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CA 2700385 C 2015/02/24

(11)(21) 2 700 385

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2008/09/12
(87) Date publication PCT/PCT Publication Date: 2009/04/02
(45) Date de délivrance/Issue Date: 2015/02/24
(85) Entrée phase nationale/National Entry: 2010/03/05
(86) N° demande PCT/PCT Application No.: GB 2008/050818
(87) N° publication PCT/PCT Publication No.: 2009/040569
(30) Priorité/Priority: 2007/09/28 (US11/906,147)

(51) Cl.Int./Int.Cl. *E21B 7/02* (2006.01), *E21B 19/00* (2006.01), *E21B 19/084* (2006.01)

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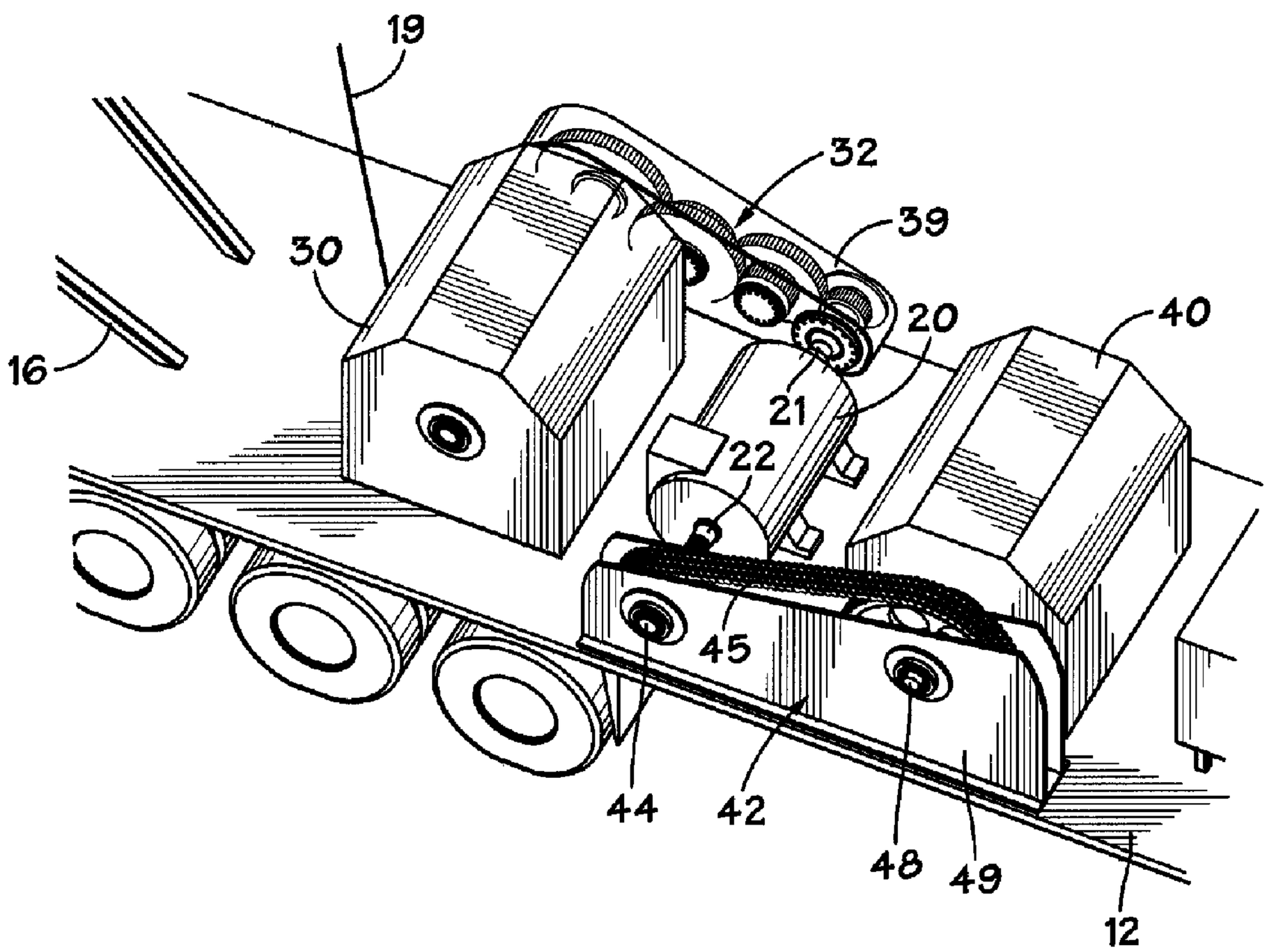
(54) Titre : APPAREIL DE FORAGE TERRESTRE MOBILE
(54) Title: A MOBILE LAND RIG



(57) Abrégé/Abstract:
A mobile land rig for use in wellbore operations, the mobile land rig comprising a vehicle (12,14), an erectable mast (16) on the vehicle (12,14), winch apparat us (30,40) on the vehicle, and electric motor 5 apparatus (20) on the vehicle for powering the winch apparatus (30,40).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 April 2009 (02.04.2009)

PCT

(10) International Publication Number
WO 2009/040569 A2

(51) International Patent Classification:
E21B 7/02 (2006.01)

(21) International Application Number:
PCT/GB2008/050818

(22) International Filing Date:
12 September 2008 (12.09.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/906,147 28 September 2007 (28.09.2007) US

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(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, BR, BW, BY, BZ, CA, CH, 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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,

[Continued on next page]

(54) Title: A MOBILE LAND RIG

(57) Abstract: A mobile land rig for use in wellbore operations, the mobile land rig comprising a vehicle (12,14), an erectable mast (16) on the vehicle (12,14), winch apparat us (30,40) on the vehicle, and electric motor 5 apparatus (20) on the vehicle for powering the winch apparatus (30,40).

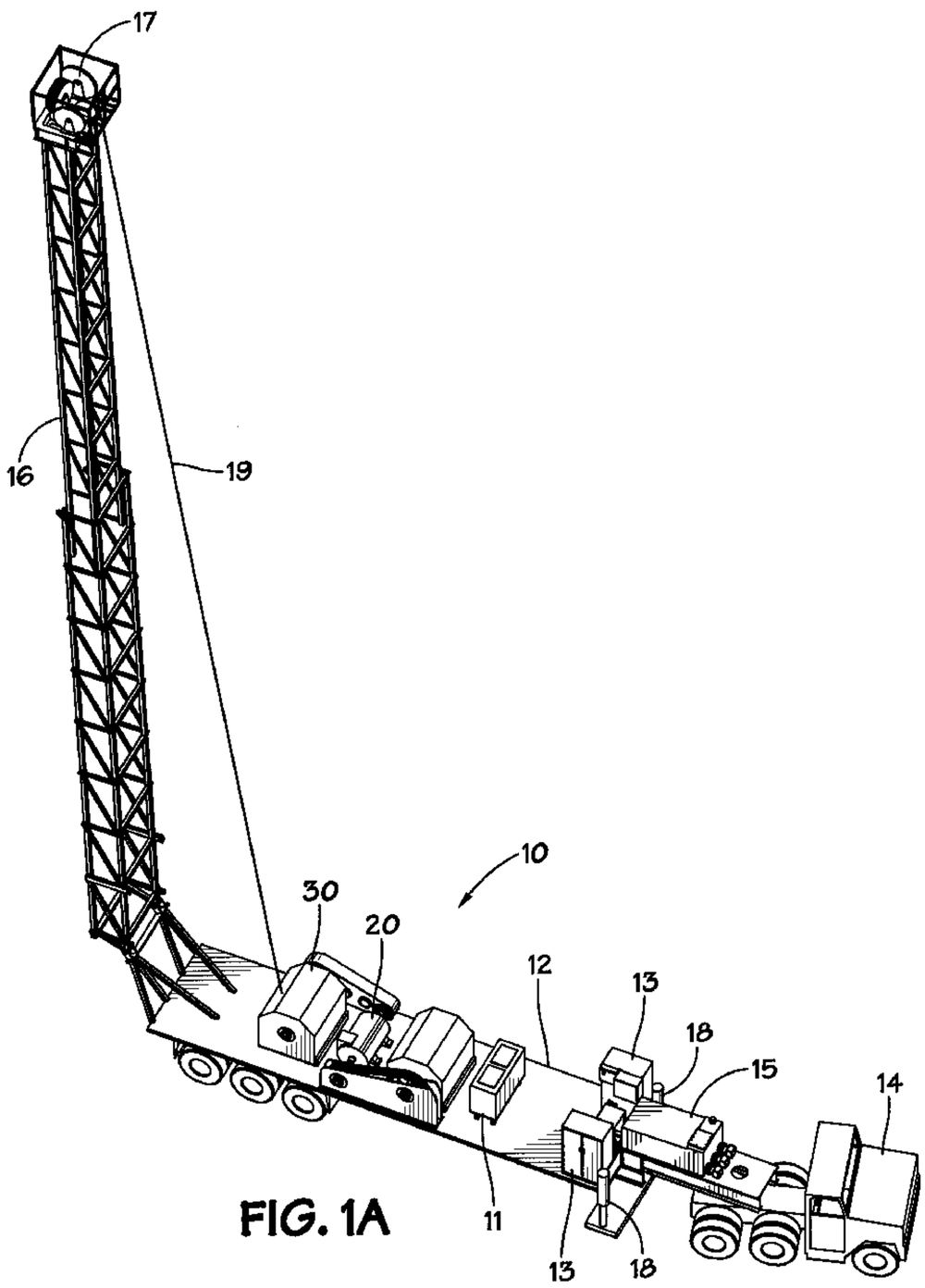

FIG. 1A

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NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report*

A MOBILE LAND RIG

The present invention relates to a mobile land rigs and to a method for facilitating servicing a well using a mobile land rig.

Well servicing rigs, which are not used to drill a wellbore, perform a variety of operations after an oil or gas well has been drilled to get a well ready for production; for example, and not by way of limitation: logging operations; swabbing operations; operations involving the insertion of pipe or tubing into the well; and a perforation operation to perforate tubing.

A typical well servicing rig is disclosed in U.S. Patent 6,003,598, which has a mobile vehicle/carrier with a collapsible mast or derrick which may be hydraulically raised and lowered by means of hydraulic pistons. A first winch and cable as provided near the crown of the derrick perform functions such as manipulating joined pipe segments if required. A second winch assembly and a drum having on it a line and item or tool, for example, a conductive wireline with a logging instrument to be lowered into the well to permit logging.

Established producing wells are often "worked over" or serviced from time to time, including replacing downhole equipment or lowering or raising objects into the wellbore such as casing, tubing, rods, tools, etc. When such service operations become necessary, often a portable workover rig is used which can be moved to the well site and set up. Certain known workover rigs have a derrick or mast which supports pulleys or block and tackle arrangements; a mainline drum about which a heavy cable is wound and the free end connected over a crown block and connected to a travelling block. By rotating the drum, the travelling block is raised or lowered on

the drilling mast as is necessary. Another drum, called a sandline drum (not used with the travelling block), has a line wound about it which goes up over the crown block and is then connected to an object such as a swab mandrel which is to be lowered into the well bore to a selected depth. The mainline drum and the sandline drum are each driven by a dedicated separate motor, typically for example a system with diesel-powered engines and associated drive shafts, clutches, right angle gear boxes, chains, and sprockets; or hydraulic motors.

