United States Patent [19]

Brown

[11] **3,774,697**

[45] **Nov. 27, 1973**

[54] **ROTARY DRIVE ASSEMBLY FOR HANDLING TUBULAR MEMBERS**

[76] Inventor: **Cicero C. Brown**, Houston, Tex.

[22] Filed: **Dec. 9, 1971**

[21] Appl. No.: **206,325**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 130,597, April 2, 1971.

[52] **U.S. Cl.** **173/20,** 173/57, 173/164, 175/215

[51] **Int. Cl.** **E21b 17/05**

[58] **Field of Search** 173/20, 57, 164; 175/52, 85; 166/77.5, 315

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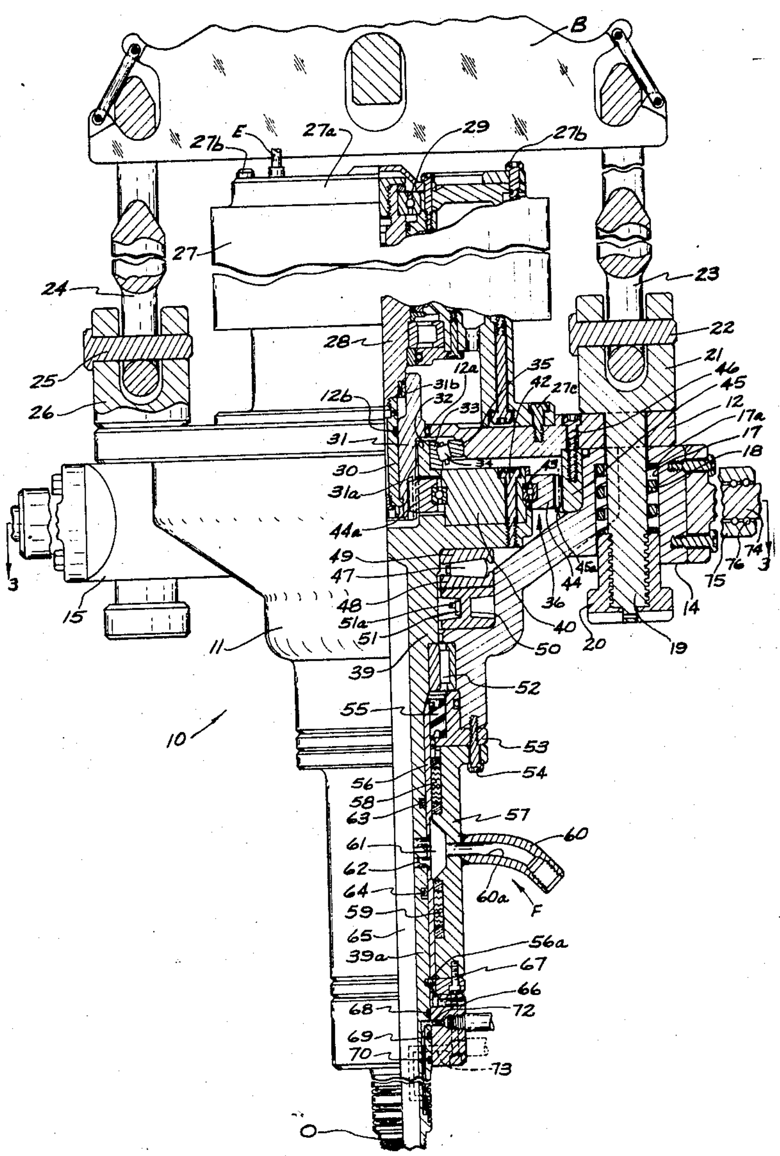
Primary Examiner—Ernest R. Purser
Attorney—Carlos A. Torres et al.

[57] **ABSTRACT**

A reversible, electric motor drive assembly pivotably supported from the traveling block in a derrick is employed to rotate, raise, lower or otherwise handle tubular pipe used in the drilling and production of oil and gas wells. Mechanical cushioning means support the assembly from the traveling block and swivel type connections are employed to provide fluid communication between external supply and return points and fluid conductors carried in the rotatable output drive of the drive assembly.

In a modified form, a reduction gear with variable gear ratios is employed to power a dual conduit system which provides a fluid passage for conveying drilling fluids to the drill bit and a separate passage for returning fluids and cuttings to the wellhead.

