through the first fluid conduit to the pumps;
- increasing the pressure of the fracturing fluid with the pumps;
- receiving the fracturing fluid from the pumps into the second fluid conduit; and
- fracturing a well by routing the fracturing fluid from the second fluid conduit into the well.



2 / 11

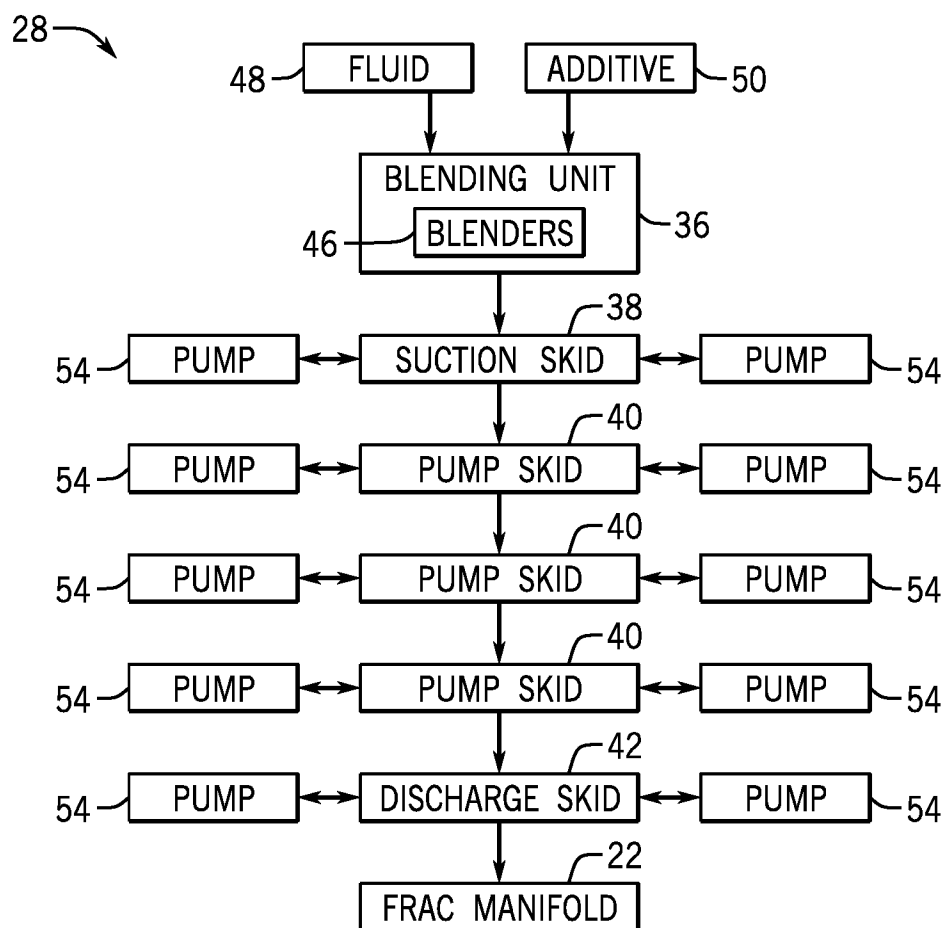


FIG. 3

3 / 11

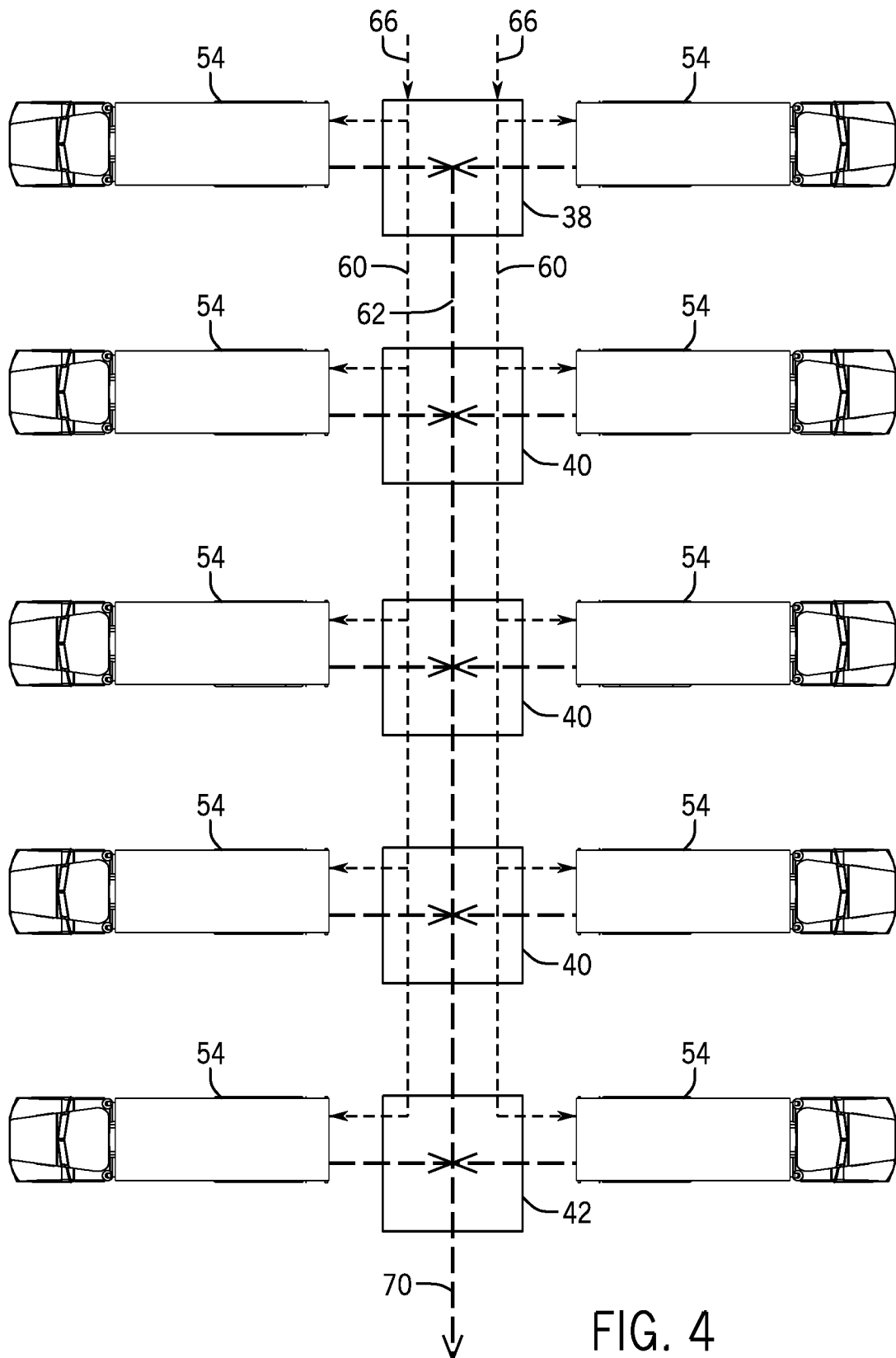