Providing hydraulic power fluid to well servicing rigs and workover rigs has presented a variety of problems. When hydraulic systems leak, hydraulic fluid is spilled polluting the environment. Hydraulically-powered motors and apparatuses, especially in multi-motor systems, are relatively heavy; relatively noisy; require a large amount of space on a rig; and are relatively complex and expensive to operate and maintain. Diesel-powered engine systems for servicing rigs and workover rigs present issues with excessive weight, power efficiency, safety concerns, excessive noise, inefficient manually operated-braking systems, diesel fume pollution and relatively high maintenance costs.

The prior art discloses a variety of mobile rigs, well servicing rigs, workover rigs, and components of them; for example, and not by way of limitation, the following U.S. Patents present exemplary systems and components thereof: U.S. Patents 2,704,653; 2,847,098; 3,109,523; 3,670,831; 3,734,210; 3,994,350; 4,257,578; 4,290,495; 4,371,046; 4,432,532; 4,478,291; 4,555,092; 4,591,006; 4,756,366; 5,094,302; 5,794,723; and 7,249,629 - these patents all incorporated fully herein for all purposes.

The present inventor has recognized the need for low weight, low cost, more efficient, safer, less noisy, environmentally-friendly mobile rigs for well servicing and workover, in certain aspects, with advanced control systems and/or improved braking performance. The present inventor has recognized the need for such rigs which are effective and efficient, yet relatively simple. The present inventor has recognized the need for such rigs with motors that are not hydraulically powered and rigs that are not powered through complicated mechanical drive arrangements. The present inventor has recognized the need for providing an electrical motor powered hoisting and braking system for the main drum and sand line drum, combined with an advanced electronic computerized control system in well servicing rig systems that are lighter quieter, safer, more efficient, and friendlier to the environment than conventional mechanical or hydraulically powered well servicing rigs.

In accordance with the present invention, there is provided a mobile land rig for use in wellbore operations, the mobile land rig comprising a vehicle, an erectable mast on the vehicle, winch apparatus on the vehicle, and electric motor apparatus on the vehicle for powering the winch apparatus.

Preferably, the winch apparatus includes a main winch and a sandline winch. The main winch is commonly known as a drawworks. Advantageously, the electric motor apparatus is a single electric motor. Preferably, both the main winch and the sandline winch are powered by the single electric motor. Advantageously, the single electric motor has a drive shaft. Preferably, the electric motor has two drive shafts. Advantageously, the drive shaft is selectively rotatably coupled and

decoupled to at least one of the main winch and the sandline winch with a coupling. The coupling may be cylindrical and preferably of circular cross-section, the coupling having a length and a diameter with a splined inner surface, the splines arranged substantially longitudinally with the length of the cylinder. Preferably, the main winch and the sandline line winch are selectively rotatably coupled to the drive shaft with at least one gear. Advantageously, the main winch and the sandline line winch are selectively rotatably coupled to the drive shaft with at least one further gear. Preferably, the at least one gear and the at least one further gear each have teeth which intermesh. Preferably, having a plurality of intermeshing gears, advantageously, reduction gears. Advantageously, the mobile land rig further comprises a chain or belt rotatably linking the at least one gear and the at least one further gear. Preferably, the at least one gear comprises a shaft, at least one of the shaft and drive shaft having a splined portion, the coupling having a splined surface, the shaft selectively rotatably coupled with the drive shaft by moving the coupling to engage the splined portion with the splined surface.

Preferably, the electric motor apparatus provides braking while the winch apparatus lowers a load.

Advantageously, the mobile land rig further comprises mast erection apparatus which is electrically powered, which preferably comprises an electric winch. Preferably, the mobile land rig further comprises vehicle levelling apparatus which is electrically powered, which preferably comprises an electrically-operated ball screw unit. Advantageously, the mobile land rig further comprises a computerized control system for controlling

the electric motor apparatus.

Preferably, the electric motor apparatus is one of: an AC induction motor; DC motor; permanent magnet motor; and a printed circuit board permanent magnet motor. Advantageously, the mobile land rig further comprises a power source for the electric motor apparatus.

Preferably, the mobile land rig further comprises a power source, which is one of: battery; and generator. Advantageously, the mobile land rig further comprises a control system in controlling communication with the electric motor apparatus and the winch apparatus, and an operator panel in communication with the control system whereby an operator can control the electric motor apparatus and the winch apparatus.

The present invention also relates to a method for facilitating servicing a well using a well servicing rig, the method comprising the steps of erecting a mast on a vehicle of a mobile land rig, the mobile land rig including winch apparatus on the vehicle and electric motor apparatus on the vehicle for powering the winch apparatus, and winching an item with the winching apparatus.

Preferably, the mobile land rig is a mobile land well servicing rig, not used for drilling wells.

In accordance with the present invention, there is provided a mobile rig for well operations which has apparatuses, for example winch apparatus, powered by an electric motor or motors. In certain aspects, such a rig has one or more single-board computers in a control system and/or one or more programmable logic controllers or a similar type of electronic control devices.

In certain particular aspects, the present invention teaches a mobile rig with a single electric motor which

provides power for a main winch apparatus and for a sandline winch apparatus. In certain aspects, the single electric motor also provides the primary braking function for each of the winch apparatuses.

In certain aspects, the present invention discloses a mobile rig with a single, dual-shaft electric motor which provides power to two winch systems.

In certain aspects, the present invention teaches a mobile rig with an electric motor or motor which is engaged for both hoisting operations and for lowering items into a wellbore, providing control of a load being lowered into a wellbore.

In certain aspects, the present invention teaches a mobile rig with a drawworks powered by its own permanent magnet electric motor and a sandline winch powered by its own permanent magnet electric motor.

In certain aspects, the present invention discloses a rig which employs electric power for a variety of rig functions, for example, but not limited to, winch operation, mast raising, and outrigger deployment; rigs in which all such operations are powered by electric motors; and/or with a motor or motors that provide control while lowering a load and/or a braking function.

Such systems and methods which employ multiple electric motors or a single electric motor, and, in one particular aspect, a rig with a single electric motor to operate two winches; and

Such systems and methods which significantly reduce or eliminate leakage of hydraulic fluids.

For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1A is a top perspective view of an apparatus in accordance with the present invention;

Figure 1B is an enlarged perspective view of part of the apparatus shown in Figure 1A;

Figure 1C is an enlarged perspective view of part of the apparatus shown in Figure 1A;

Figure 1D is a top view of part of the apparatus shown in;

Figure 1E is a partial cross-section view of part of the apparatus shown in Figure 1A;

Figure 1F is a partial cross-section view of part of the apparatus shown in Figure 1A;

Figure 1G is a partial cross-section view of part of the apparatus shown in Figure 1A;

Figure 2A is a perspective view of an apparatus in accordance with the present invention;

Figure 2B is a side view of the apparatus shown in Figure 2A;

Figure 2C is a top perspective view of the apparatus shown in Figure 2A;

Figure 2D is a top view of the apparatus shown in Figure 2A;

Figure 2E is an enlarged top view of part of the apparatus shown in Figure 2D;

Figure 2F is a perspective view of part of the apparatus shown in Figure 2A;

Figure 2G is a partial cross-section view of part of the apparatus shown in Figure 2A;

Figure 2H is a partial cross-section view of part of the apparatus shown in Figure 2A;

Figure 2I is a partial cross-section view of part of the apparatus shown in Figure 2A;

Figure 3A is a side view of an apparatus in accordance with the present invention;

Figure 3B is a top view of the apparatus shown in Figure 3A; and

Figure 4 is a side schematic view of an apparatus in accordance with the present invention.

Figures 1A to 1G show an apparatus 10 in accordance with the present invention which includes a vehicle with a trailer 12 moved by a truck 14 and a mast 16 which can be raised from the trailer 12 to an erected position as shown in Figure 1A. Levelling jacks 18 support the trailer 12. Optionally, no separate truck is used and the rig is self-propelled.

An electric motor 20 provides power to operate a main winch 30 (also called a drawworks) and a sandline winch 40. The motor 20 has two drive shafts, with one shaft extending from each end of the motor. One drive shaft 21 drives the main drum winch 30 via a gear system 32. Optionally, a chain drive system is used. Another drive shaft 22 drives the sandline winch via a chain drive system 42. A shiftable cutout coupling 23 selectively couples the drive shaft 21 to a shaft 37a of the gear system 32. A housing 39 encloses the gears and shafts.

A shiftable cutout coupling 24 selectively couples the drive shaft 22 to a shaft 44 of the chain drive system 42. The gear system 32 includes intermeshed gears 35a - 35f on shafts 38a-38d, respectively, which drive a drive shaft 36 of the main drum winch 30. The chain drive system 42 drives a drive shaft 46 of the sandline winch 40. The chain drive system 42 has a chain 45 on

sprockets 46a, 46b mounted, respectively, on the shaft 44 and a shaft 48. A housing 49 partially encloses the chain 45. The system 10 includes a blowout preventer control cabinet 15; an AC drive compartment 13; and a water cooled resistor tank 11 for removing the power (heat) generated during braking functions with the motor 20.

In one particular aspect, the motor 20 is a 1250 horsepower (930 kW) AC induction motor which provides a main winch hoisting capacity of 500 horsepower and a lowering capacity of 1250 horsepower (930 kW). In other particular aspects, the motor's horsepower is between 800 horsepower to 1500 horsepower (600 kW to 1120 kW). Such a motor can provide controlled lowering of a load, for example up to 250,000 pounds (113,636 kilograms). Any system in accordance with the present invention can have such an electric motor or any other suitable electric motor.

Comparing the system 10 in one particular comparison to a traditional rig with two separate hydraulically powered motors, one for each winch (for example 500 horsepower (370 kW) motors) and using a 1250 horsepower (930 kW) AC motor with the system 10, it is anticipated that the system 10 will achieve a tripping in time of 22 seconds, and a tripping out time of 30 seconds (total tripping time 52 seconds); whereas with the traditional system tripping in time is 26 seconds, tripping out time is 55 seconds, for a total tripping time of 81 seconds. ("Tripping in time" is the time required to lower tools, tubing, or other well components approximately sixty feet (18m) into the hole and "tripping out time" is the time required to raise tools, tubing, or other well components approximately sixty feet up out of the hole.) A single

joint of drill pipe used in a drill string or tool string is usually in the order of thirty feet (9m) long.

Figures 2A to 2I show a system 100 in accordance with the present invention which in some aspects is like the system 10, Figure 1A (like numerals indicate like parts). A motor 120, similar to the motor 20, Figure 1A, has a single drive shaft 122 which drives both the gear system 32 and the chain drive system 42, thus a single motor drive shaft drives the main winch 30 and the sandline winch 40.

