United States Patent [19]

Bender

[11] **3,792,836**

[45] **Feb. 19, 1974**

[54] **SIMPLIFIED WELL RIG**

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[22] Filed: **Mar. 6, 1972**

[21] Appl. No.: **231,993**

[52] **U.S. Cl.** ..... **254/139,** 91/411, 60/97 H, 92/129

[51] **Int. Cl.** **B66c 23/60**

[58] **Field of Search** ..... 254/139, 139.1, 184; 187/9, 187/95; 212/145; 91/411, 413; 92/129; 60/97 H

[56] **References Cited**

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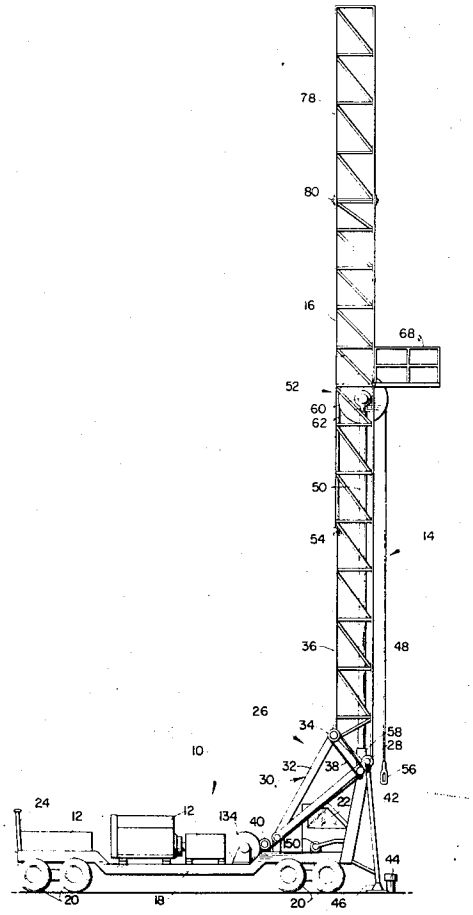
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Primary Examiner—Richard A. Schacher
Assistant Examiner—Gene A. Church
Attorney, Agent, or Firm—Strauch, Nolan, Neale, Nies & Kurz

[57] **ABSTRACT**

A multipurpose oil well rig of simple construction with hydraulically actuable working components. The rig lift system has three hydraulically driven piston rods or rams, one or more of which may be actuated to provide a range of lift capacity from high speed/low power to low speed/high power. The rig may be portably mounted on a transport vehicle. All conventional mechanisms of an oil well rig are eliminated. That is, the rig does not have drawworks, drums, brakes, sprockets and associated lift chains, clutches, a transmission, line spoolers, weight indicators, or travelling blocks.