FIG. 4

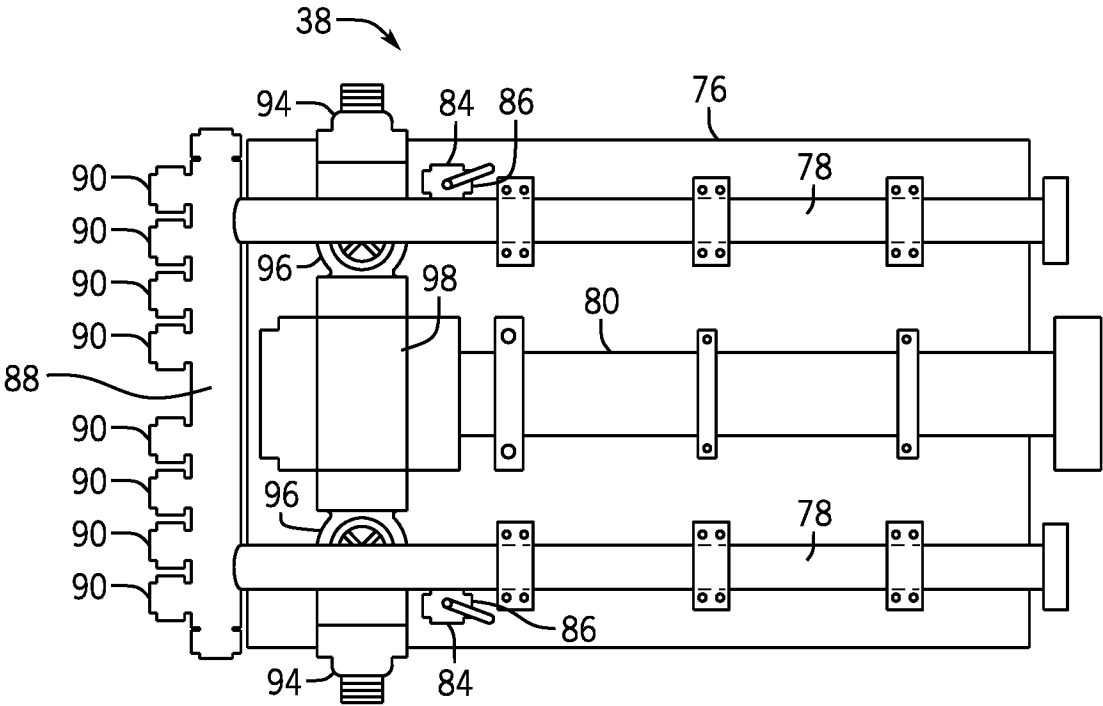


FIG. 5

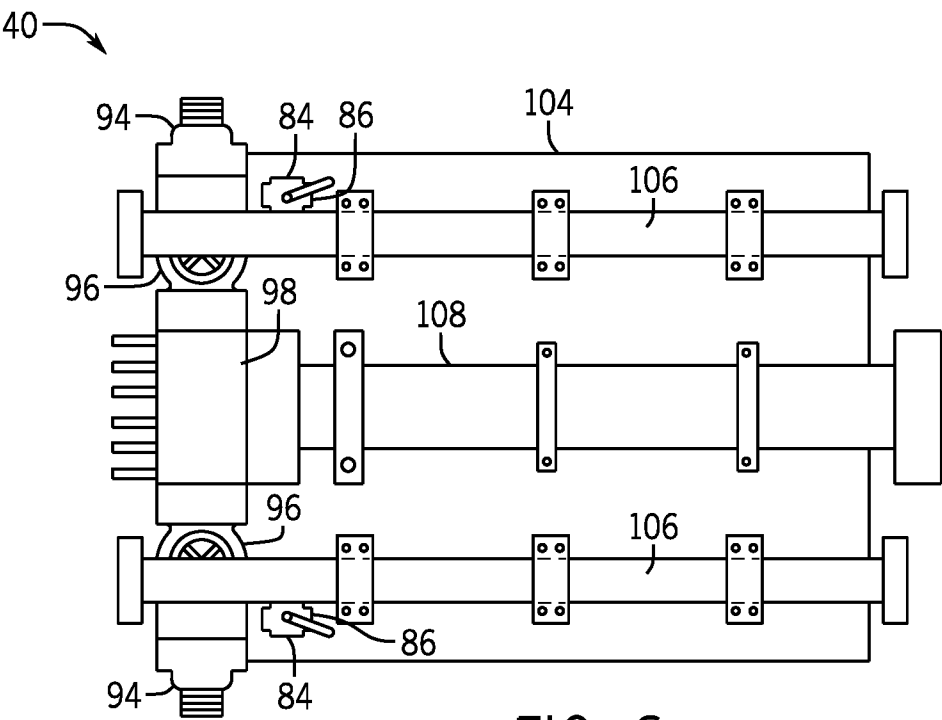
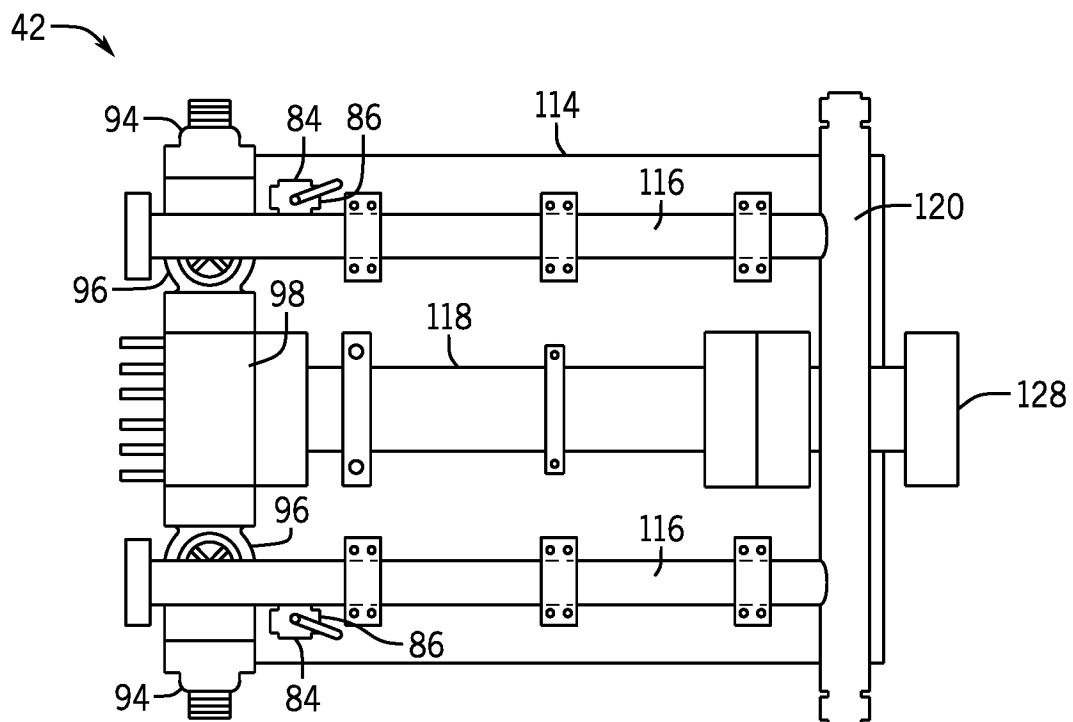
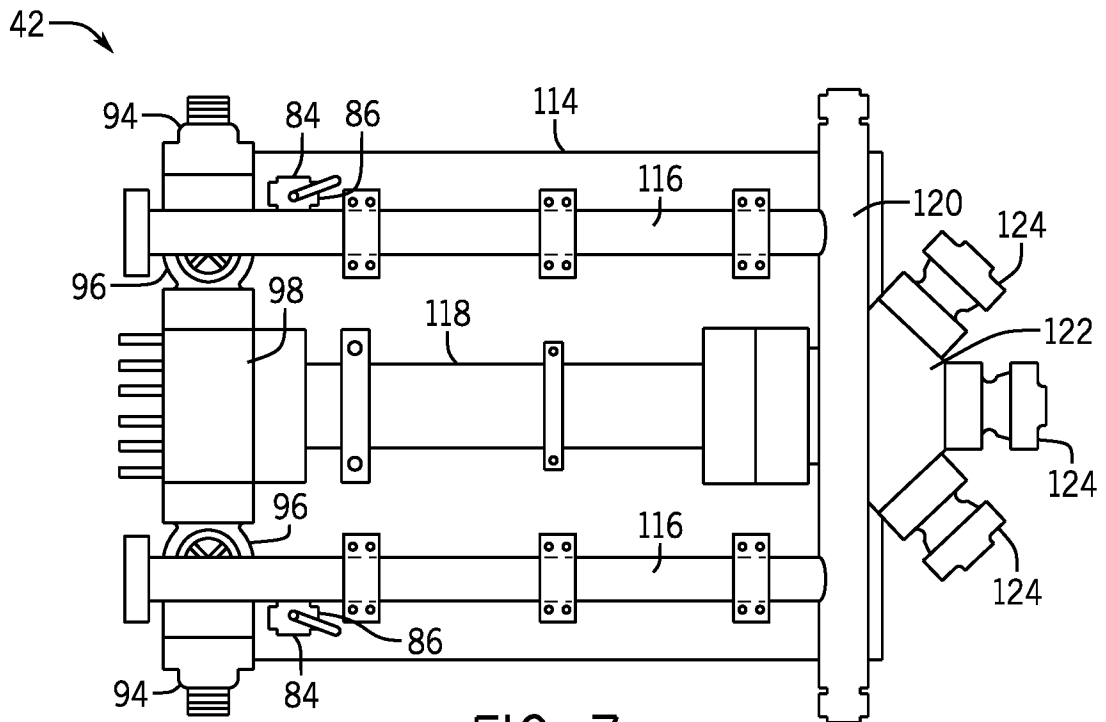