A coupling 102 couples the motor drive shaft 122 to the drive shaft 37a of the gear system 32 and a shifting mechanism 104 selectively couples the drive shaft of the gear system 32 to the drive shaft 44 of the chain drive system 42. Figure 2G shows the shifting mechanism 104 in a neutral position (engaging neither splines 106 on the shaft 37a nor splines 108 on the shaft 44). Figure 2H shows the system with the main winch 30 (drawworks) engaged; the shifting mechanism 104 has engaged the splines 106 on the shaft 37a. Figure 2I shows the system with the sandline winch 40 engaged; the shifting mechanism 104 has engaged the splines 108 on the shaft 44.

Figures 3A and 3B show a system 200 in accordance with the present invention which includes a truck 202 that pulls a trailer 204. An erectable mast 206 initially rests on the trailer 204. The trailer 204 includes outrigger levelling jacks 208. The trailer 204 supports a main drum or drawworks winch 210 and a sandline winch 220. In one particular aspect, the mast is raised by a system ST (shown schematically) which has a small electrically-powered winch or an electrically-powered ball screw system BC. A system SY (shown

schematically) with an electric motor raises and lowers the outrigger levelling jacks 208. Optionally, the system SY includes an electrically operated ball screw system BR (shown schematically) built into the outrigger system.

In one aspect, the main drum winch 210 has an internal electric motor system and the sandline winch 220 has an internal electric motor system. In one aspect the motors are AC permanent magnet motors (which may be the case for any motor in any system in accordance with the present invention) with an AC drive system 250.

The AC drive system converts DC power to variable frequency AC power and includes a cooling unit 252 and an interface panel 254 for the cooling unit. In the cooling unit, water or forced air cools the resistors in a bank 218 that become hot while burning off the power developed during the motor's braking function. The AC motors can "brake" the load during load lowering or stopping. The AC motor simply acts like a generator while braking the load. As it acts like a generator, it produces power which is burned off through the bank of resistors. Such a system has no brake pads or brake shoes and no physical exertion is performed by a mobile rig operator to try to manually brake the load through long lever handles and mechanical linkage to brake bands.

The computerized control system provides signals to the AC motor to safely determine the motor speed and braking activity. The panel 254 is mounted to the floor of the trailer and includes electrical switch gear and control relays for operating the resistor cooling unit 252 and/or air blowers for cooling off the resistor bank. It communicates with temperature sensors associated with the resistor bank.

A system with the blowout preventer panel 214 has control valves and gages which close the blowout preventer, for example in the event of an undesirable escape of gas (blowout) from the wellbore.

An operator panel 222, in communication with the apparatuses, winches, and devices of the system 200, allows an operator to perform the various functions of the system 200.

The electric motors 230, 240 may, in accordance with the present invention, be any suitable electric motor (as may be true for any system in accordance with the present invention) including, but not limited to: AC induction motors; permanent magnet motors; printed circuit board permanent magnet motors; or direct current (DC) motors.

Power is supplied to the motors 230, 240 from a power source 260 which may include (as is true for powering any motor of any system in accordance with the present invention): local utility power; power from batteries; power from a power storage device or facility; and/or one or more independent engine generator units.

Figure 4 shows schematically a system 300 in accordance with the present invention which has a truck 302 with a trailer 304 having an erectable mast 306 and levelling jacks 308. A system operator 310 in a cabin 312 controls the various apparatuses, winches, and functions of the system 300 via a control system 314. A system 324 raises the mast 306.

The system 300 has a main winch 320, a sandline winch 330, and an electric motor 340 which provides power for both winches. Appropriate lines 331, 332 around appropriate sheaves 333-335, support and move various items, for example tubing 336 and/or tool 337 in a wellbore 338.

Power for the electric motor 340 is provided from a power source 350 (shown schematically). The electric motor 340 can run both winches. The levelling jacks 308 and the system 324 can include electrically operated ball screw units.

The embodiments of the present invention for which an exclusive property or privilege is claimed are defined as follows:

1. A mobile land rig for use in wellbore operations, the mobile land rig comprising a vehicle, an erectable mast on the vehicle, a main winch apparatus and a sandline winch on the vehicle, and a single electric motor on the vehicle for driving both the main winch and the sandline winch, wherein the single electric motor has a drive shaft selectively rotatably coupled and decoupled to at least one of the main winch and the sandline winch with a coupling, the main winch selectively rotatably coupled to the drive shaft with at least one gear and at least one further gear intermeshing therewith and the sandline winch selectively rotatably coupled to the drive shaft with at least one gear with at least one further gear with a chain or belt linking the at least one gear and the at least one further gear.

2. The mobile land rig as claimed in Claim 1, wherein the at least one gear and the at least one further gear each have teeth which intermesh.

3. The mobile land rig as claimed in Claim 1 or 2, wherein the at least one gear comprises a shaft, at least one of the shaft and drive shaft having a splined portion, the coupling having a splined surface, the shaft selectively rotatably coupled with the drive shaft by moving the coupling to engage the splined portion with the splined surface.

4. The mobile land rig as claimed in any one of Claims 1 to 3, wherein said electric motor has two drive shafts.

5. The mobile land rig as claimed in any one of Claims 1 to 4, wherein the electric motor apparatus provides braking while the winch apparatus lowers a load.

6. The mobile land rig as claimed in any one of Claims 1 to 5, further comprising mast erection apparatus which is electrically powered.

7. The mobile land rig as claimed in any one of Claims 1 to 6, further comprising vehicle levelling apparatus which is electrically powered.

8. The mobile land rig as claimed in any one of Claims 1 to 7, further comprising a computerized control system for controlling the electric motor apparatus.

9. The mobile land rig as claimed in any one of Claims 1 to 8, wherein the single electric motor is one of: an AC induction motor; DC motor; permanent magnet motor; and a printed circuit board permanent magnet motor.

10. The mobile land rig as claimed in any one of Claims 1 to 9, further comprising a power source for the electric motor apparatus.

11. The mobile land rig as claimed in any one of Claims 1 to 10, further comprising a power source, which is one of: battery; and generator.

12. The mobile land rig as claimed in any one of Claims 1 to 11, further comprising a control system in controlling communication with the single electric motor and the winch apparatus, and an operator panel in communication with the control system whereby an operator can control the single electric motor and the winch apparatus.

13. The mobile land rig as claimed in any one of Claims 1 to 12, wherein the mobile land rig is a mobile land well servicing rig.

14. A method for facilitating servicing a well using a well servicing rig, the method comprising the steps of erecting a mast on a vehicle of a mobile land rig, the mobile land rig including a main winch apparatus and a sandline winch on the vehicle and said single electric motor on the vehicle for powering the main winch apparatus and sandline winch in well servicing operations, wherein the single electric motor has a drive shaft selectively rotatably coupled and decoupled to at least one of the main winch and the sandline winch with a coupling, the method further comprising the step of selectively coupling and uncoupling the single electric motor from rotational engagement with one of the main winch and sandline winch, the main winch selectively rotatably coupled to the drive

shaft with at least one gear and at least one further gear intermeshing therewith and the sandline winch selectively rotatably coupled to the drive shaft with at least one gear and at least one further gear with a chain or belt linking the at least one gear and the at least one further gear.

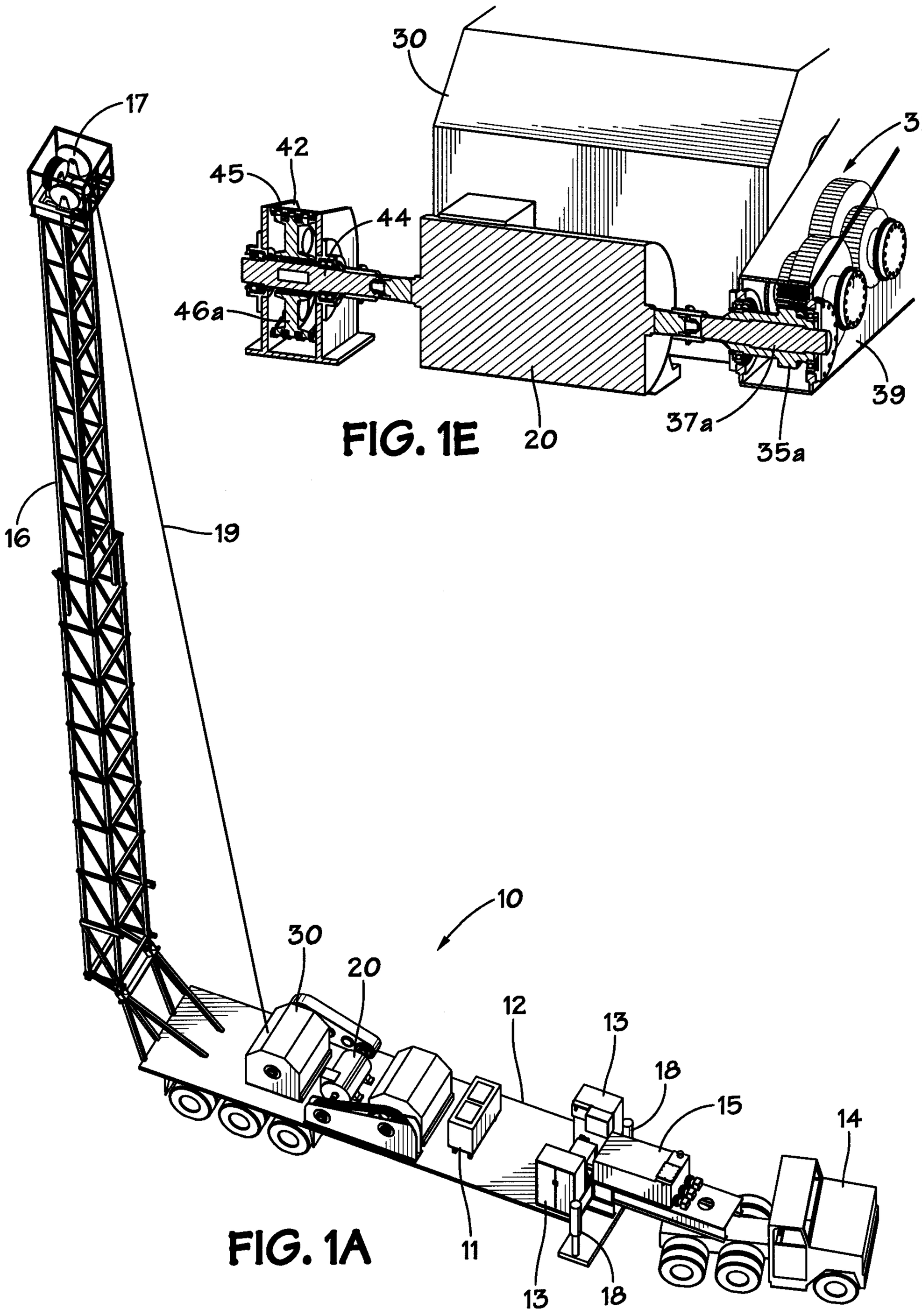
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FIG. 1E