13 Claims, 6 Drawing Figures



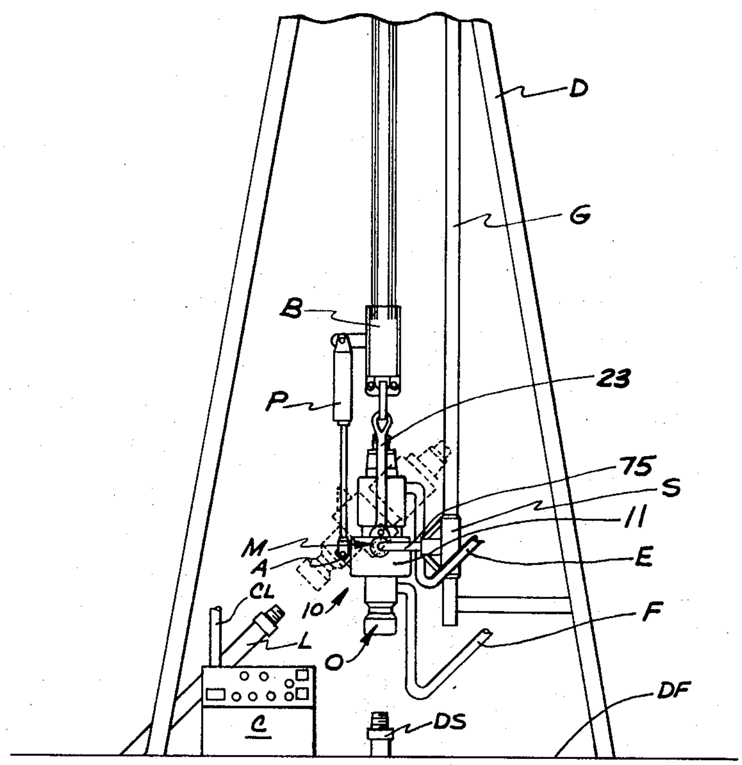


Fig. 1

CICERO C. BROWN
INVENTOR.

BY Carlos A. Torres
Bill B. Berryhill

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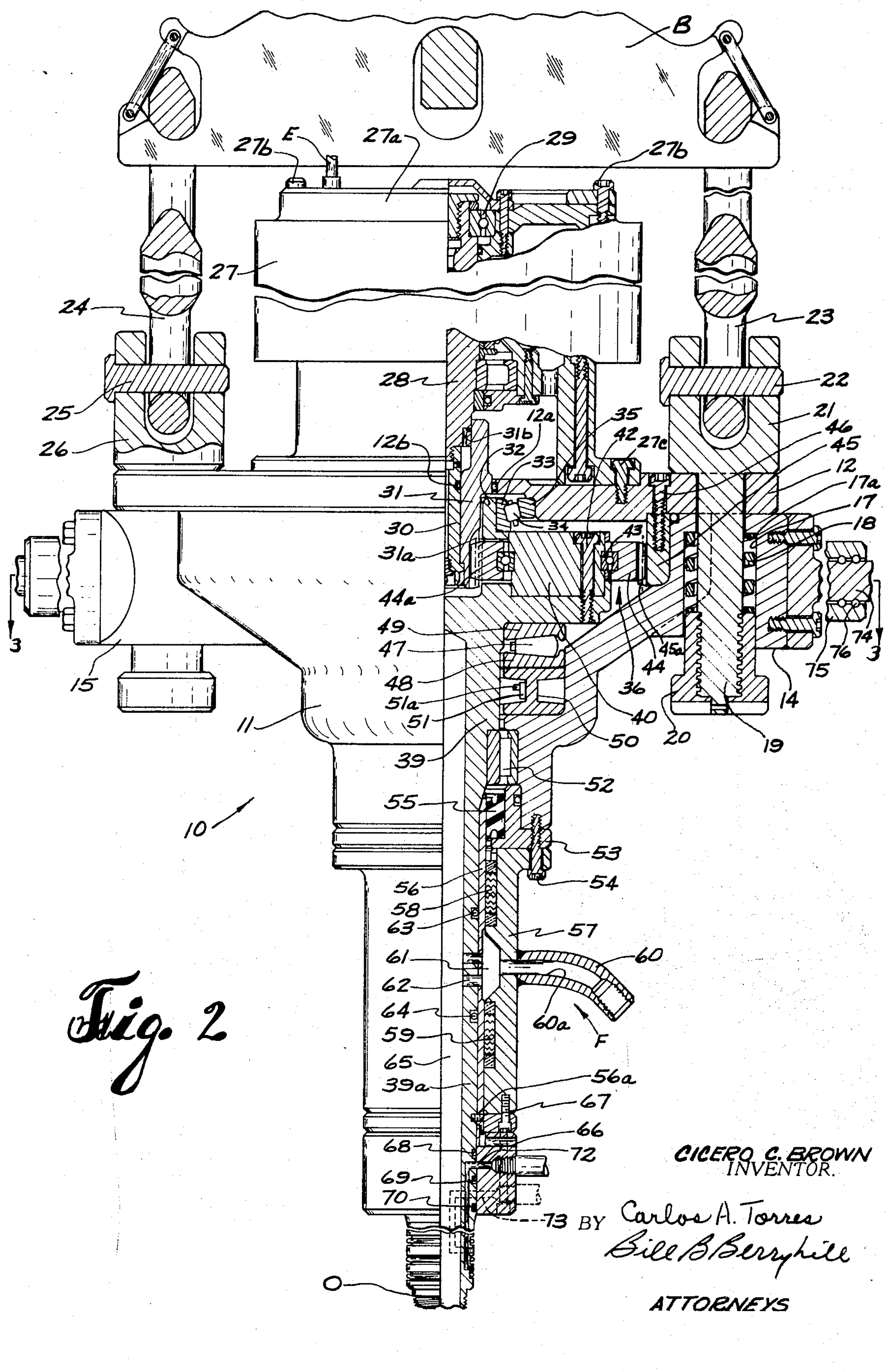