49 Claims, 20 Drawing Figures



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SHEET 1 OF 6

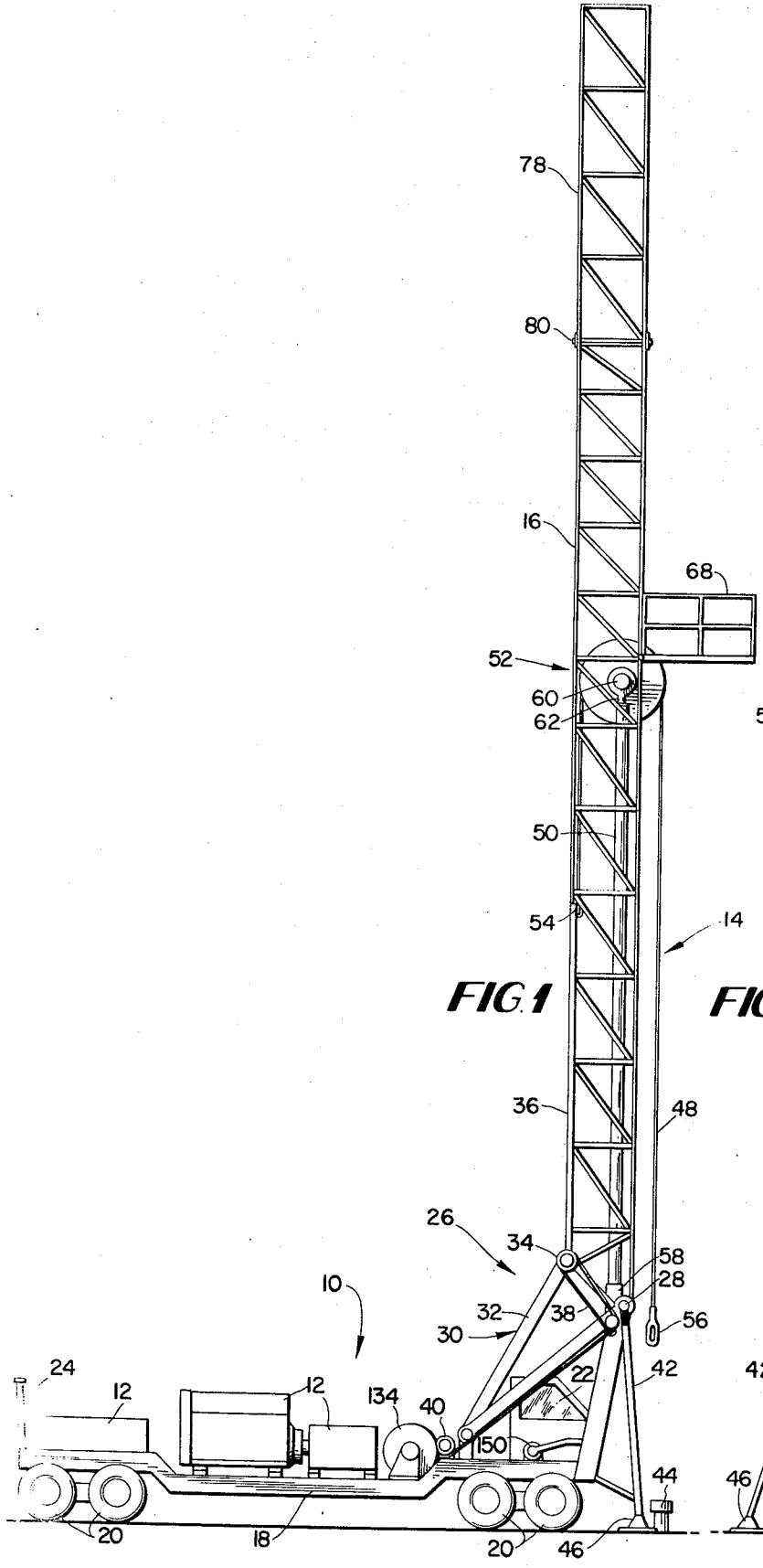


FIG. 1

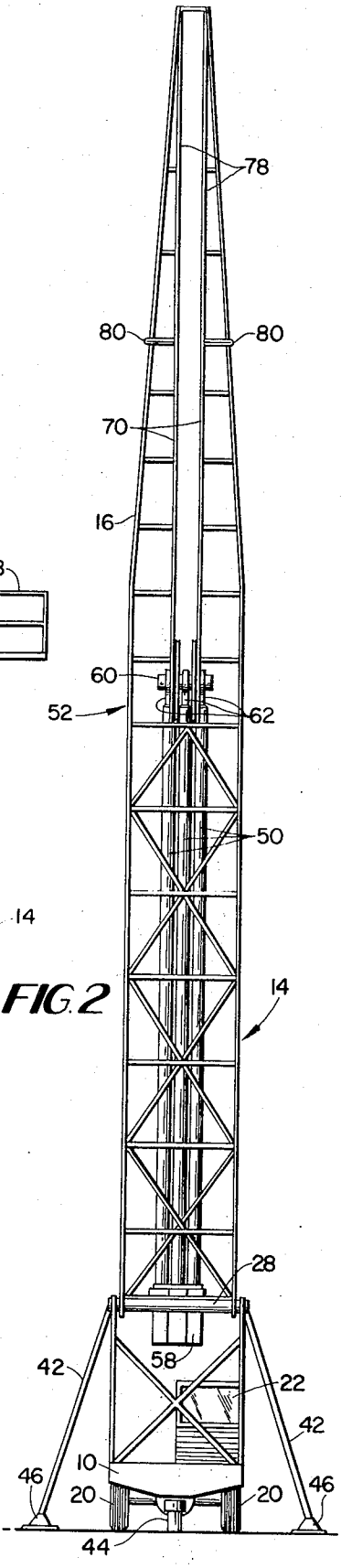


FIG. 2

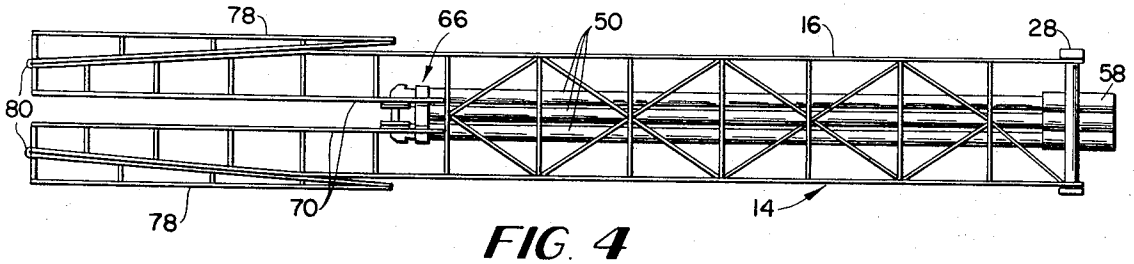


FIG. 4

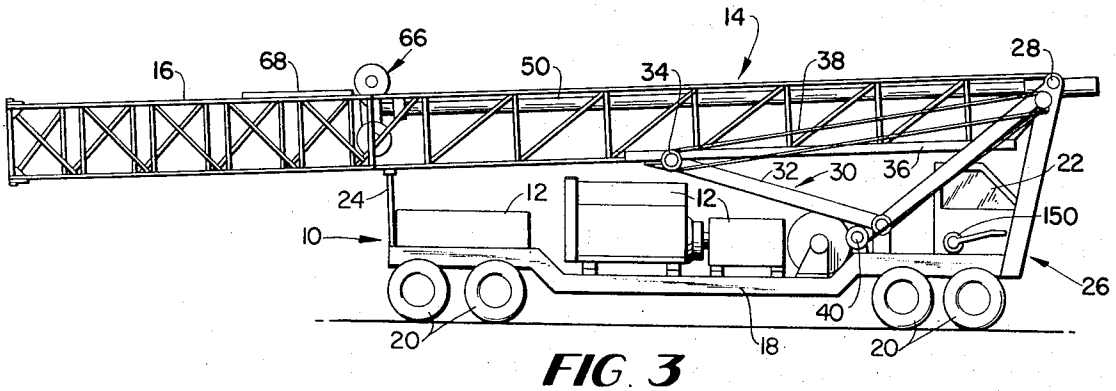


FIG. 3

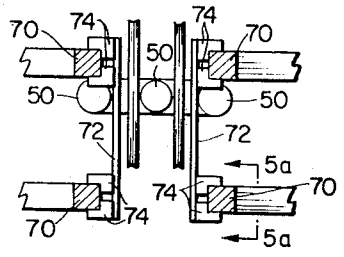


FIG. 5

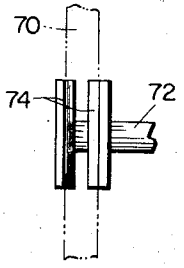


FIG. 5a

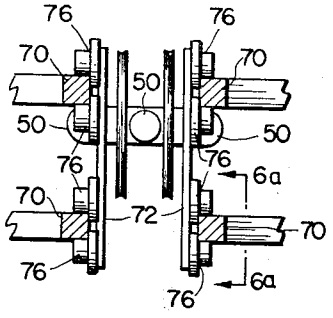


FIG. 6

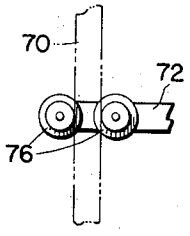


FIG. 6a

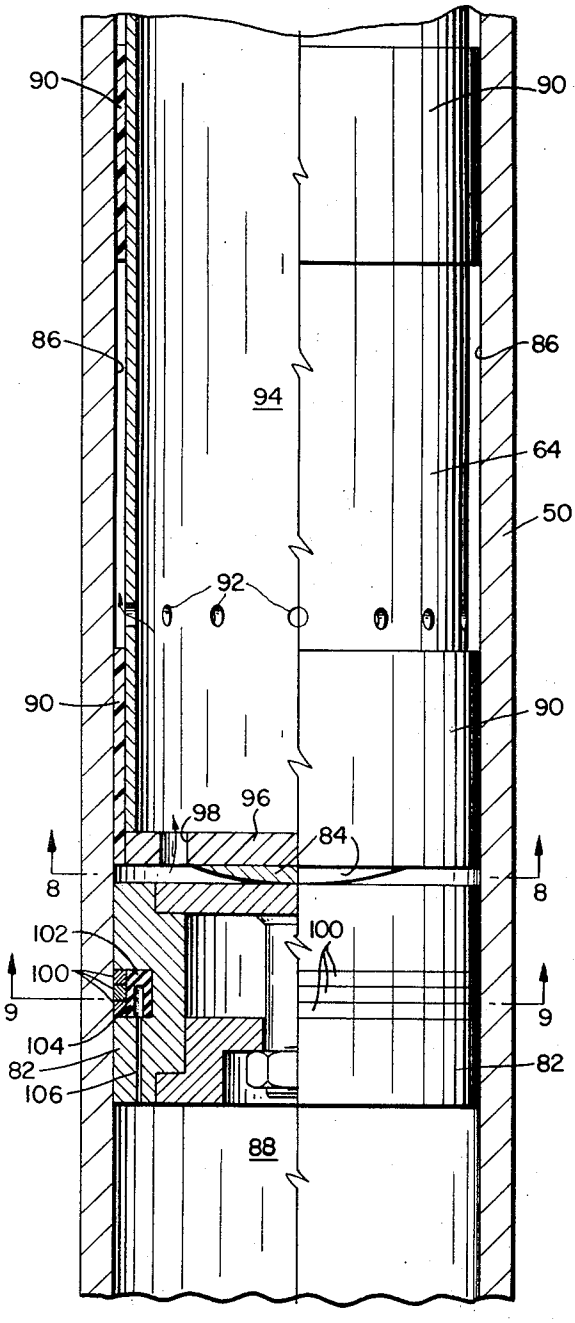


FIG. 7

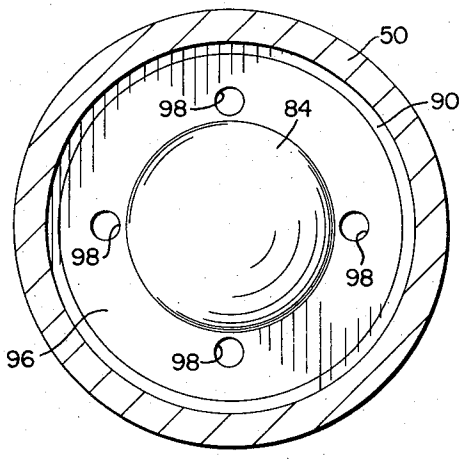


FIG. 8

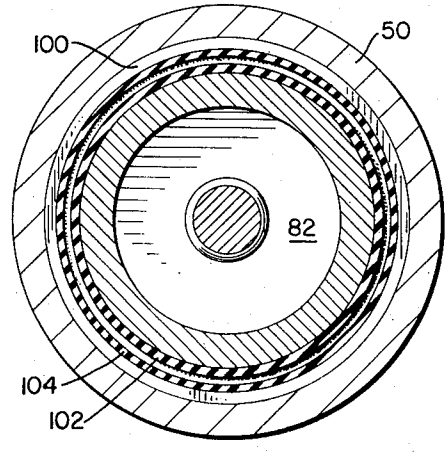


FIG. 9

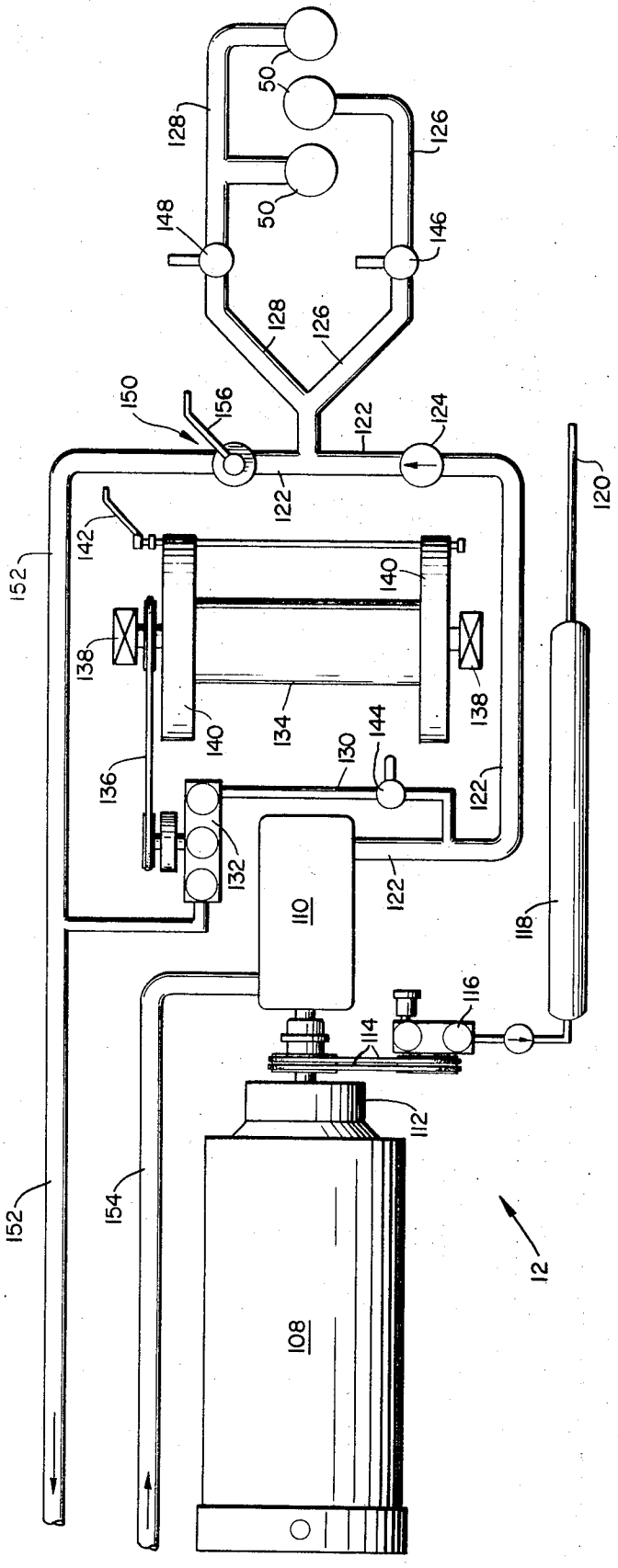

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FIG. 10

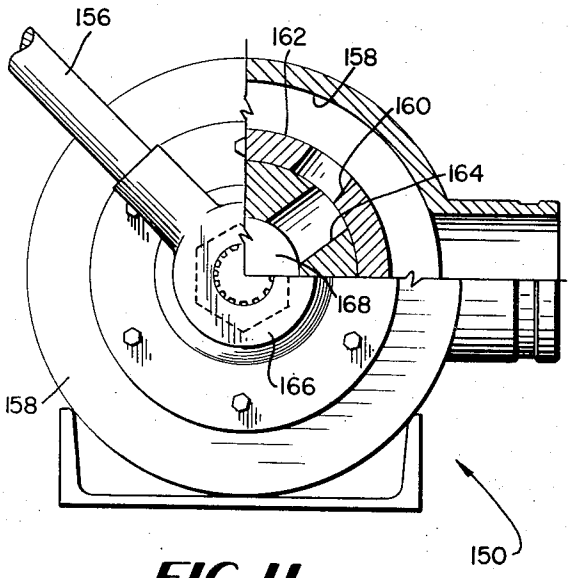


FIG. 11

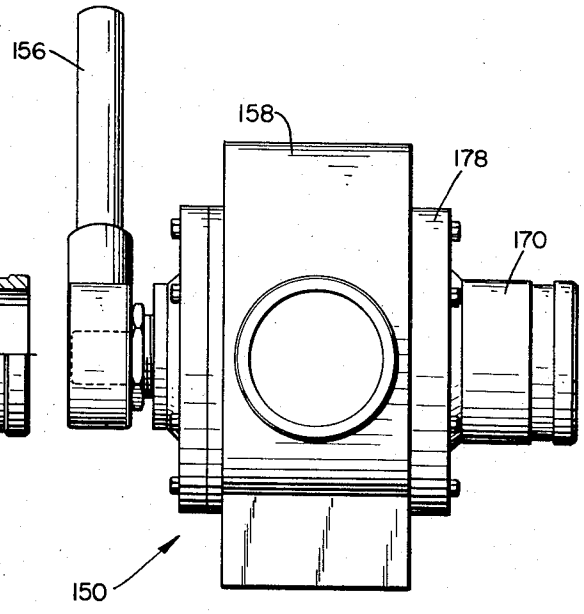


FIG. 12

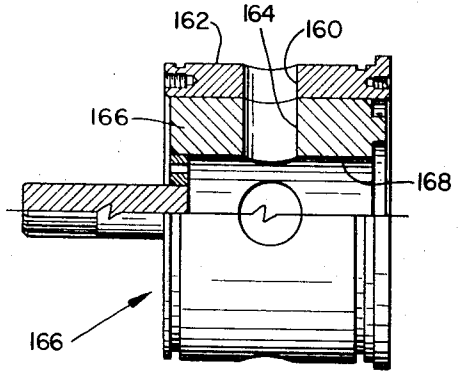


FIG. 13

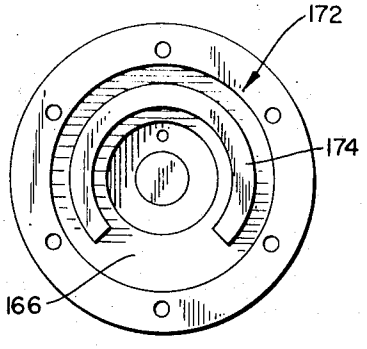


FIG. 14

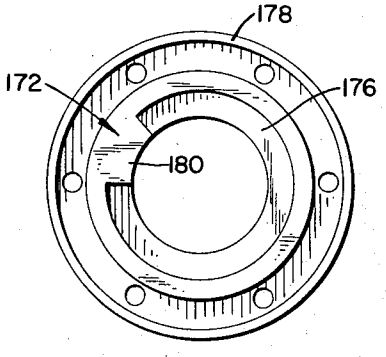


FIG. 15

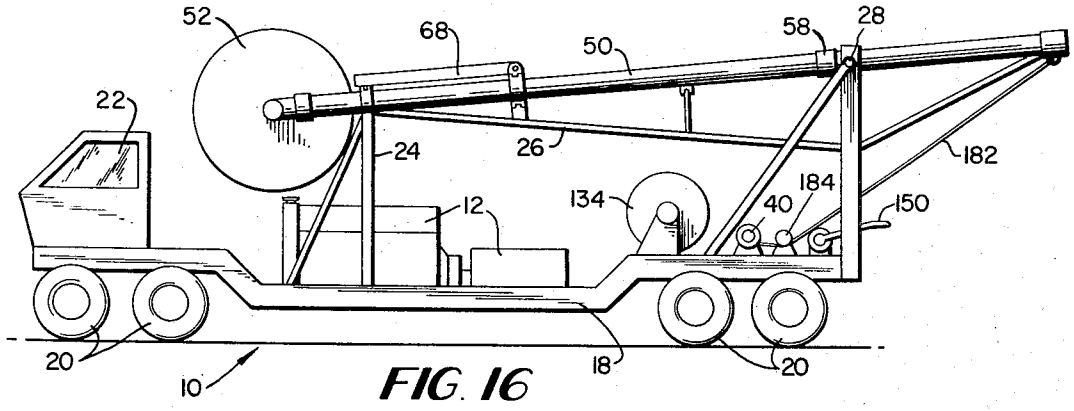


FIG. 16

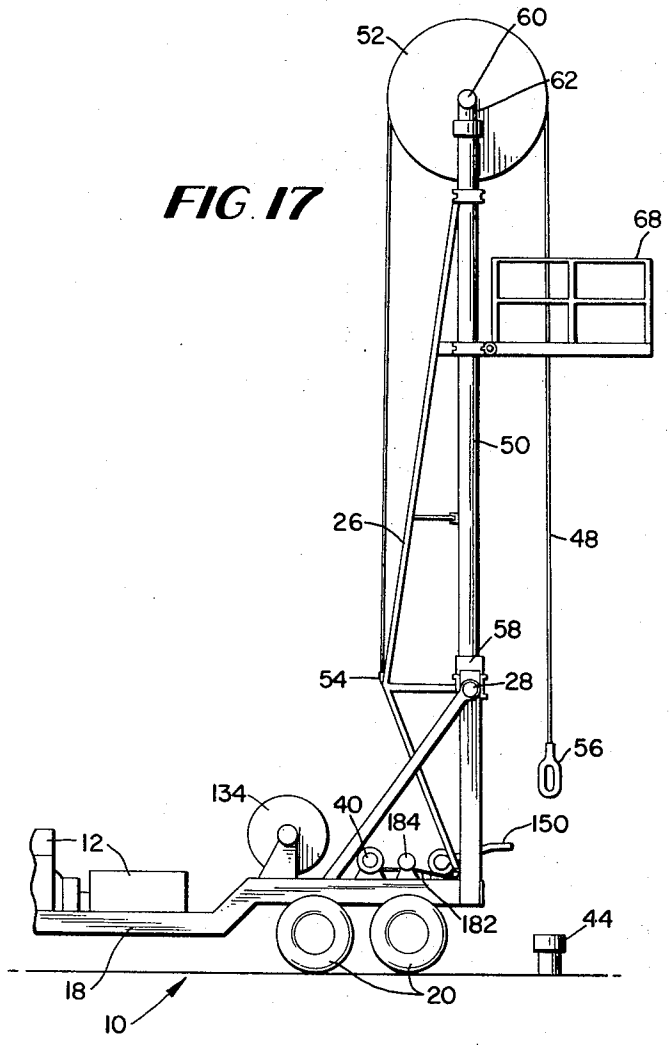


FIG. 17

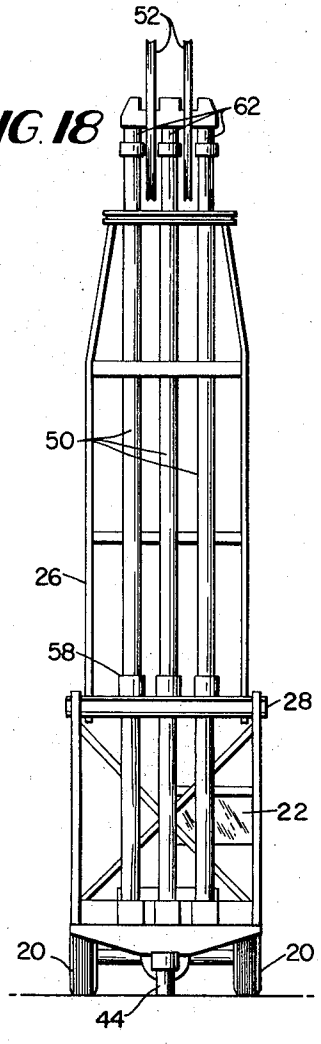


FIG. 18

SIMPLIFIED WELL RIG

BACKGROUND OF THE INVENTION

Oil well drilling, servicing, and/or pumping equipment has always been massive and expensive. The early developments in the art of derrick structures included permanent structures which had to be left at the well site long after completion of the drilling operation.

Soon the trend to portable derrick structure began. Significant progress over the years provided a transportable yet easily self-erected derrick which could be quickly and efficiently converted from a transport disposition to an operational mode with a minimum of time and labor. Twenty or more of my patents, issued over the last thirty years, evidence this development.