FIG. 1A

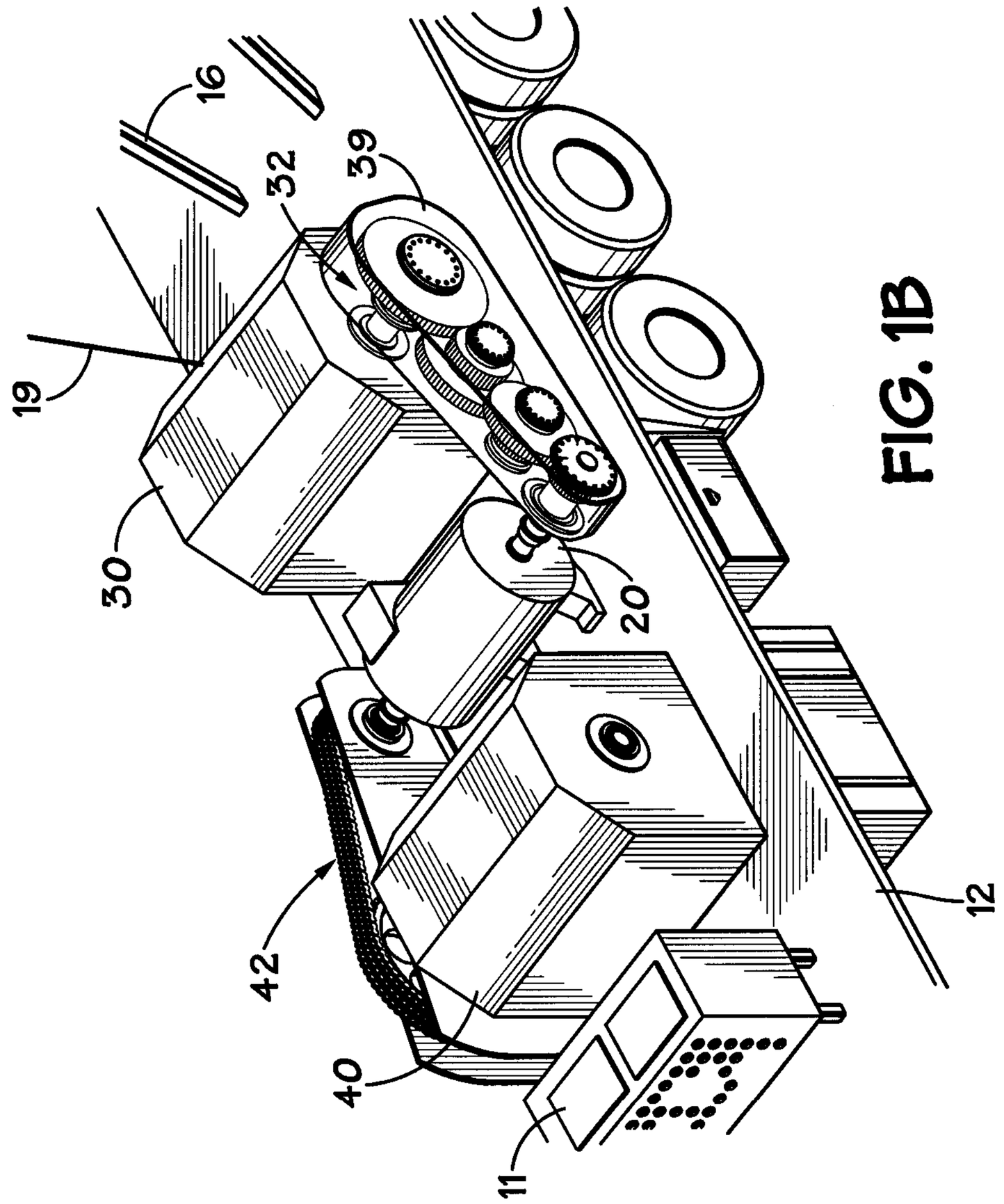

FIG. 1B

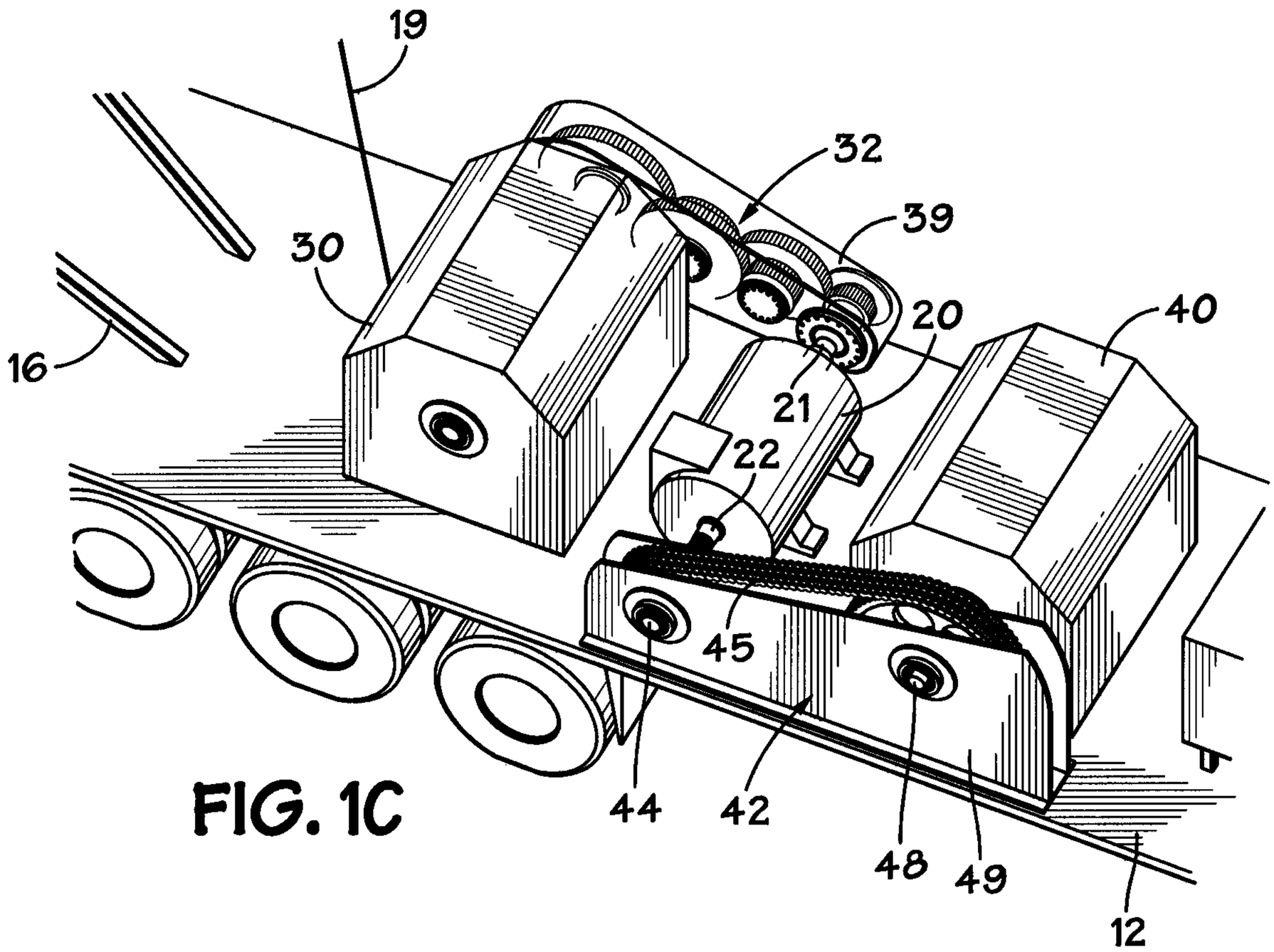
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FIG. 1C