Fig. 2

CICERO C. BROWN
INVENTOR.

BY Carlos A. Torres
Bill B Berryhill

ATTORNEYS

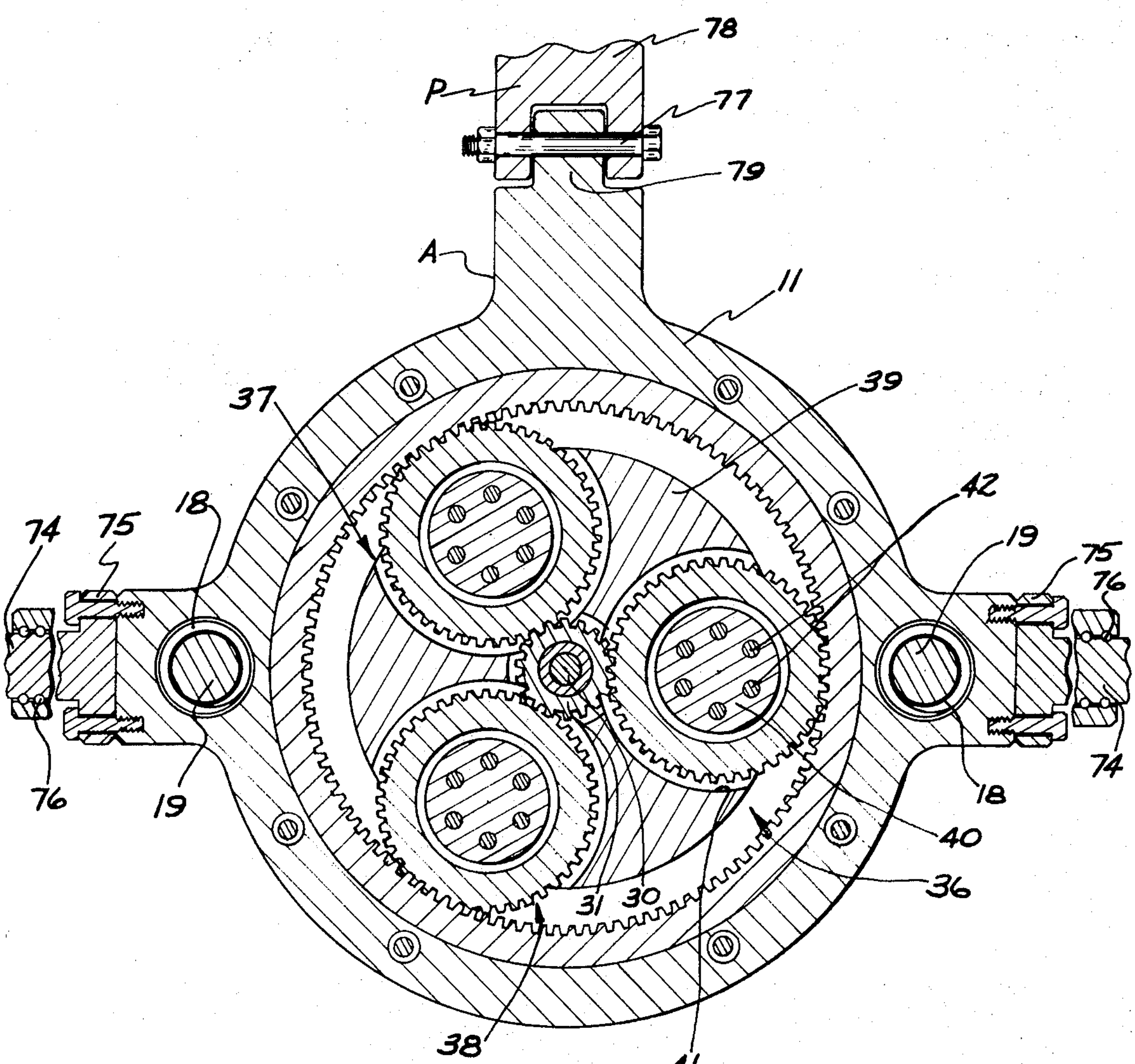

Fig. 3

CICERO C. BROWN