Although the development of the derrick art has progressed in providing easily transportable rig assemblies, little has changed since the earliest days of oil well drilling, pumping and servicing concerning the mechanically operative parts of an oil well rig, including drawworks, crown blocks and travelling blocks, and lift line arrangements. These elements and their associated parts cause significant difficulty and resultant unnecessary maintenance expense in the attempt for efficient, yet satisfactorily acceptable oil well drilling, pumping, and servicing.

There is a paucity of prior art teachings relevant to hydraulic rigs for servicing, pumping or drilling wells. U. S. Pat. No. 2,324,096 discloses an hydraulic lift wherein the free end of the piston rod includes a sheave over which a lift line, fixed at one end, is trained, to provide a two-to-one lift ratio, lift line free end to piston rod travel, but the device disclosed is for a catline only and could not be used as the main lift structure for the derrick. By definition, a "catline" is a small capacity, purely auxiliary line used with a derrick to raise and lower pipe sections, tools and other small items needed about the derrick area. Similar two-to-one ratio hydraulic lifts useful in remote environments are indicated by prior U. S. Pat. Nos. 2,897,907 and 2,931,627. Obviously, a two-to-one ratio hydraulic lift is not novel per se use thereof in a pumping rig having a fluid pressure counterbalance system being disclosed in my prior U. S. Pat. No. 3,538,777. A small capacity, single cylinder well drilling rig is shown in U. S. Pat. No. 2,807,441. The only known prior use of hydraulics in portable rig assemblies for handling pipe or casing sections on the order of 30 to 60 foot lengths is disclosed in U. S. Pat. No. 2,595,307, and there a hydraulic lift is used only to raise the derrick to a vertical, operational disposition. Otherwise, that disclosed rig is completely conventional.