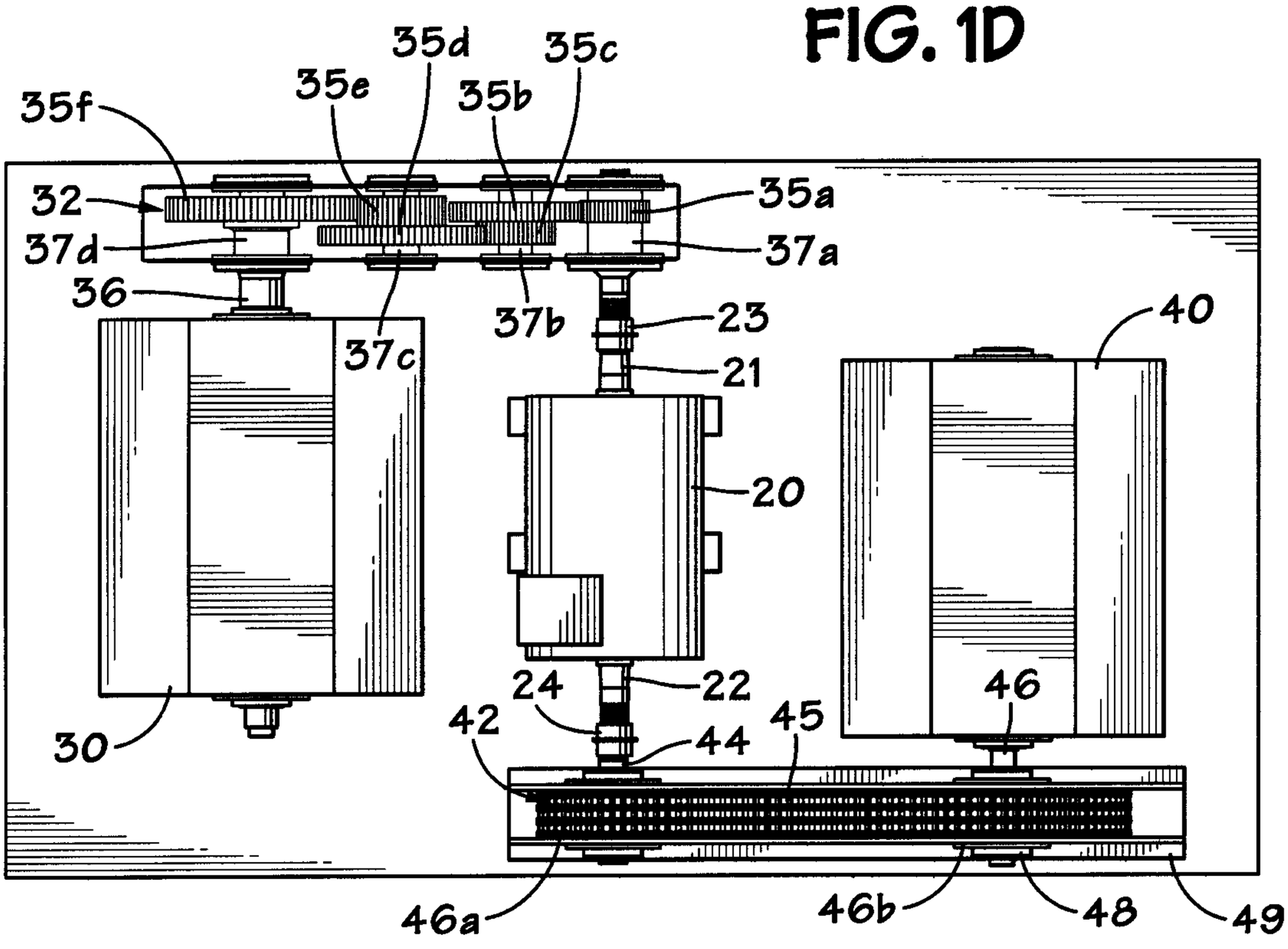
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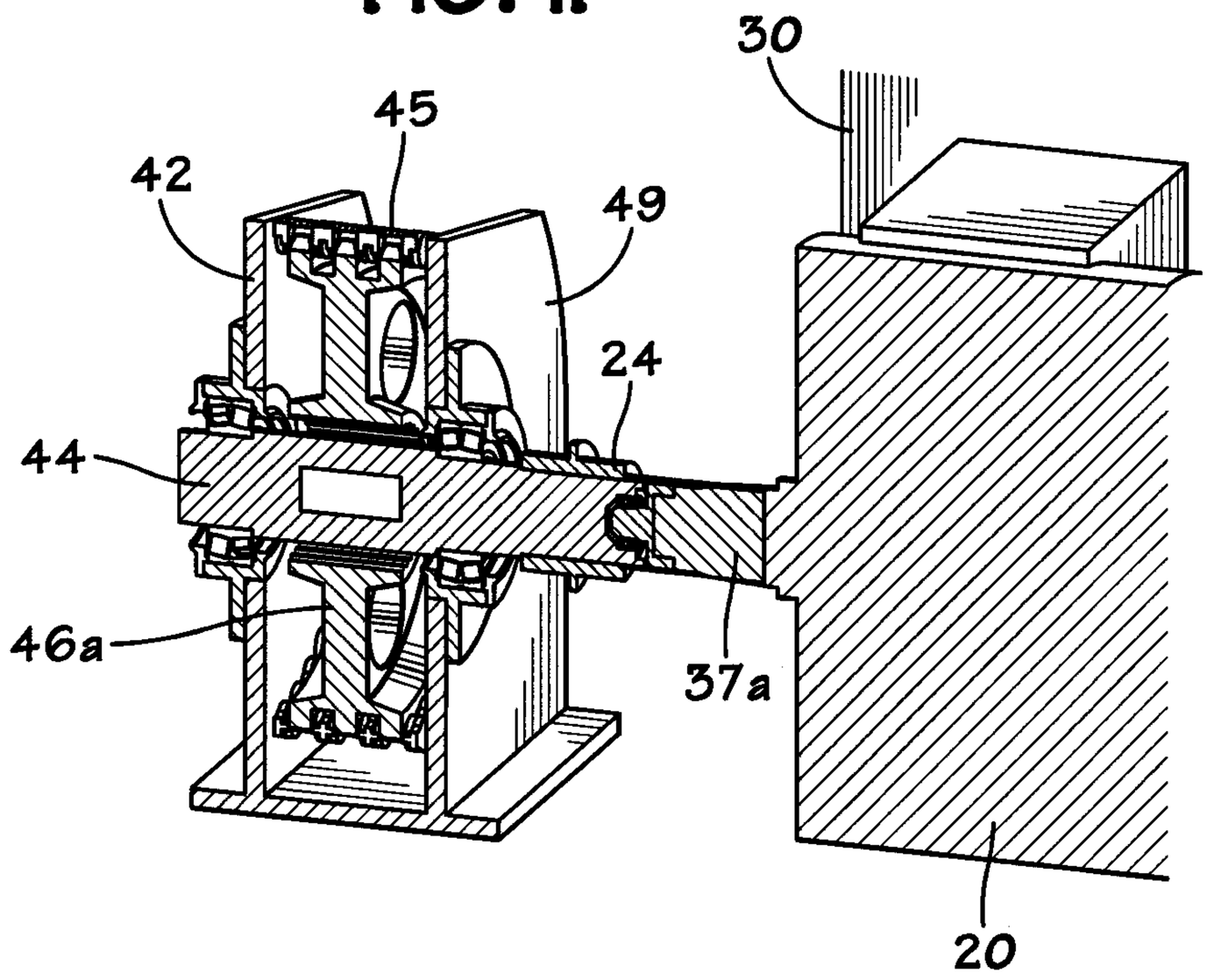
FIG. 1D

FIG. 1F



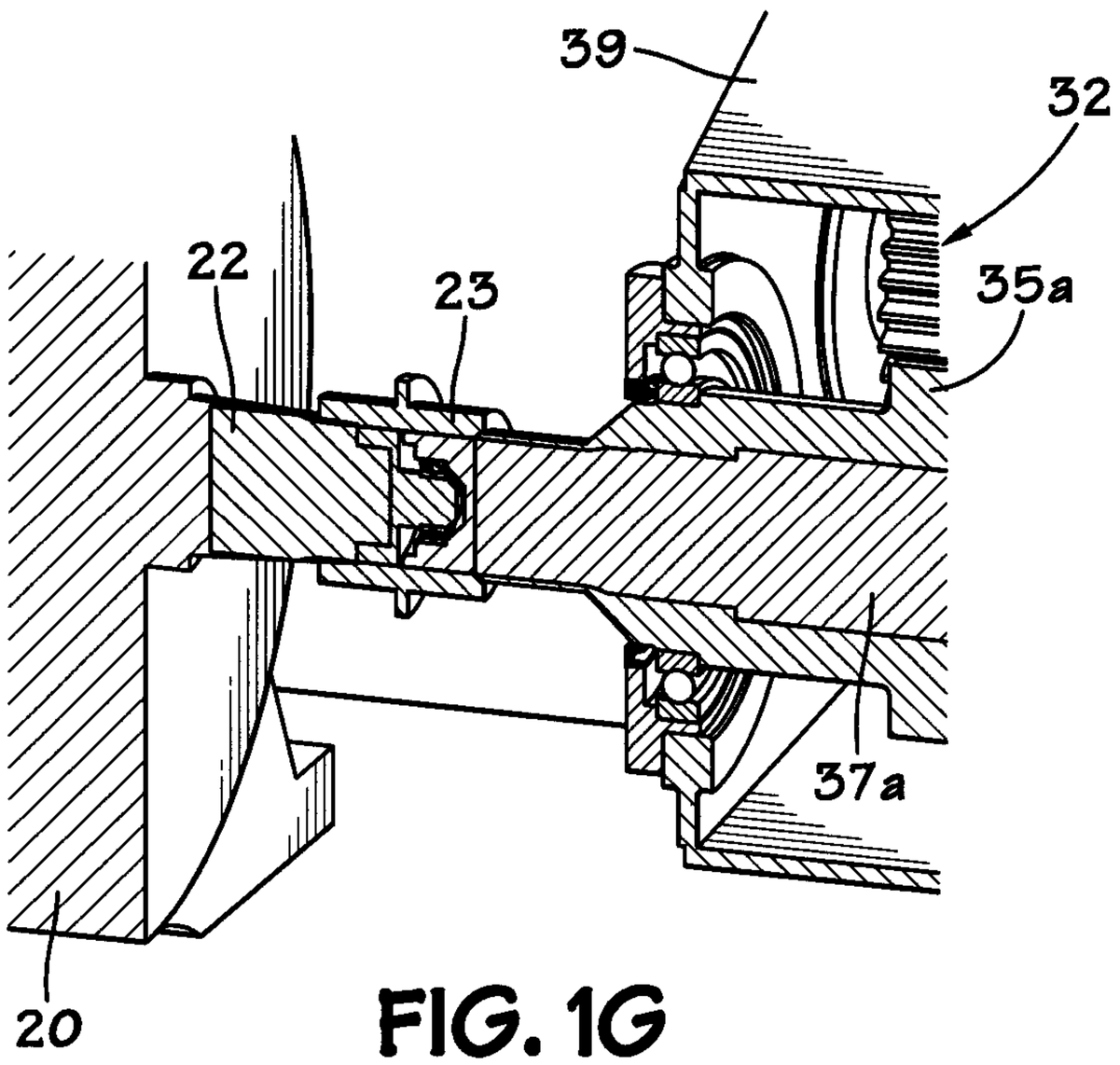


FIG. 1G

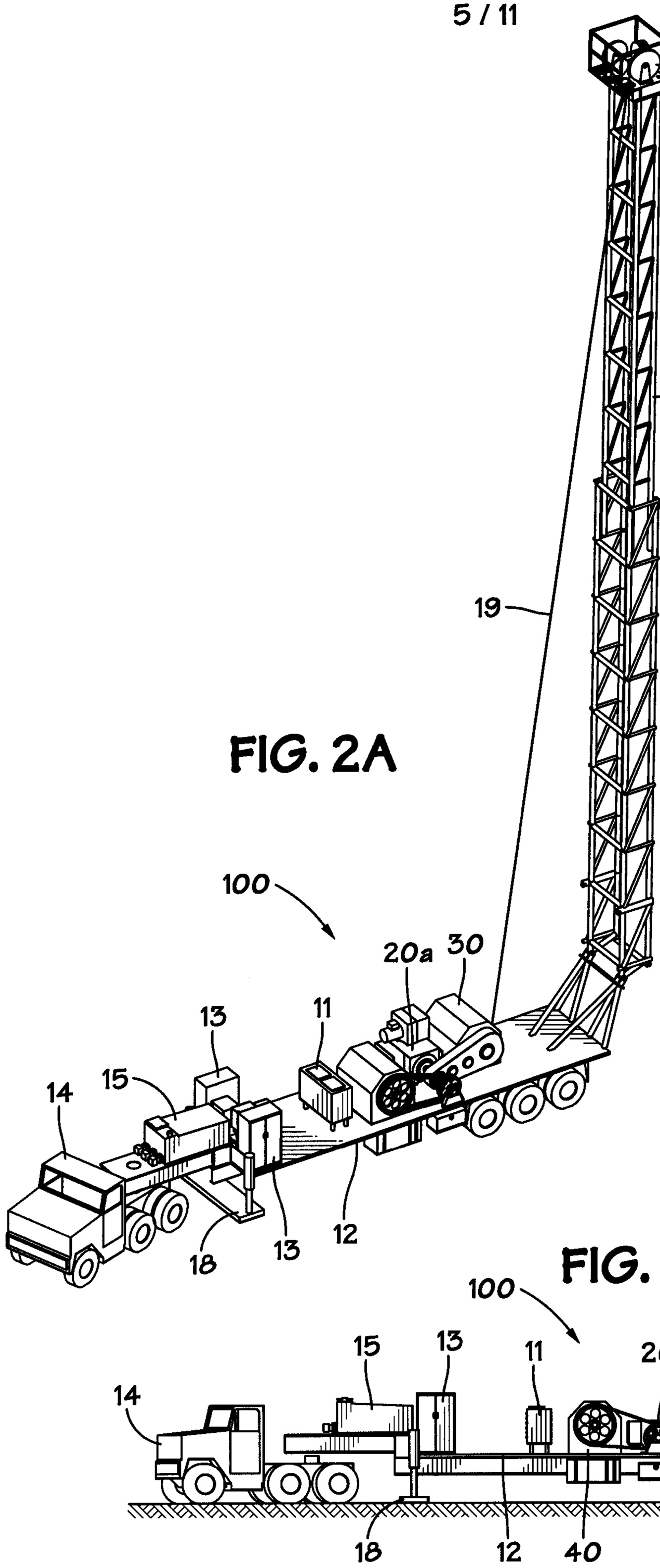
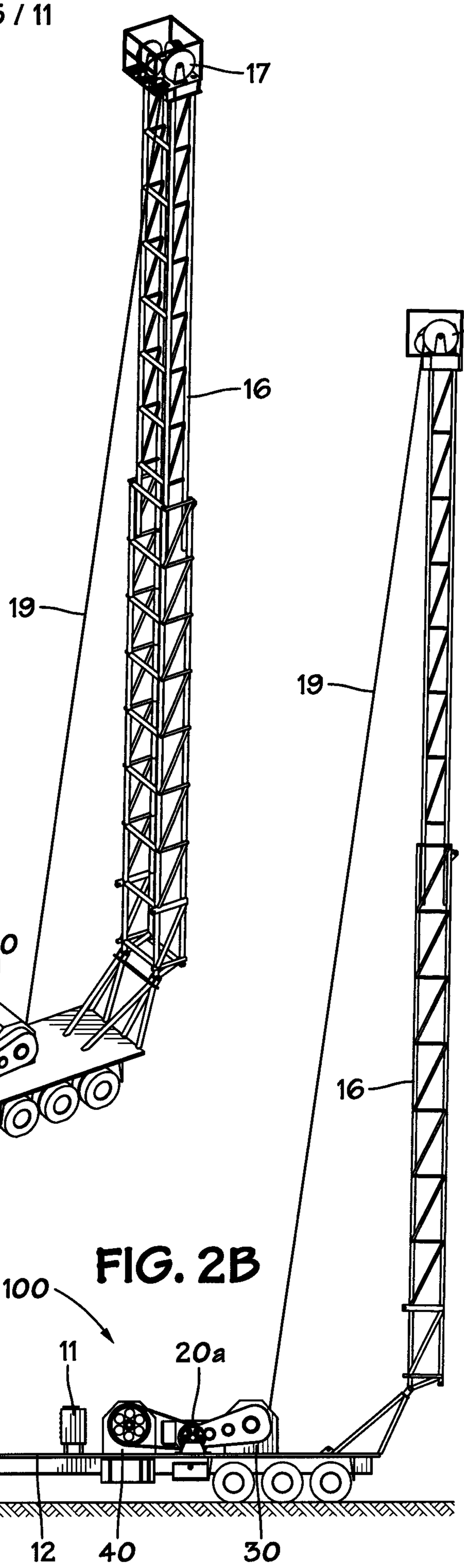