FIG. 6

5 / 11



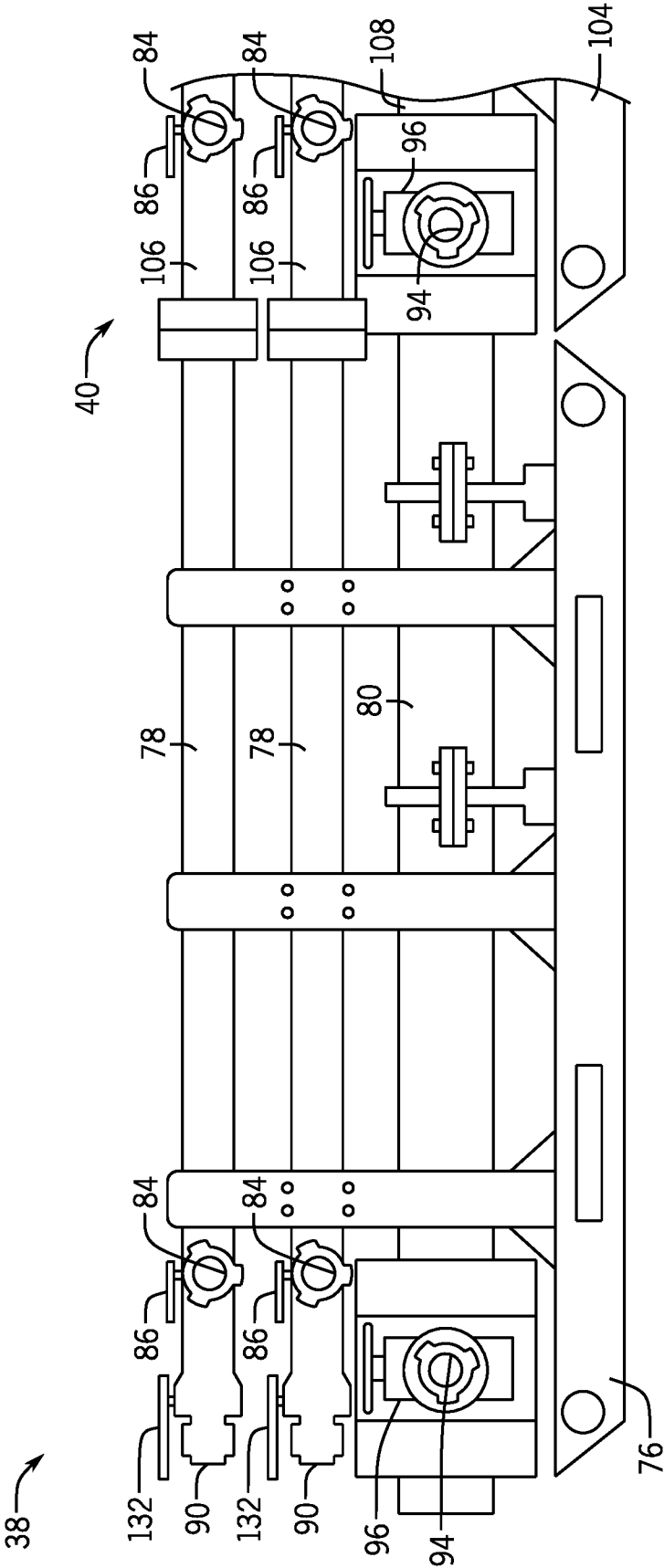


FIG. 9

7 / 11