At least two components of the present invention, including guide means for the travelling crown and a folding derrick structure having outboard wing units, are somewhat similar to previously known counterpart components. A wheeled guide for the travelling block of a conventional drill rig is disclosed in U. S. Pat. No. 3,376,938, and a derrick for a small drilling rig having folding wing sections forming the upper terminal portion of the derrick when the rig is in an operational disposition as disclosed in U. S. Pat. No. 2,183,867.

The present invention provides a greatly simplified, low cost, hydraulically operated well rig assembly in

which the conventional, cumbersome, expensive and troublesome components of oil well rigs, in existence previous to the present invention, are entirely eliminated. The invention herein disclosed and claimed has absolutely no drawworks, no grooved drums, no brakes, no chains, no sprockets, no clutches, no gear transmission, no line spooler, no conventional crown block, no travelling block, and the need for a weight indicator is entirely eliminated. These former essential components are replaced by a hydraulic ram assembly which provides a full range of power and lift velocity capacities employing a lift line of relatively short length rather than the conventional long four to six strand lift line threaded through a travelling block and crown to deadline and fastline ends. Elimination of the many components set forth above also provides a rig assembly of significantly less overall weight and size compared to prior art rigs, which therefor may easily be transported from well to well and easily raised to a vertical operational position or lowered to a horizontal position for transport.

SUMMARY OF THE INVENTION

Accordingly, a principal object of this invention is to provide a well servicing, pumping and/or drilling rig in which a fluid pressure actuated lift assembly having a range of high speed/low power to low speed/high power lift capacities is provided to replace the usual drawworks assembly.