100
14
15
13
11
20a
30
12
18
13

FIG. 2A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19
100
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13
11
20a
14
18
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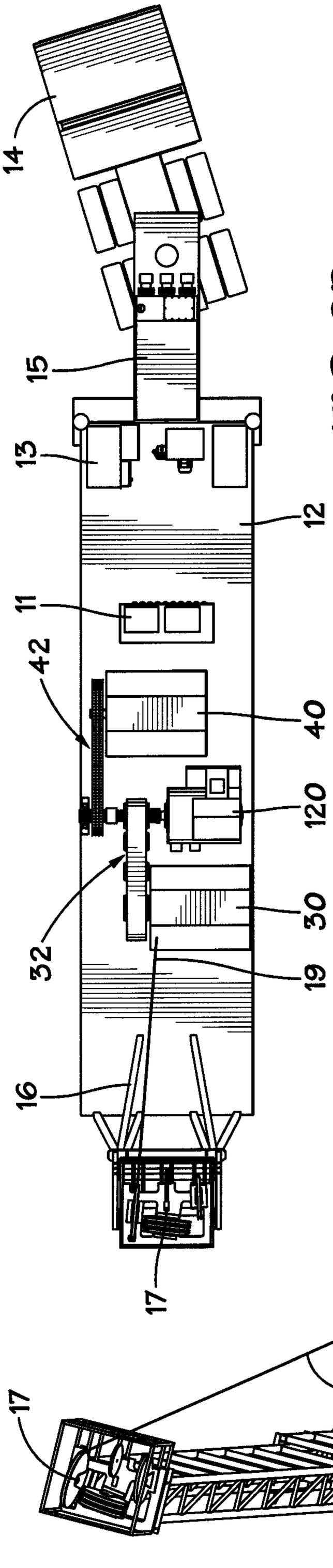
40
30

FIG. 2B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13
12
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120
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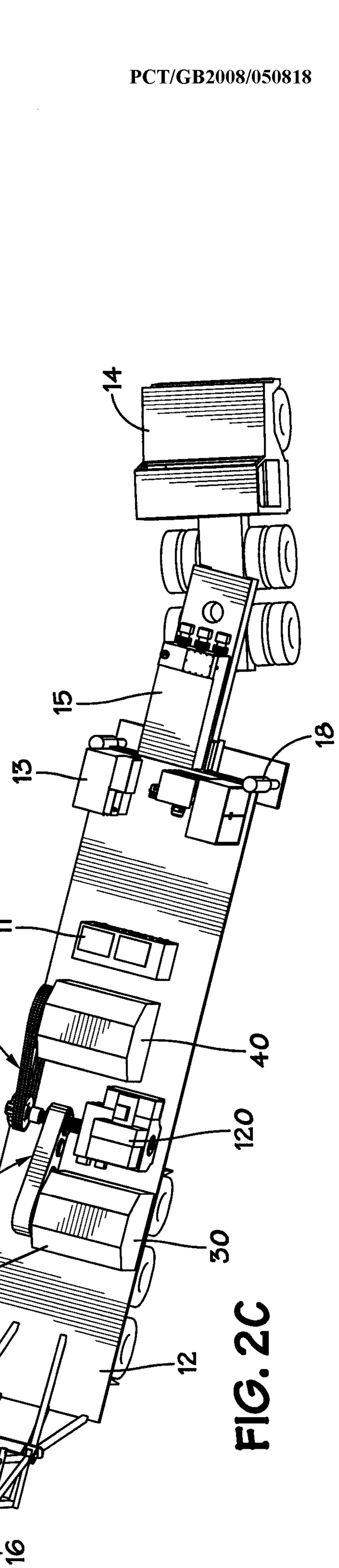
19
16
17

FIG. 2D


14
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120
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12
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FIG. 2C

FIG. 2E

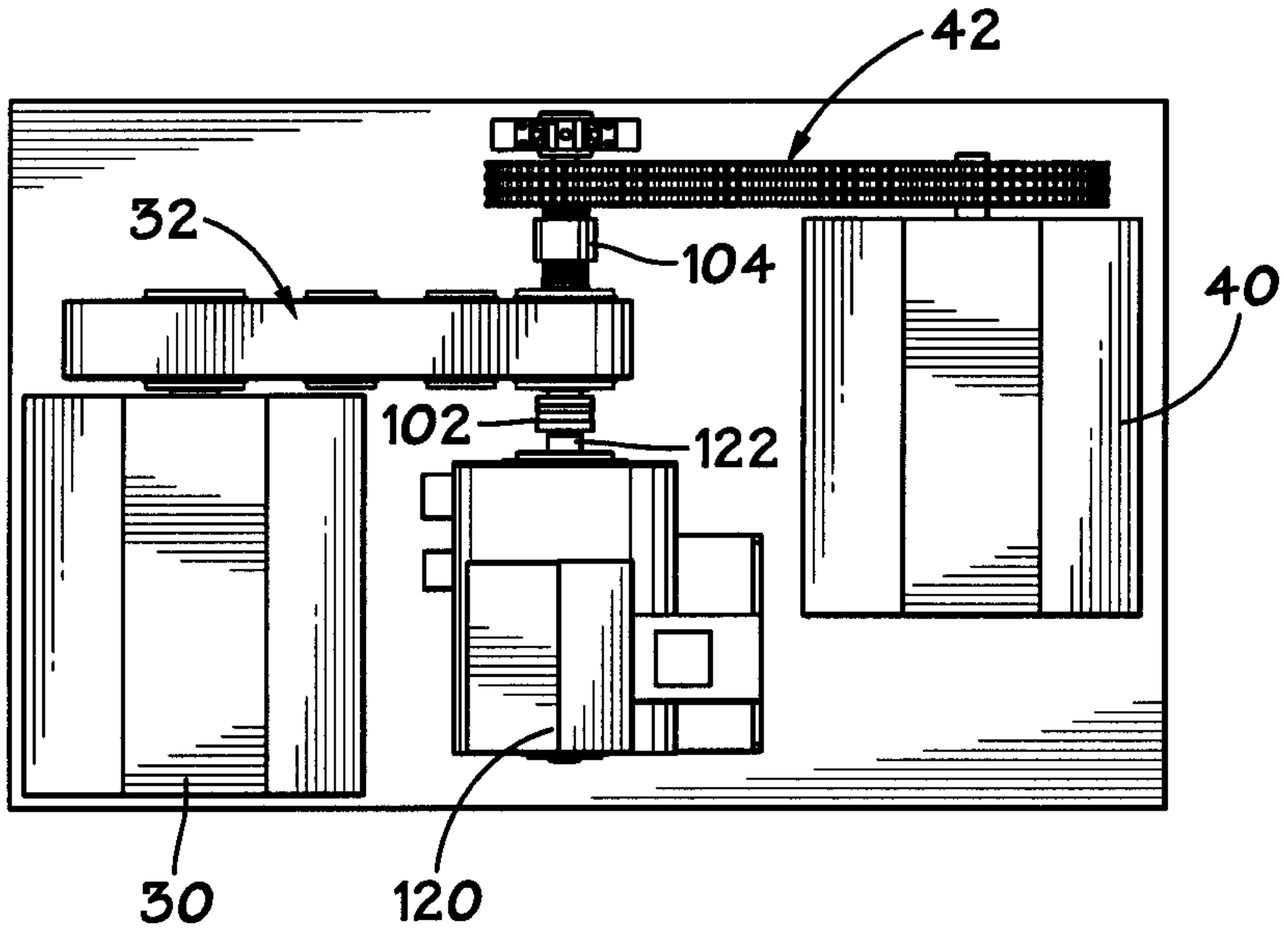
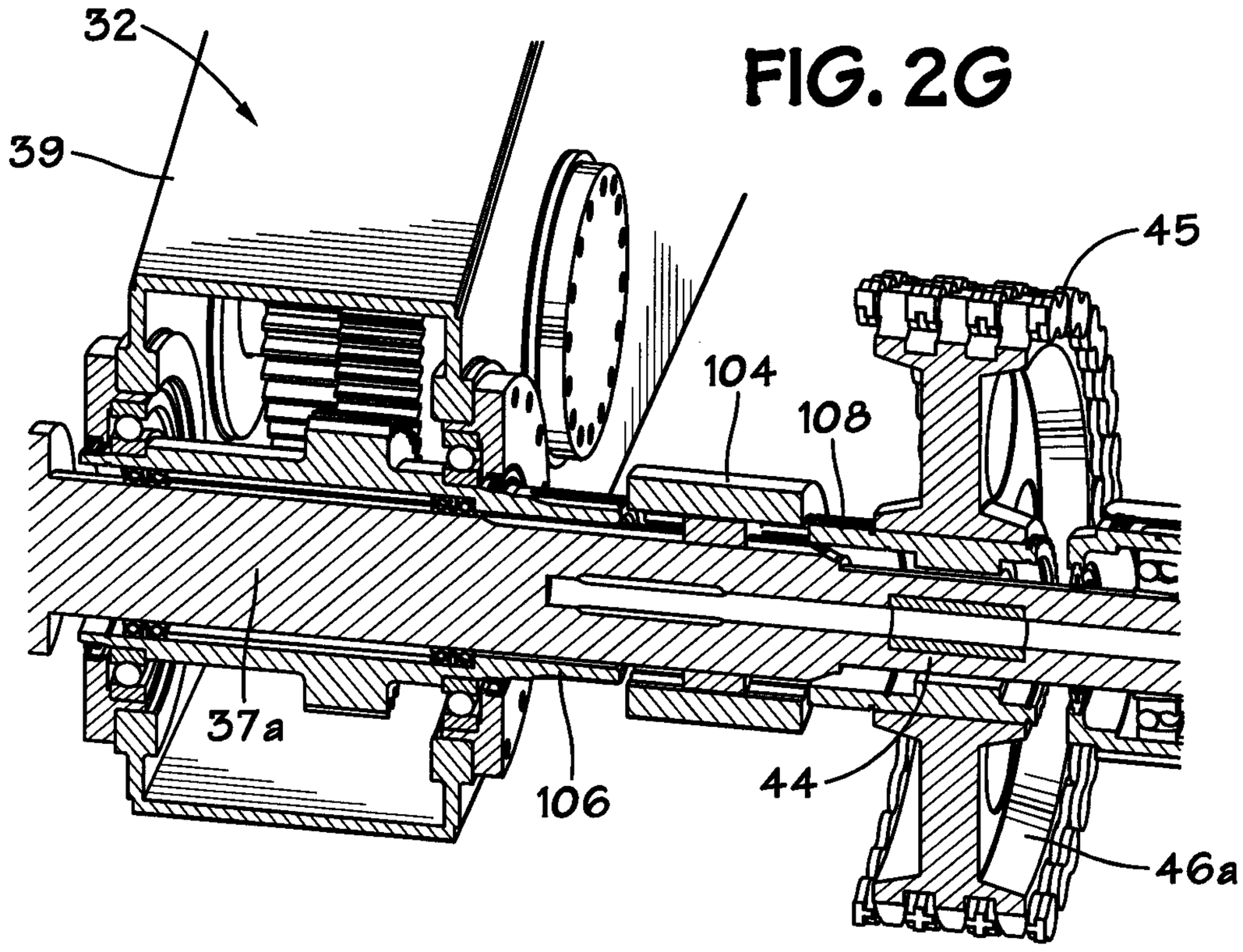