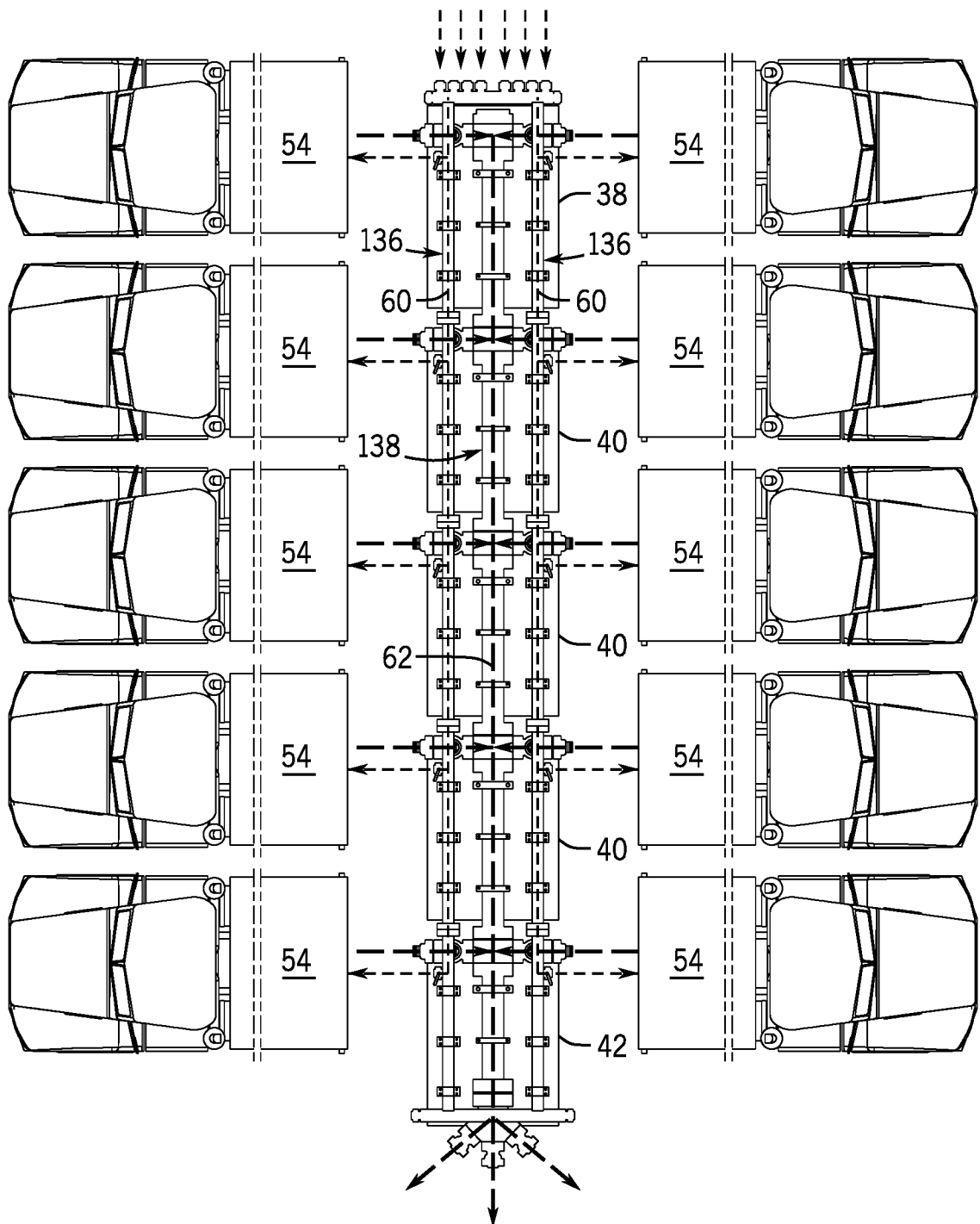


FIG. 10

8 / 11