INVENTOR.

BY Carlos A. Torres
Bill B. Berryhill

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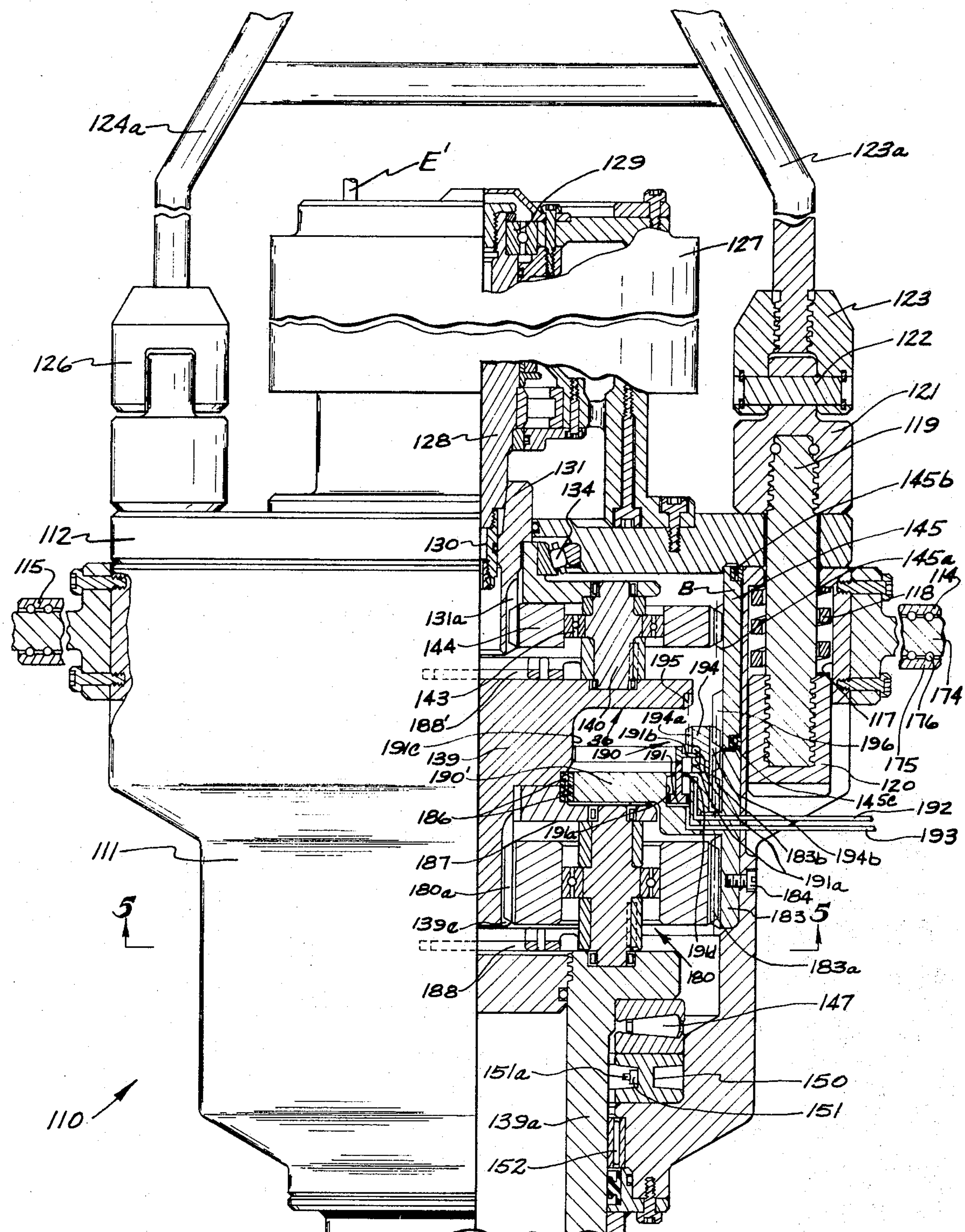