It is a further object of this invention to provide a multipurpose oil well rig which entirely eliminates the need for drawworks, grooved drums, brakes, chains, sprockets, clutches, gear transmission, line spoolers, weight indicators, conventional crown blocks, and travelling blocks.

Another object of the present invention resides in providing a multipurpose fluid pressure operable rig which may be mounted on a truck transporter.

Yet another object of the present invention is to provide a multipurpose fluid pressure operable well rig having at least a pair, and preferably three hydraulically operable rams, selectively actuable, individually or in various combinations to provide a variety of lift speed — power capacity ratios.

A still further object of the present invention is to provide a multipurpose fluid pressure operable well rig having an easily controlled, balanced master rotary valve therein for controlling lift.

Still another object of the invention is to provide a multipurpose fluid pressure operable well rig having, in combination, sand reel line and catline auxiliary components, all driven from a single prime mover.

It is a further object of the invention to provide a multipurpose fluid pressure operable well rig having multiple hydraulic ram drives, each ram including a free drive piston operable against a lightweight hollow piston rod situated thereabove, whereby one or more of the rams may be powered without drag being encountered from an unpowered ram.

It is a still further object of the invention to provide a multipurpose fluid pressure operable well rig wherein a lift line is fixed at one end to the rig and trained over sheaves mounted on top of the vertically movable lift component or crown of the rig so that movement of the crown through a given distance imparts twice that length of movement to the free, working end of the lift line.

It is another object to provide an easily transportable fluid pressure operable well rig having derrick components foldable to a storage position whereby the rig may be reduced to a size for legal travel over conventional raodways, the derrick components also having guide tracks to stabilize the travelling crown of the rig.

It is yet another object of the invention to provide a transportable fluid pressure operable well rig which requires no steadying guys when operational, and which need not include any conventional derrick components at all.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred structural embodiments of this invention are disclosed in the accompanying drawings in which:

FIGS. **1** and **2** are side elevation and end elevation views respectively, illustrating one embodiment of the invention in an operational disposition, over a well head;

FIGS. **3** and **4** are side elevation and top plan views, respectively, of the embodiment shown in FIGS. **1** and **2**, but in a transport or portable mode;

FIGS. **5** and **5a** and **6** and **6a** are detail views, FIGS. **5** and **6** being in section and illustrating two embodiments of the crown guide means used in the embodiment of the invention depicted in FIGS. **1–4** and FIGS. **5***a* and **6***a* being partial section views taken along lines 5a-5a of FIG. **5** and **6***a*—**6***a* of FIG. **6**, respectively;

FIG. **7** is a partial elevation view, half in section, illustrating one hydraulic ram component of the invention;

FIGS. **8** and **9** are section views taken along lines **8**—**8** and **9**—**9** of FIG. **7**, respectively;

FIG. **10** is a diagrammatic top plan view of the closed circuit hydraulic fluid pressure system of the invention;

FIGS. **11** and **12** are quarter-sectioned side elevation and end views, respectively, of the master, balanced rotary control valve of the invention;

FIG. **13** is a half-sectioned end view of the plug member of the rotary valve shown in FIGS. **11** and **12**;

FIGS. **14** and **15** are side elevation views of the cooperating stop means defining limits of movement of the rotary valve shown in FIGS. **11–14**;

FIG. **16** is a side elevation view of another embodiment of the invention, in a transport mode; and

FIGS. **17** and **18** are partial side and full end views, respectively, of the embodiment of the invention illustrated in FIG. **16**, showing the rig in an operational disposition, over a well head.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** through **4** inclusive illustrate one embodiment of the invention including a truck transporter **10**, hydraulic fluid pressure system **12**, well hoist **14**, and derrick cage **16**. The truck **10** is rather conventional, having the usual bed **18**, wheels **20** and operator's cab **22**. A brace **24** at one end of the truck bed serves as a mid-support for the derrick **16** when the rig is in its transport mode (FIG. **3**), and a bracing and frame structure **26** at the other end of truck **10** constitutes the base and horizontal pivot mount **28** for well hoist **14** and derrick **16**.

The derrick **16** may be raised from a horizontal, transport position (FIG. **3**) to its vertical, operational position (FIGS. **1** and **2**) by a lifting paired leg lever system **30**, more fully illustrated and completely described in my prior U. S. Pat. No. 2,593,246. Briefly, lift **30** includes paired lift legs **32** having wheels **34** at their outer ends which ride along rails **36** of derrick **16** to push derrick **16** into a vertical disposition, rather than pulling the derrick, as is done in the previously known, gin pole lift method. A simple sheave and line arrangement **38** moves the lever legs **32** utilizing a winch **40** on truck bed **18** to provide the necessary lifting force. Once raised to a vertical position, derrick **16** may be locked in place and the legs **32** then form an integral part of the derrick mast structure. Locking of the derrick assembly in upright position is done by a safe, simple wedge lock arrangement (not shown), which is fully shown and described in my prior U. S. Pat. No. 2,968,373, FIGS. **5–8** inclusive incorporated herein by reference thereto. Major advantages of incorporating the wedge lock mechanism of that patent are to assure an automatically actuable wedge locking unit as well as to prevent overtravel of the derrick beyond a vertical disposition during erection. The lock is firmly and securely engaged during operation of the rig and must be manually disengaged in order to lower the derrick to a transport mode.

The opposite side of the bracing and frame structure **26** includes a pair of outrigger extension derrick support legs **42** (FIGS. **1** and **2**) which are disposed so they straddle a well head **44** located forward of the center of gravity of derrick **16** in order to securely balance the rig during operation. This structure is more fully illustrated and discussed in detail in my prior U. S. Pat. No. 3,156,328. The outer ends **46** of legs **42** are disposed forwardly of the vertical axis of travel of lift line **48** of well hoist **14**. As is clear from an inspection of FIG. **1**, this outrigger extension system properly balances the lift forces on the derrick, which is offset forward of the truck front wheels **20**, those lift forces tending to overbalance and dislodge truck **10** from its stable disposition.

This unique well hoist assembly **14** includes a bank of fluid pressure rams or cylinders **50** and sheave assembly **52**, over which lift line **48** is trained, the deadline end of lift line **48** being fixed to the derrick structure by an anchor device **54**. This results in a simple two to one lift mechanism, movement of sheave assembly **52** through a given distance imparting twice that given distance of movement to the lift end **56** of lift line **48**. The three cylinders **50** are secured together by suitable means and to derrick **16** by an "egg crate" arrangement **58** (FIG. **2**) comprising three closed end tubes secured to a horizontal pivot mount **28**. Similar simple mounting structure may be provided near the upper ends of the three cylinders to secure the same to derrick **16**. Sheave assembly **52**, in a preferred embodiment, comprises a pair of oversized sheaves rotatably mounted on an axle **60** which is secured to the upper ends **62** of hollow piston rods **64** (FIG. **7**) in cylinders **50**. Each sheave is oversized so that the working end of lift line **48** falls outside of derrick **16** and to spread the balance of lift forces exerted on the rig dur-

ing operation to either side of cylinders **50** as viewed from FIG. **1.**

Lift line **48** will be in two equal length sections, joined at lift end **56** by a suitable yoke (not shown). Lift line **48** may be constructed of the usual stranded cable as shown or may be a flat, woven wire belt (not shown). In another embodiment (FIGS. **3** and **4**) sheave assembly **52** has two sets **66** of two wheels each, whereby the lift forces exerted on the rig are still spread outwardly from the cylinders **50** yet smaller and less expensive sheaves may be employed.