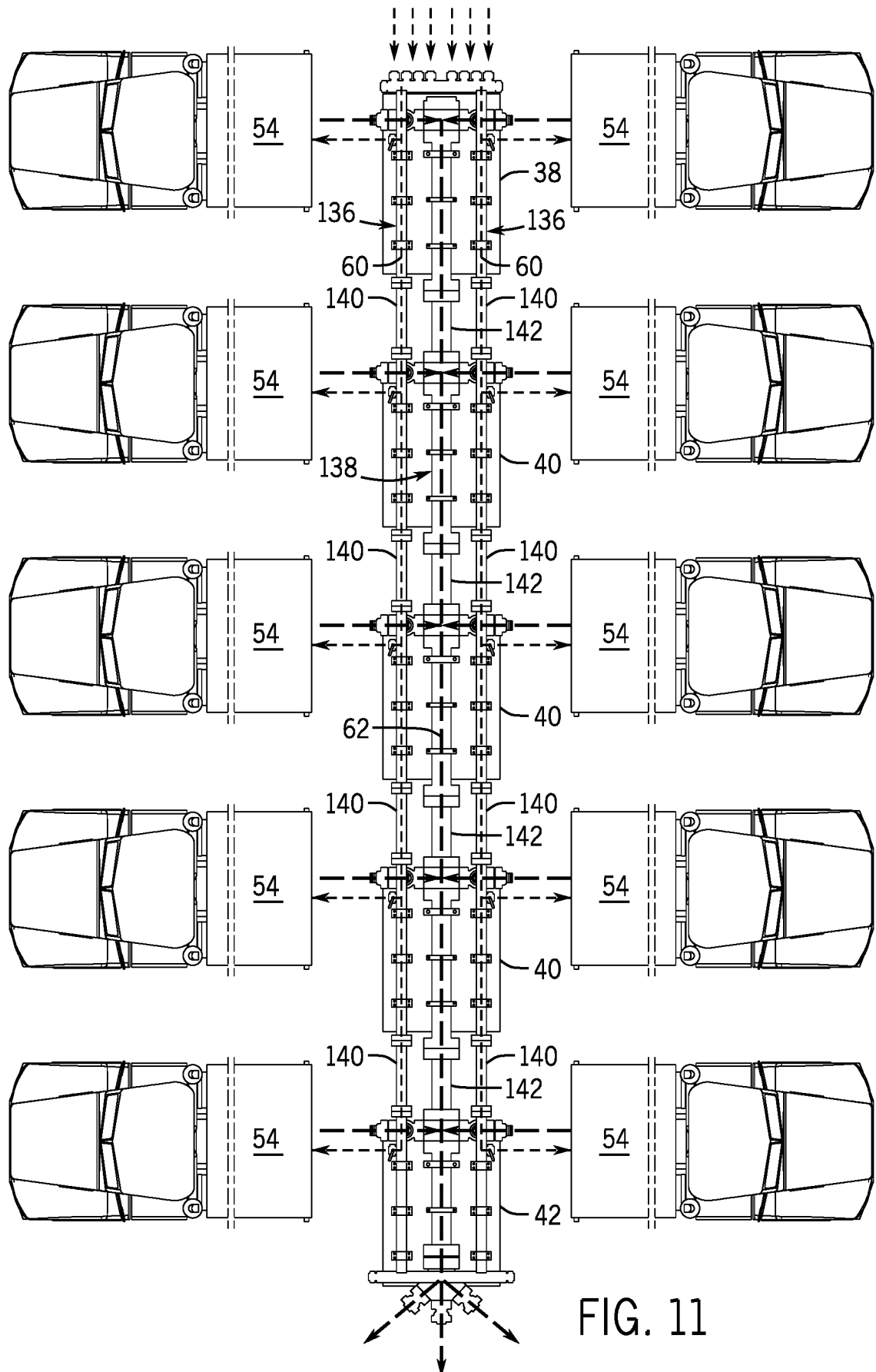
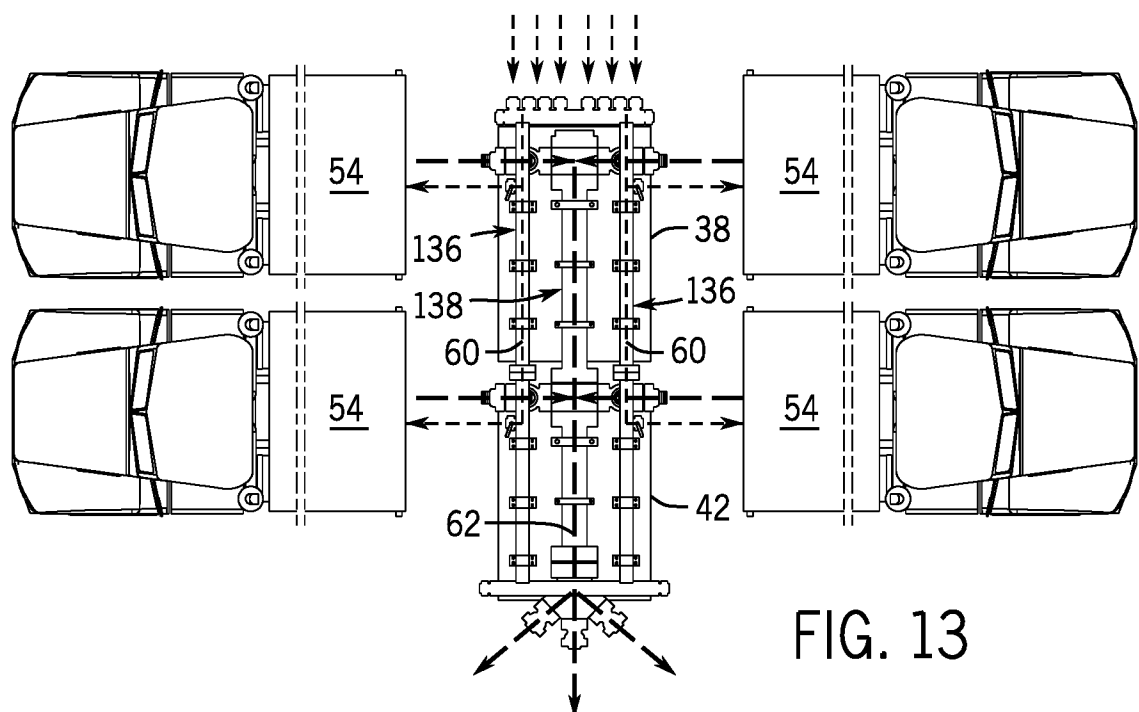