Fig. 4A

CICERO C. BROWN
INVENTOR.

BY Carlos A. Torres
Bill B. Berryhill
ATTORNEYS

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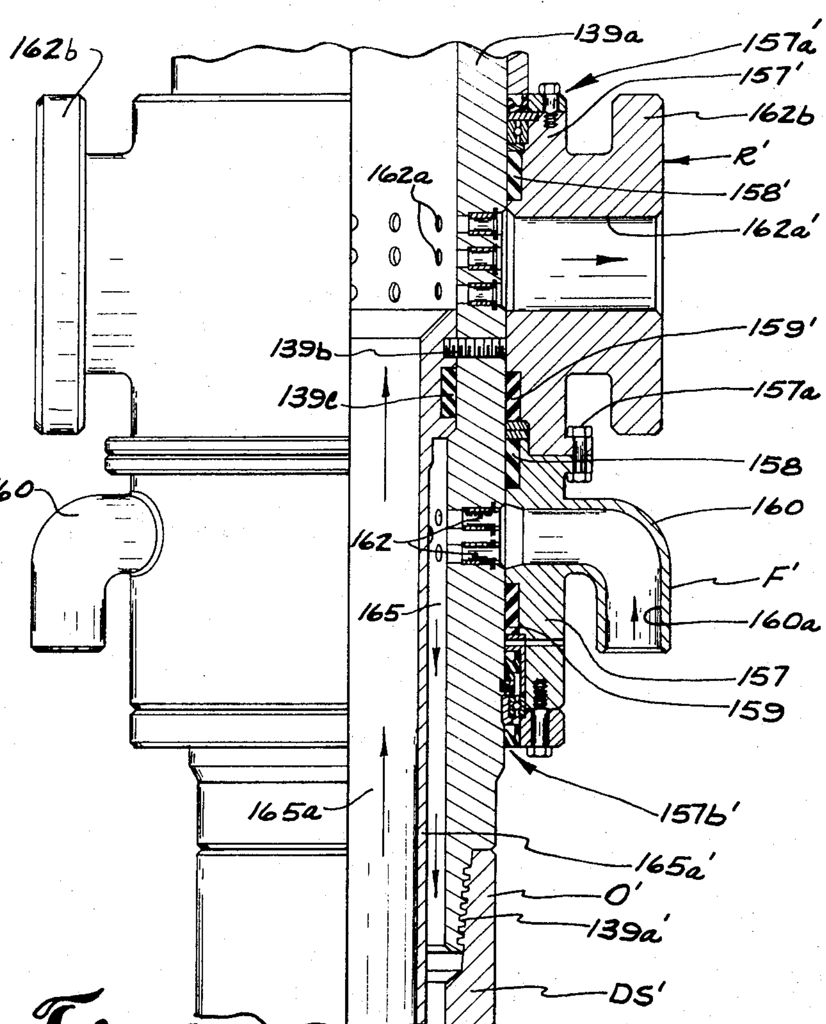

Fig. 4B

CICERO C. BROWN
INVENTOR.