As illustrated by FIGS. **1** and **4,** the derrick **16** can include the usual pipe racking platform **68,** shown in an extended, operative position in FIG. **1,** and folded to a storage position for transport, as illustrated in FIG. **4.**

FIGS. **5, 5***a* and **6, 6***a* illustrate a guide structure for sheave assembly **52** as it reciprocates vertically within the upper portion of derrick cage **16.** Two pairs of inboard rails **70** are formed along the interior front and back sides of derrick **16,** as viewed from FIG. **1,** and a pair of outboard guide braces **72** are fixed across the outer ends of sheave assembly **52.** Each outer free end of guide braces **72** has either a pair of slide blocks **74** (FIGS. **5–5***a*) or a pair of freely rotatable rollers **76** (FIGS. **6–6***a*) for guiding and stabilizing the reciprocal movement of sheave assembly **52** to as close to a true vertical movement as possible within derrick **16.** When the rig is in a transport mode, (FIGS. **3** and **4**) derrick **16** should be shortened in overall length in order that the structure and its supporting truck **10** may legally travel over conventional roadways. For this reason, the terminal upper end of derrick **16** is bisected, resulting in a pair of wing elements **78** each pivoted to the main portion of derrick **16** at **80,** and foldable outwardly to a storage position (FIG. **4**). Suitable locking mechanisms may be used to secure wings **80** in both the extended and folded dispositions (not shown).

The internal construction of each cylinder **50** is best shown by FIGS. **7–9** inclusive. Each cylinder **50** includes a free piston **82** therewithin, driven upwardly from beneath by fluid under pressure, the source of which is described in detail below, and piston rod **64** thereabove. Driving contact between piston **82** and its rod **64** is cushioned by a semispherical or convex abutment plate **84** formed on the base of each piston rod **64.** A floating piston arrangement is used since not all three cylinders will be driven together all the time and because the upper ends **62** of all three rods **64** are secured together by sheave assembly **52** for simultaneous movement irrespective of whether one, two or all three rods are being driven by their pistons **82** or not.

In preferred embodiments, the cylinders **50** are quite massive, each having an internal diameter of, e.g., 8, 15, or more inches. The overall length of each cylinder may be from 15 to 30 feet. Thus, during each stroke, a considerable amount of hydraulic fluid may remain on the interior walls **86** of each cylinder which must be permitted to drain back into pressure area **88** of each cylinder **50** to prevent hydraulic locking of rod **64.** At the same time, area of contact between each rod and its cylinder should be minimized, particularly when only one or two pistons are being driven under fluid pressure, to minimize drag on the assembly.

Frictional contact between piston rods and cylinders is minimized by forming rod **64** with an external diameter less than the internal diameter of the cylinder **50** and providing a pair of guide rings **90** to fill the gap between rod **64** and cylinder wall **86,** stabilizing vertical movement of the rod and providing the only contact between each rod and its associated cylinder. In a preferred embodiment, guide rings **90** are made of a polytetrafluoroethylene compound such as "Teflon" or, alternatively, they may be made of brass. In either event, hydraulic locking of rod **64** is prevented by provision of a series of breather holes **92** through and circumferentially spaced apart around the cylindrical wall of hollow piston rod **64** which enables fluid communication from the exterior to the hollow interior **94** of rod **64.** The base end **96** of piston rod **64** is also provided with breather holes **98** circumferentially spaced about abutment plate **84** (FIG. **8**) enabling drainage for fluid scraped from walls **86** and trapped between or beneath rings **90** to the area between a piston **82** and its rod **64.**

Hydraulic locking of a piston **82** within its cylinder **50** is prevented by a stack of piston rings **100** backed up by a flexible seal **102,** being inverted U-shape in cross-section (FIG. **7**). Fluid scraped from wall **86** passes between rings **100** against flexible seal **102,** forcing the outer seal wall **104** inwardly so that fluid may pass to a weep hole **106** formed in piston **82** and communicating from the seal groove to pressure area **88** beneath the piston.

As shown in FIG. **7,** a piston **82** and its associated rod **64** are made hollow and are constructed of several components to reduce weight and expense of manufacture, considering their massive size. Nevertheless, each could be made of solid material if desired.

Turning now to FIG. **10,** the fluid pressure system **12** for the invention will be discussed in detail. A prime mover **108** in the form of a standard diesel engine drives a hydraulic fluid pump **110** through a torque converter **112** which, of course, reduces drive power to the pump as pressure within the system **12** increases.

A mechanical power take-off comprising auxiliary drive belts **114** connected to a small air compressor or hydraulic pump **116** is interposed between torque converter **112** and primary fluid pump **110.** The secondary compressor or pump **116** provides fluid pressure for an accumulator tank **118** and outlet line **120** to drive the motor of a catline winch (not shown).

While any standard hydraulic pump **110** might be employed, I prefer to use a constant displacement rotary screw type pump such as the "IMO" pump marketed by De Laval Turbine, Inc. of Trenton, New Jersey. This pump has only three moving parts, providing constant displacement axial flow of fluid, without need of reciprocating parts.

In any event, pump **110** provides hydraulic fluid under pressure to a primary outlet line **122** which directs fluid through a check valve **124,** provided to prevent backflow to the pump **110,** to branch lines **126** and **128.** A hydraulic power take-off line **130** may be interposed in primary outlet line **122** to provide a hydraulic power source for motor **132** which drives the usual sand line reel **134.** A standard sand line is used to bail sand out of a well during servicing thereof and the system is designed to free wheel the line to well bottom, which may be several thousand feet, and then quickly raise the line to clean the well and well bore.

A standard sand reel system is illustrated which includes a chain drive **136,** clutches **138,** brakes **140** and brake lever **142,** besides reel **134.** A hydraulic fluid

control lever **144** provides the primary on-off power to motor **132,** which may be a Staffa motor (a rotary vane pump).

Branches **126** and **128** direct fluid under pressure to the cylinders **50** for variable, controlled lift power for the well hoist **14.** Branch **126** directs fluid to the base of the centrally disposed cylinder **50** and branch **128** directs fluid to the two outboard cylinders **50.** Selector control valve **146** provides on-off power in branch **126** while selector control valve **148** provides the on-off control for branch **128.** A balanced rotary control valve **150** is located downstream of branches **126** and **128** and is either closed to direct drive fluid to branches **126** and **128,** or open, to direct drive fluid through an exhaust line **152,** which is connected to a conventional fluid storage tank (not shown). The fluid pressure circuit is completed by a pump inlet line **154** from the storage tank (not shown) to the inlet of primary hydraulic fluid pump **110.**

WELL HOIST OPERATION

To initiate a lifting cycle, rotary control valve **150** is closed to direct drive fluid to branches **126** and **128.** In a preferred embodiment, branches **126** and **128** have equal flow capacity (therefore, equal internal diameters). Assuming that selector control valve **148** is closed, all drive fluid is directed to central cylinder **50,** beneath piston **82,** and the well hoist **14** is driven upwardly under X speed at Y power. With controls set in this disposition, hoist **14** is operated at maximum speed under minimum lift power. If more power but less speed is required, selector valve **146** is closed and valve **148** is opened, to direct drive fluid to the two outboard cylinders **50.** Assuming all three cylinders **50** have the same dimensions and thus equivalent lift power capacities, well hoist **14** will now operate at **0.5X** speed or velocity but at a power rating of **2Y.** For maximum power, both selector valves **146** and **148** are opened so that all three cylinders **50** are open to drive fluid, thus increasing lift power to **3Y** while reducing lift velocity to 0.33X. Under any of these three conditions, the hoist is lowered merely by opening balanced rotary control valve **150** thereby allowing fluid to drain from beneath pistons **82** to the hydraulic fluid storage tank via exhaust line **152.** For ease of operation, all control valves **146, 148, 150** and **144,** as well as controls for auxiliary pump **116,** pump **110** and prime mover **108** may be mounted on a conventional control console, (not shown) along with balanced valve **150.**

Specific examples are given to illustrate the "X" velocity and "Y" power capacities set forth above. Assuming the pump provides pressure at 1,000 psi to 8 inch O.D. cylinders **50,** having an internal diameter of about 7.5 inches, 44,000 pounds of lift force, or "Y" is provided to each cylinder **50.** Of course, the effective lift force provided to end **56** of lift line **48** will be one-half, or 22,000 pounds, due to the two-to-one simple pulley arrangement of lift line **48** over sheave assembly **52.** If selector valve **148** is opened and **146** is closed, thereby directing drive fluid to the two outboard cylinders **50,** lift force is doubled to 88,000 pounds with rods **64** now moving at one-half the velocity of the first example set forth because input quantity of fluid under pressure remains constant, whether fluid is directed to one, two or all three cylinders, assuming that pump pressure remains at 1,000 psi. Similarly, effective lift force in the lift line **48** is now 44,000 pounds. When all three cylinders **50** are open to drive fluid, by opening both selector valves **146** and **148,** power is tripled to 132,000 pounds at one-third the velocity set forth in the first example. Again, effective lift force in lift line **48** will be 66,000 pounds.