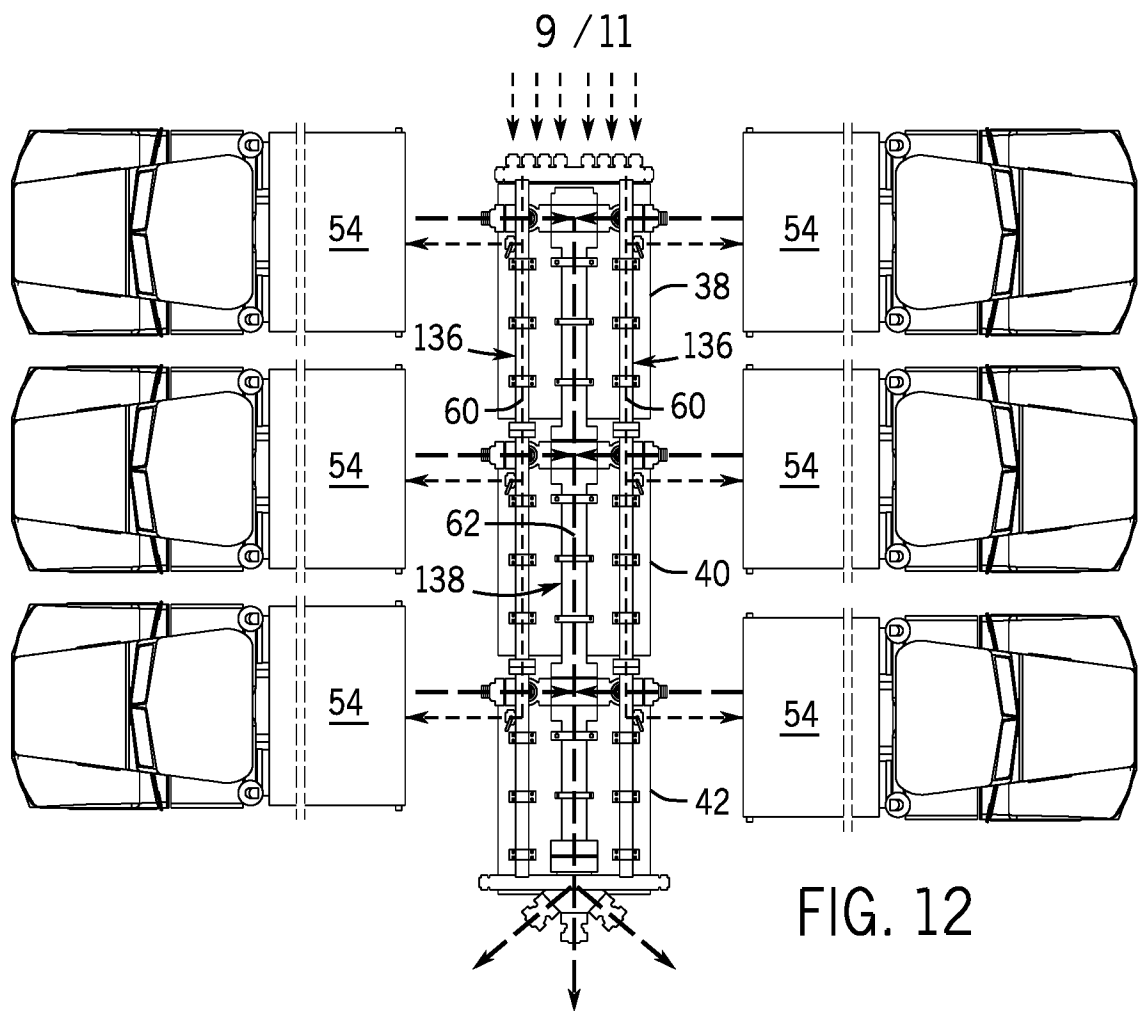
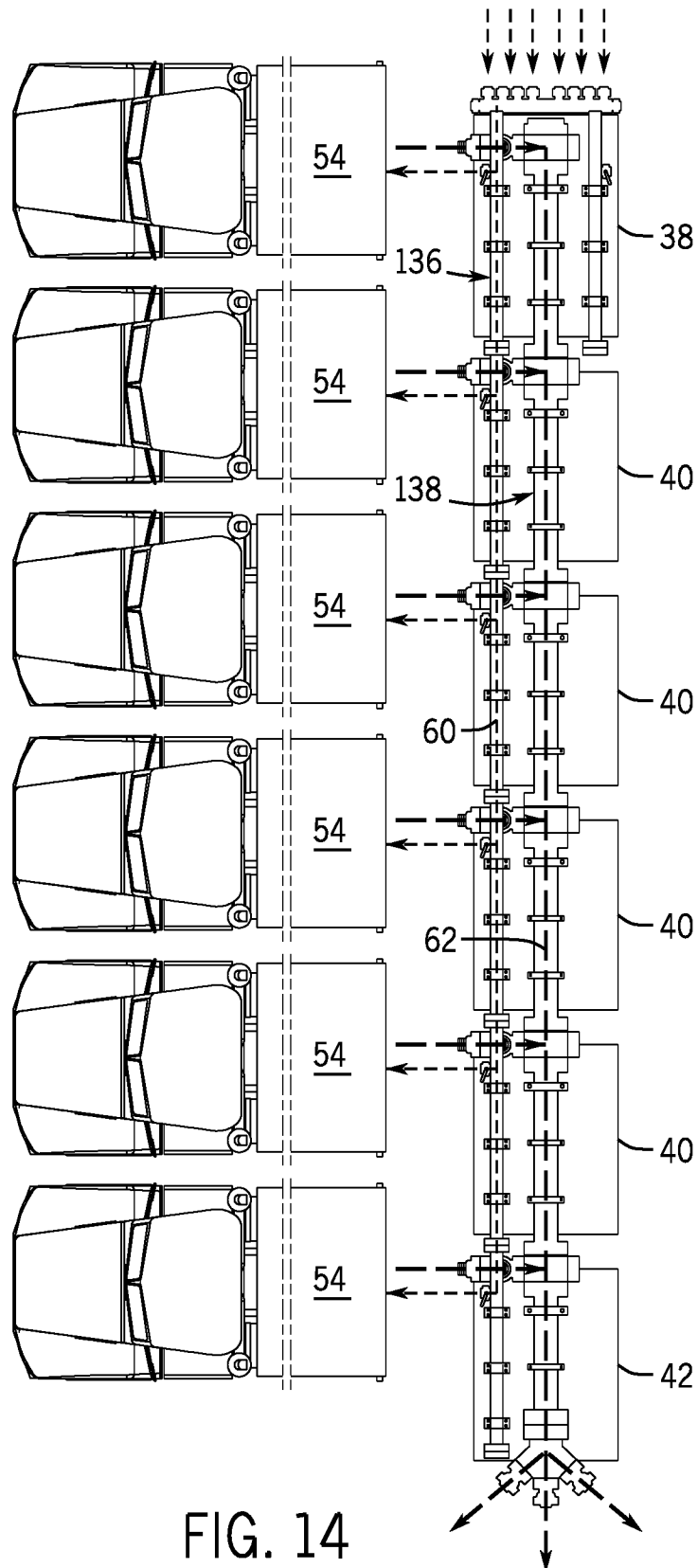