FIG. 2F

FIG. 2G



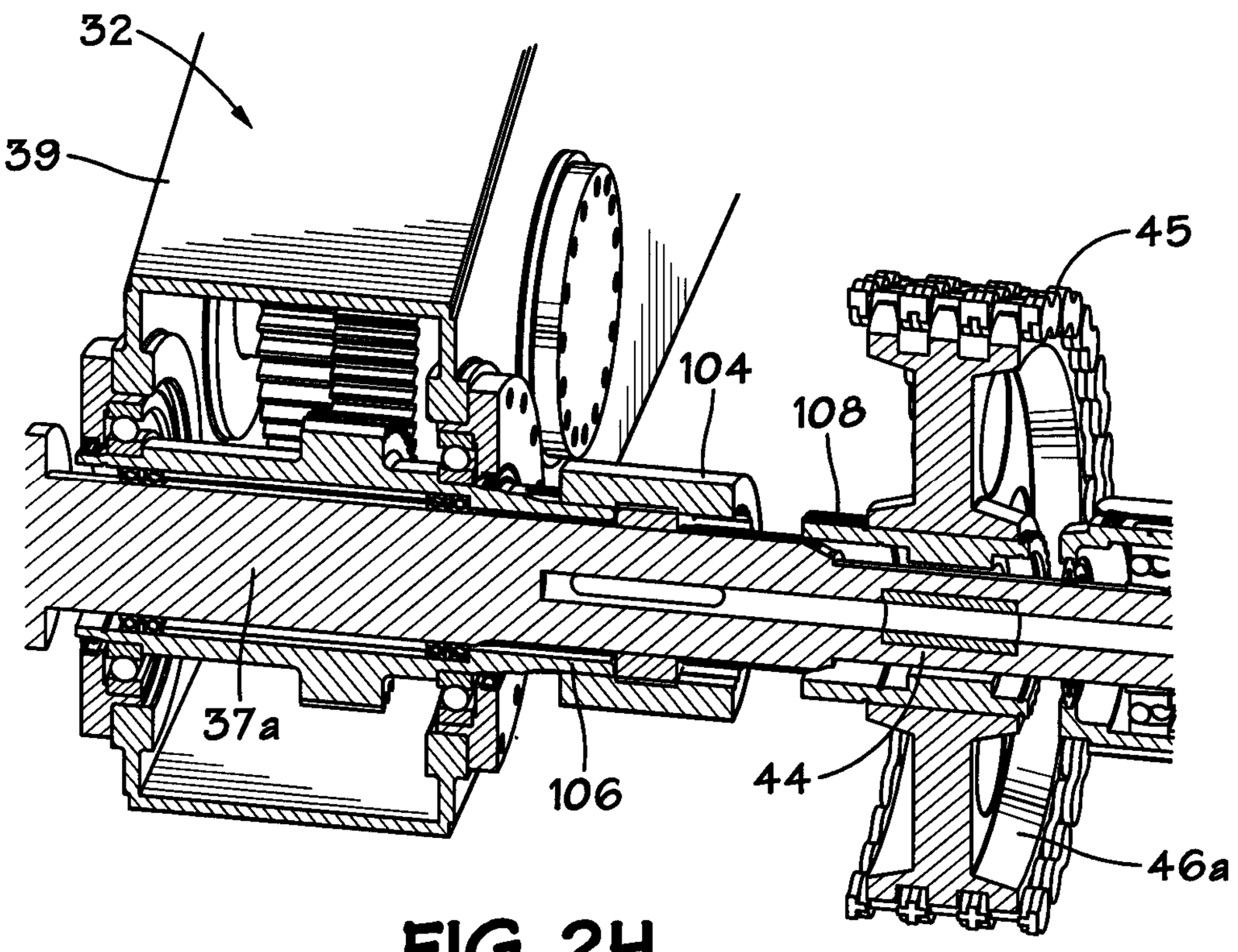
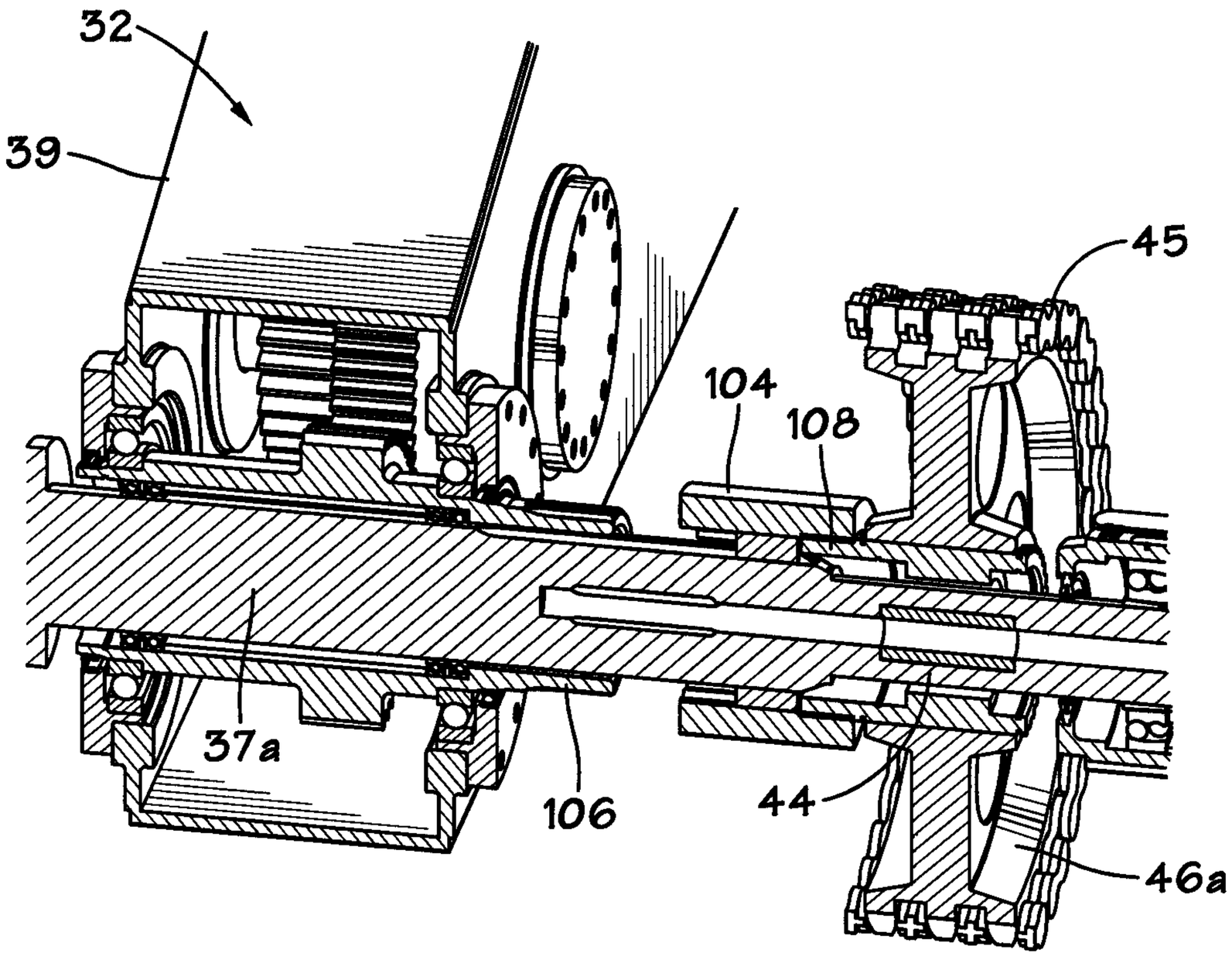