If extremely large, fifteen inch I.D. diameter cylinders are used, 176,000 pounds of force are provided by each cylinder **50** if the pump **110** provides fluid at a pressure of 1,000 psi. Thus, with selector valve **146** open and **148** closed, 88,000 pounds of lift force is imparted to lift line end **56.** With valve **148** open and **146** closed, or with the two outboard cylinders **50** being driven, 176,000 pounds of lift force are imparted to lift line end **56** and with all three cylinders open, 264,000 pounds of lift force may be provided in lift line end **56.** With a pump rating of 2,000 psi, the figures given for both examples will be doubled.

Due to the tremendous power ratings and capacities of the fluid pressure system, it is desirable that the master control or rotary control valve **150** be a balanced valve as illustrated in FIGS. **11–15** so that a minimum of manual force may be exerted on control handle **156** thereof to operate well hoist **14.** Valve **150** includes an outer annular chamber **158** having four equispaced ports **160** formed through the interior wall **162** thereof, arranged to communicate with four similarly spaced ports **164** formed through a rotary plug **166** which has an interior plug chamber **168** and an axial outlet **170,** control handle **156** being secured to plug **166** on the side opposite outlet **170.** Since four cooperating ports **160–164** are provided, arithmetic dictates that only a 45° arc rotation of plug **166** is required to move valve **150** from a fully closed to a fully open position. Since the valve is balanced by provision of four equispaced cooperating ports about an axial flow center, the valve may also be easily set in an infinite number of positions between fully open and fully closed. Stop means **172** define the fully open and closed positions (FIGS. **14** and **15**). As shown, an annular projecting rib **174** extending 270° and formed on the outer face of plug **166** cooperates with an annular groove **176** formed in the rear wall **178** of chamber **158,** about outlet **170,** and includes a 45° arc stationary abutment **180** which defines the limit stops of the valve.

Another embodiment of the overall protable well rig is illustrated in FIGS. **16** through **18.** Components are similar to those illustrated in FIGS. **1–4,** except that the overall unit is considerably smaller in size and capacity. For example, rod stroke distance in the embodiment shown in FIGS. **1–4** is designed to be about 30 feet, with an effective lift line movement of about 60 feet, while in the embodiment illustrated by FIGS. **16–18,** rod stroke will be 15 feet, with an effective lift line movement of 30 feet. The major significant feature of this latter embodiment is the complete elimination of the derrick cage **16.** Only minimal bracing and frame structure **26** is required for integrity of the structure. Additionally, outrigger extension legs **42** are unnecessary, and the sheave and line arrangement **38** may be replaced by a simple single line **182** trained about a pulley **184** to winch **40** to pivot well hoist **14** from a stored, transport position (FIG. **16**) to an upright operative position (FIGS. **17, 18**).

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are

therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by letters Patent is:

1. A well servicing, drilling and/or pumping assembly comprising a fluid pressure lift device and a lift line operable by said lift device, said fluid pressure lift device comprising: a prime mover; pump means driven by said prime mover for providing fluid under pressure; and lift means powered by said fluid under pressure comprising at least a pair of reciprocable piston-cylinder fluid motors, said lift line operatively connected to the reciprocating components of said fluid motors, and means for selectively directing fluid under pressure to one or both of said fluid motors whereby said fluid under pressure is directed to one of said fluid motors, for relatively high speed/low power lift capacity, or to more than one of said fluid motors for relatively low speed/high power lift capacity said fluid under pressure comprising hydraulic fluid, said fluid pressure lift device further comprising a closed circuit hydraulic fluid system including said pump, powered by said prime mover, having a primary hydraulic outlet branched to said fluid motors, exhaust means from said outlet, an accumulator tank for reserve fluid in fluid communication with said exhaust means, pump inlet means connecting said accumulator tank to said pump, thereby completing said circuit, and torque converter means, interposed between said prime mover and said pump, for reducing power input to said pump in response to increased pressure in said hydraulic system.

2. The assembly as recited in claim **1** wherein said primary outlet includes check valve means therein for preventing fluid backflow to said pump.

3. The assembly as recited in claim **1** wherein said pump comprises a constant displacement, rotary screw pump.

4. The assembly as recited in claim **1** wherein said fluid exhaust means include a control valve to selectively direct fluid to said fluid motors and to said accumulator tank.

5. The assembly as recited in claim **4** wherein said control valve is a balanced rotary valve comprising an outer annular fluid chamber communicating with said exhaust line, a plurality of circumferentially spaced ports on the inner face of said annular chamber, a plug member coaxially disposed within said annular chamber and having a plurality of corresponding ports therethrough alignable with said annular chamber spaced ports, and means defining a hollow chamber within said plug member, communicated to said plug ports and to said exhaust line, said plug member being rotatable within and about the axis of said annular chamber to a fully open valve position with said ports aligned and to a fully closed valve position with said chamber ports out of alignment with said plug ports.

6. The assembly as recited in claim **5** wherein each set of ports comprises four in number, each set of four ports being equally circumferentially spaced apart whereby said plug member is rotatable through a **45°** arc in moving between fully open and fully closed limit positions.

7. The assembly as recited in claim **6** wherein said plug member and said annular chamber further include cooperating stop means for defining the end limits of said 45° arc movement.

8. The assembly as recited in claim **1** wherein said hydraulic system exhaust means further comprise an auxiliary drive branch line, a hydraulically drive motor, driven by fluid under pressure from said auxiliary drive branch line, and a sand reel driven by said hydraulically driven motor.

9. The assembly as recited in claim **1** wherein said prime mover further comprises an auxiliary motor, power take-off means from said prime mover to said auxiliary motor, said auxiliary motor comprising an air compressor and winch means driven from said air compressor, said winch means being a catline reel.

10. The assembly as recited in claim **1** wherein said primary hydraulic outlet further comprises a primary branch line interposed between said outlet and said exhaust line, a first secondary branch line from said primary branch line to one of said fluid motors, and a second secondary branch line from said primary branch line to another of said fluid motors.

11. The assembly as recited in claim **10** wherein each said secondary branch line includes control means therein for independently selectively stopping flow to the fluid motor associated therewith.

12. The assembly as recited in claim **1** wherein said reciprocable piston-cylinder fluid motors are each generally vertically disposed with said reciprocating components arranged to move in a generally vertical direction.

13. The assembly as recited in claim **2** wherein each fluid motor comprises a generally vertically disposed cylinder, a piston in said cylinder driven by said hydraulic fluid, and a piston rod above each piston driven by its piston and extending beyond the upper terminal end of its cylinder, said lift line being operatively connected to the extended upper ends of said piston rods.

14. The assembly as recited in claim **13** wherein each said piston is a free floating piston, driving its piston rod by abutting the lower end thereof.

15. The assembly as recited in claim **14** wherein each piston rod lower end includes an abutment plate having a convex contour arranged to contact said floating piston during upward drive by said piston.

16. The assembly as recited in claim **15** wherein each piston rod is a hollow piston rod throughout its length and further comprises breather means defined through the side walls and lower end thereof for preventing hydraulic locking of the piston rod within its cylinder.

17. The assembly as recited in claim **14** wherein each piston rod has an outside diameter less than the internal diameter of its cylinder, and includes a pair of anti-friction guide rings mounted therearound.