FIG. 11





11 / 11

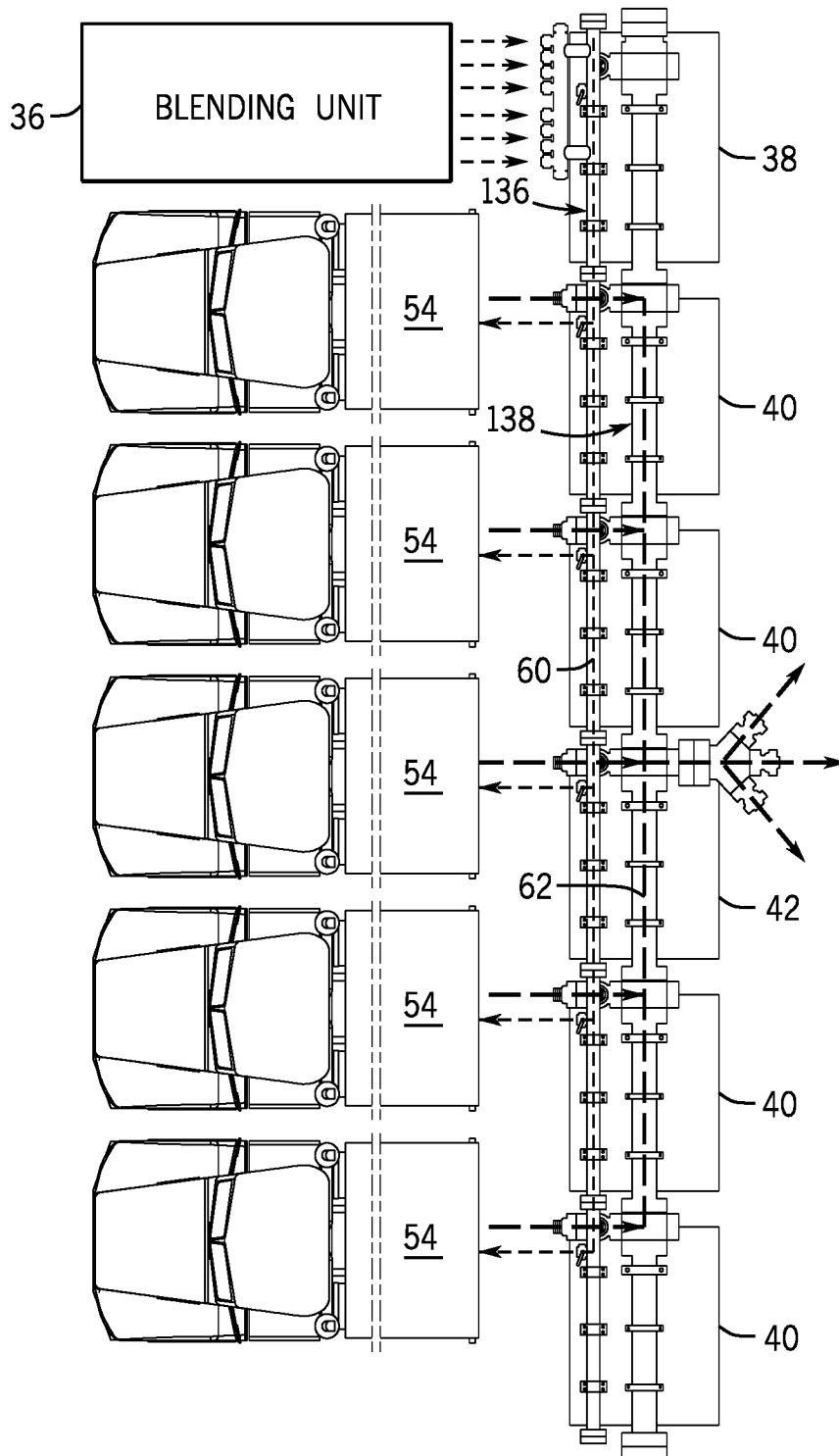


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/039793

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21B 43/26; E21B 43/25; E21B 43/27; E21B 43/28 (2016.01)

CPC - E21B 43/26; E21B 43/25; E21B 43/28; E21B 43/283 (2016.08)

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)

IPC - E21B 43/25; E21B 43/26; E21B 43/27; E21B 43/28

CPC - E21B 43/25; E21B 43/26; E21B 43/28; E21B 43/283

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

USPC - 166/177.5; 166/308.1; 166/308.2 (keyword delimited)

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

Orbit, Google Patents, Google, YouTube

Search terms used: fracking, well stimulation fluid, intake, conduit, pumps, discharge, skids, modular, module, trailer, fracturing, fluid, suction skid, discharge skid, manifold, platform, welhead

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013/0284455 A1 (GE OIL & GAS PRESSURE CONTROL LP) 31 October 2013 (31.10.2013) entire document	1, 6-10, 17-20
Y	US 2012/0181015 A1 (KAJARIA et al) 19 July 2012 (19.07.2012) entire document	1, 6-10, 17-20
A	US 2014/0290768 A1 (FTS INTERNATIONAL SERVICES, LLC) 02 October 2014 (02.10.2014) entire document	1-20
A	US 2014/0069651 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION) 13 March 2014 (13.03.2014) entire document	1-20
A	US 2014/0138079 A1 (US WELL SERVICES LLC) 22 May 2014 (22.05.2014) entire document	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 August 2016

Date of mailing of the international search report

16 SEP 2016

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774