FIG. 2H

FIG. 21



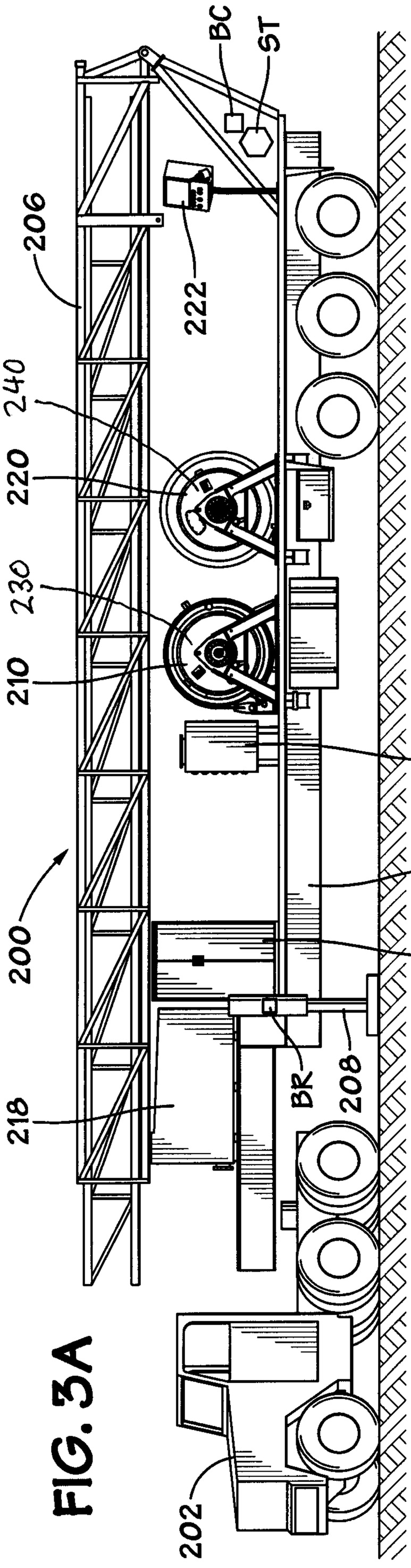

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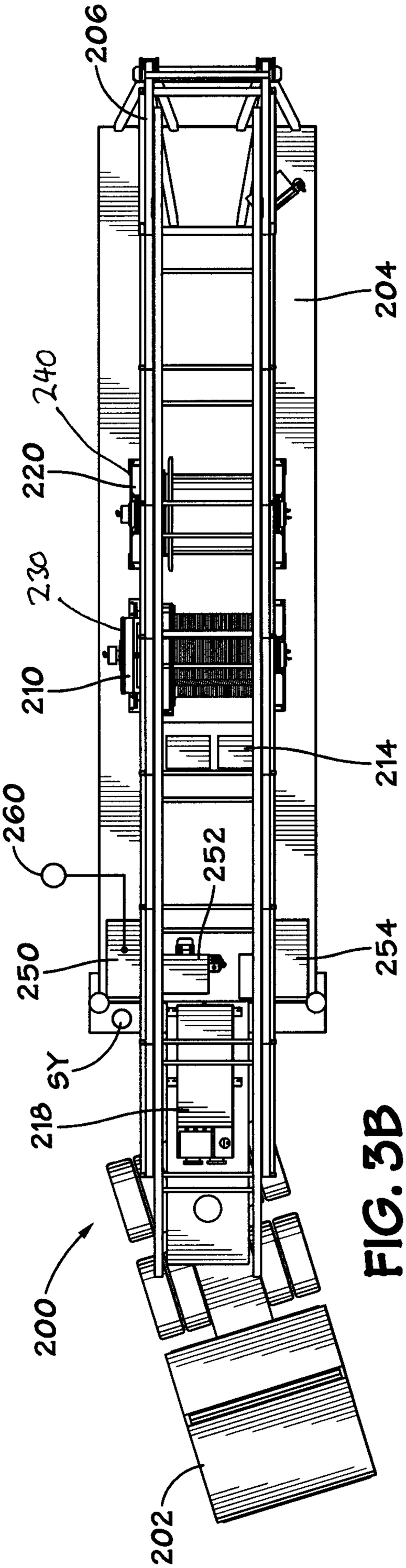
FIG. 3A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SY
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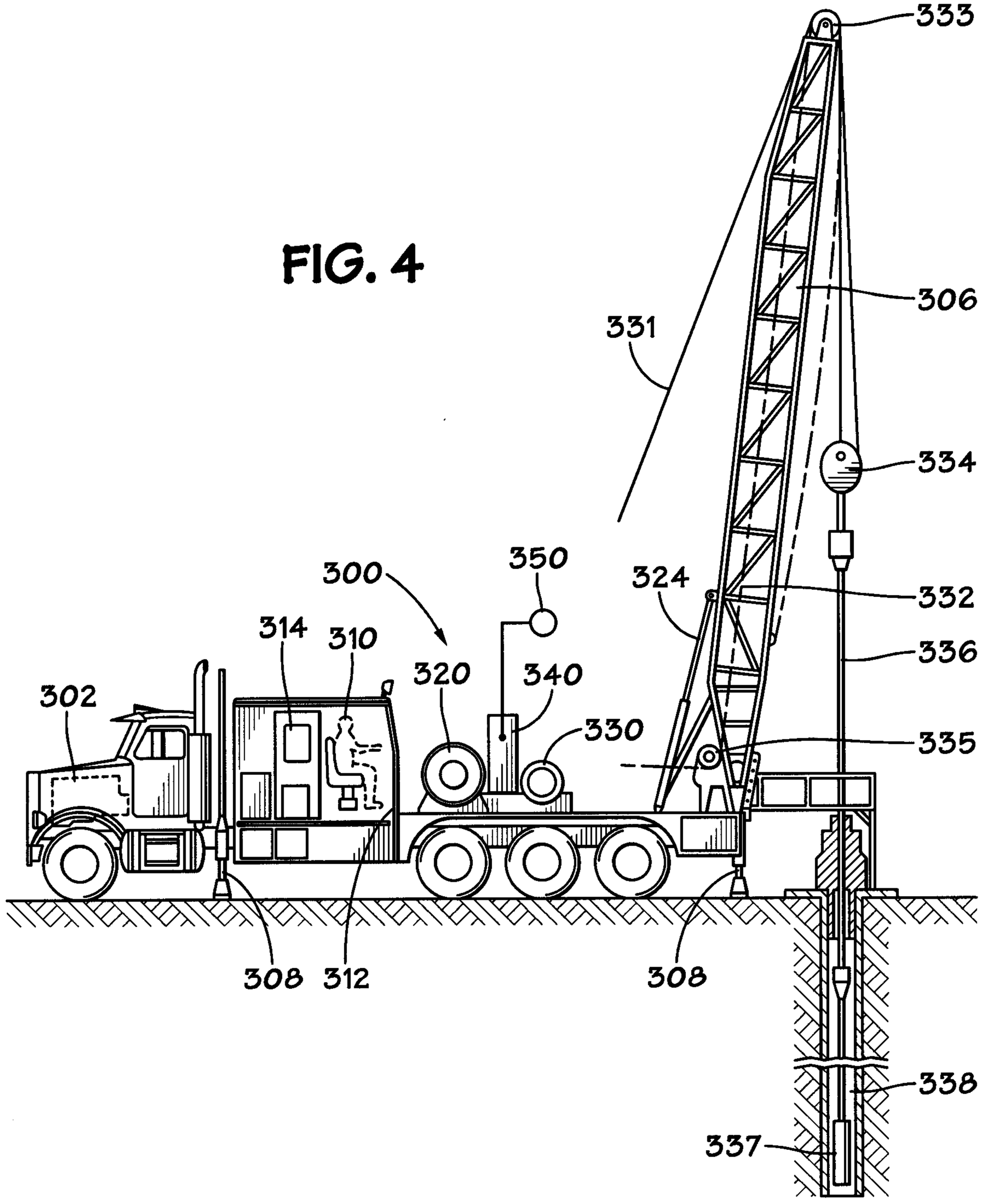
FIG. 3B

FIG. 4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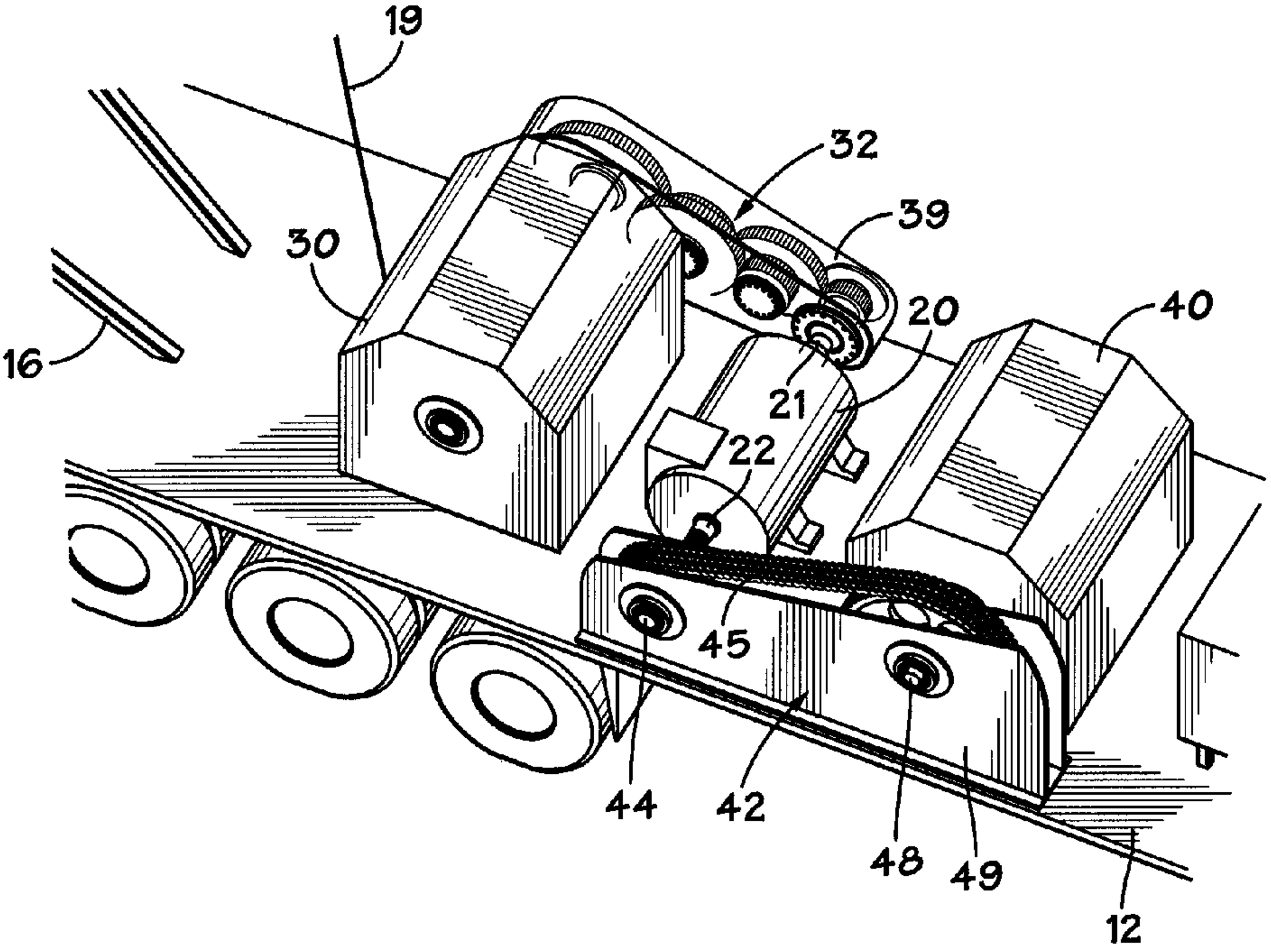
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