18. The assembly as recited in claim **17** wherein said guide rings are made of a polytetrafluoroethylene compound.

19. The assembly as recited in claim **17** wherein said guide rings are made of brass.

20. The assembly as recited in claim **14** wherein each said piston further comprises a plurality of piston rings located circumferentially therearound, and annular fluid pressure bleed means internally of said piston

rings for draining fluid accumulated on said piston rings during movement of said piston to prevent hydraulic lock of said piston within its cylinder.

21. A well servicing, drilling, and/or pumping assembly comprising a fluid pressure lift device and lift line means operable by said lift device comprising: a prime mover; pump means driven by said prime mover for providing fluid under pressure; and lift means powered by said fluid under pressure comprising at least three reciprocable piston-cylinder fluid motors, said lift line means operatively connected to the reciprocating components of said fluid motors and means for selectively directing fluid under pressure to one of said fluid motors for relatively high speed/low power lift capacity, to two of said fluid motors for relatively intermediate speed and power lift capacity, and to at least three of said fluid motors for relatively low speed/high power lift capacity, said fluid under rpessure comprising hydraulic fluid, said fluid motors being mounted in a side by side relationship, said means for selectively directing fluid under pressure to one or more of said fluid motors comprising a closed circuit hydraulic fluid system driven from said pump, including a primary hydraulic outlet, a first hydraulic branch in fluid communication with the centrally disposed fluid motor of said fluid motors, a second hydraulic branch in fluid communication with the fluid motors mounted outboard of said centrally disposed fluid motor, exhaust line means connected to said outlet line downstream of said first and second branches, an accumulator tank for reserve hydraulic fluid connected to said exhaust line means, pump inlet means connecting said accumulator tank to said pump, thereby completing said circuit, and torque converter means interposed between said prime mover and said pump, for reducing power input to said pump in response to increased pressure in said hydraulic system.

22. The assembly as recited in claim **21** wherein said exhaust line means includes a control valve for selectively directing fluid to said fluid motors and to said accumulator tank.

23. The assembly as recited in claim **23** wherein said control valve is a balanced rotary valve comprising an outer annular fluid chamber communicated to said exhaust line, a plurality of circumferentially spaced ports on the inner face of said annular chamber, a plug member coaxially disposed within said annular chamber and having a plurality of corresponding ports therethrough alignable with said annular chamber spaced ports, and means defining a hollow chamber within said plug member, communicated to said plug ports and to said exhaust line, said plug member being rotatable within and about the axis of said annular chamber to a fully open valve position with said ports aligned and to a fully closed valve position with said chamber ports out of alignment with said plug ports.

24. The assembly as recited in claim **23** wherein each set of ports comprises four in number, each set of four ports being equally circumferentially spaced apart whereby said plug member is rotatable through a **45°** arc in moving between fully open and fully closed positions.

25. The assembly as recited in claim **24** wherein said plug member and said annular chamber further include cooperating stop means for defining the end limits of said 45° arc movement.

26. The assembly as recited in claim **21,** wherein said primary hydraulic outlet includes check valve means therein for preventing fluid backflow to said pump.

27. The assembly as recited in claim **21** wherein each of said hydraulic branches further includes control means for independently selectively enabling fluid flow through the respective branch line.

28. The assembly as recited in claim **21** wherein each fluid motor comprises a generally vertically disposed cylinder, a piston in said cylinder driven by said hydraulic fluid, and a piston rod above each piston and extending beyond the upper terminal end of its cylinder, said lift line being operatively connected to the extended upper ends of said piston rods.

29. The assembly as recited in claim **28** wherein each said piston is a free floating piston, driving its piston rod by abutting the lower end thereof.

30. The assembly as recited in claim **29** wherein each piston rod lower end includes a convex abutment plate arranged to contact the top of said floating piston during upward movement thereof.

31. The assembly as recited in claim **29** wherein each piston rod is hollow throughout its length and further comprises breather means defined through the side walls and lower end thereof for preventing hydraulic locking of said piston rod within its cylinder.

32. The assembly as recited in claim **31** wherein each piston rod has an outside diameter less than the internal diameter of its cylinder and includes a pair of antifriction guide rings mounted therearound.

33. The assembly as recited in claim **32** wherein said guide rings are made of a polytetrafluoroethylene compound.

34. The assembly as recited in claim **32** wherein said guide rings are made of brass.

35. The assembly as recited in claim **28** wherein each said piston includes a plurality of piston rings located circumferentially therearound, and annular fluid pressure bleed means internally of said piston rings for draining fluid accumulated on said piston rings during movement of said piston to prevent hydraulic lock of said piston within its cylinder.

36. The assembly as recited in claim **28** wherein said lift line means is secured at one end to said assembly, said rod upper ends including sheave means over which said lift line means are trained, the free end of said lift line arranged to depend vertically therefrom over a well head, whereby vertical movement of said rods through a given distance imparts a movement of twice said given distance to the free end of said lift line.

37. The assembly as recited in claim **36** wherein said sheave means comprise axle means mounted across said piston rod upper ends, and a pair of sheaves rotatably mounted by said axle means, said lift line means comprising a pair of generally flat belts secured to a stationary part of said assembly on one side of said three cylinders and being trained over said sheaves with lift means secured to said lift line means free end.

38. The assembly as recited in claim **21** wherein said assembly further comprises a wheeled transporter and pivotal mounting means for said fluid motors arranged to mount said fluid motors on said transporter in a generally horizontal disposition for transport, and to raise and position said fluid motors in a generally vertical

disposition, over a well head, for drilling, pumping, and/or servicing of a well.

39. The assembly as recited in claim **38** wherein said pivotal mounting means comprises a horizontal pivot structure mounted adjacent one end of said transporter, and bracing and frame means securing said fluid motors together as a unitary structure, said bracing and frame means being mounted on said horizontal pivot structure.

40. The assembly as recited in claim **39** wherein said bracing and frame means further comprise a racking platform, mounted mesially of said fluid motors, said platform being pivotal to a horizontal storage position over said fluid motors.

41. The assembly as recited in claim **39** wherein said bracing and frame means further include a derrick cage surrounding and mounting said fluid motors as a unitary structure, and extending above said fluid motors a distance at least equal to the effective stroke distance of said fluid motor reciprocating members, the upper ends of said reciprocating members including sheave means over which said lift line means are trained, and sheave support means joining said upper ends together, and guide means in the upper portion of said derrick cage for stabilizing movement of said reciprocating members, said sheave support means and said sheave means during operation of said assembly.

42. The assembly as recited in claim **41** wherein said guide means comprise a plurality of guide tracks formed in said derrick cage adjacent said sheave support means, a pair of outboard guide braces secured to the outer ends of said sheave support means, and anti-friction guide means on each guide brace joined to said guide tracks to stabilize vertical movement of said upper ends within said derrick cage upper portion.

43. The assembly as recited in claim **42** wherein each of said anti-friction guide means comprise a pair of slide blocks mounted on each outer free end of said outboard guide braces.

44. The assembly as recited in claim **42** wherein each of said anti-friction guide means comprise a pair of freely rotatable wheels mounted on each outer free end of said outboard guide braces.

45. The assembly as recited in claim **41** wherein said derrick cage upper portion includes a pair of upper, terminal wing members foldable into a storage position when said assembly is disposed for transport, thereby reducing the overall length of said derrick cage.

46. The assembly as recited in claim **41** wherein said bracing and frame means further comprise a pair of folding outrigger struts, adjacent said horizontal pivot structure, arranged to be positioned in spaced apart relationship on the side of a well head opposite the disposition of said transporter to balance said assembly during operation.

47. The assembly as recited in claim **39** wherein said bracing and frame means further comprise lift means for raising said fluid motors from a horizontal transport position to a vertical, operational disposition.

48. The assembly as recited in claim **39** wherein said bracing and frame means include closed end support means for the ends of said fluid motors.

49. The assembly as recited in claim **39** wherein said bracing and frame means are located entirely beneath the upper ends of said fluid motors.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,792,836 Dated February 19, 1974

Inventor(s) Emil A. Bender

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 46, change "protable" to --portable--.

Claim 23, line 1, change "23" to --22--.

Signed and sealed this 6th day of August 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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