BY Carlos A. Torres
Bill B. Berryhill

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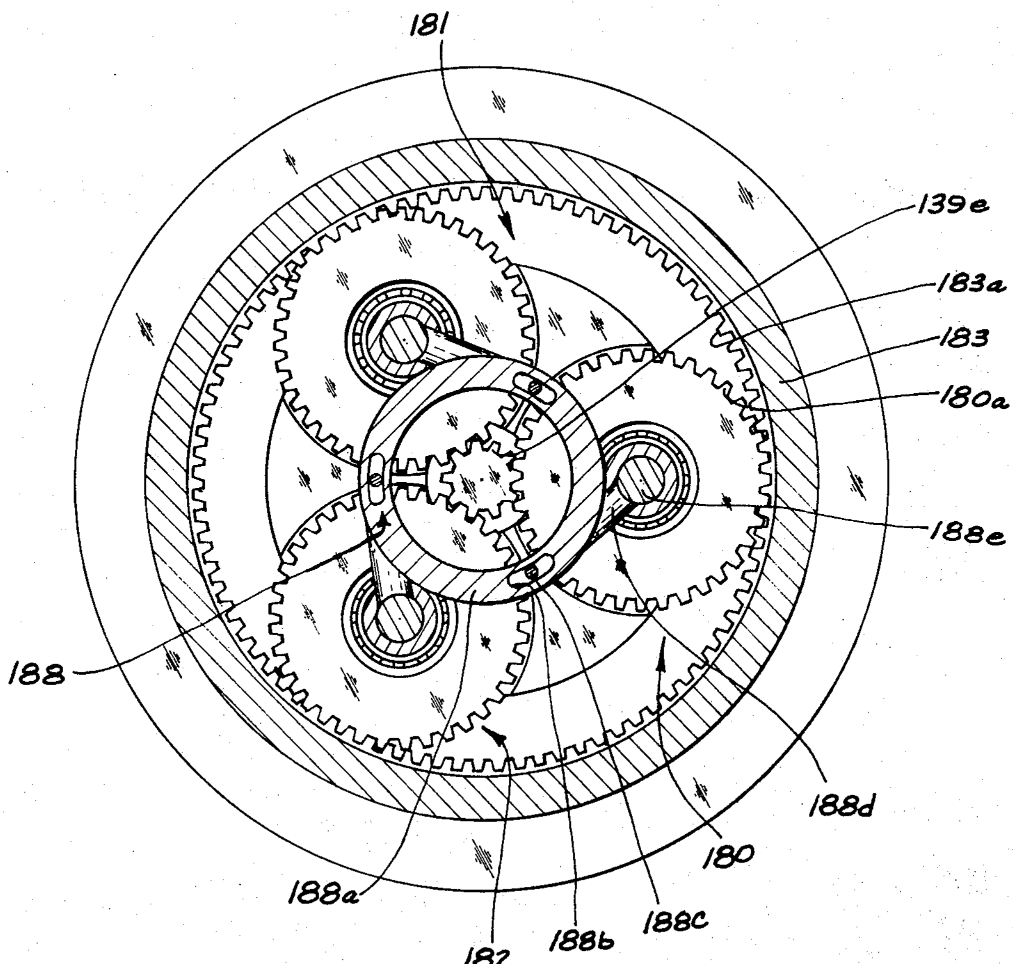

Fig. 5

CICERO C. BROWN
INVENTOR.

BY Carlos A. Torres
Bill B. Berryhill

ATTORNEYS

ROTARY DRIVE ASSEMBLY FOR HANDLING TUBULAR MEMBERS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U. S. Patent application, Ser. No. 130,597 entitled ELECTRIC POWER SWIVEL AND SYSTEM FOR USE IN ROTARY WELL DRILLING, filed Apr. 2, 1971.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to means for handling tubular fluid conducting members. In the specific application to be described, the present invention relates to vertically movable powered drive means for imparting rotary, vertical and pivotal motion to drill pipe and other tubular well members employed in the drilling and production of petroleum wells.

2. Brief Description of the Prior Art

In the conventional method of drilling wells, large internal combustion engines or other power sources are employed to rotate a rotary table set in the floor of a drilling derrick. Rotary motion of the rotary table is conveyed to a square kelly which is free to slide vertically through the rotary table while it is rotated by the table. The lower end of the kelly is threadedly engaged to the upper end of a string of drill pipe and the rotary motion is carried to a bit located at the lower end of the string.

As lengths of pipe are added to or removed from the drill string, it is necessary to employ auxiliary equipment such as wrenches, tongs, ropes and chains to threadedly engage and disengage the pipe members employed in the string. The technique, which is well known, is slow and extremely dangerous.

Other operations conventionally employed during the drilling of a well may require cocking the kelly over to connect into or release a short length of drill pipe. The cocking and threading or unthreading requires manual movement of the heavy equipment away from its normal vertical position which again necessitates the use of cumbersome, dangerous equipment.

In the parent of the present application, the power swivel therein described employs a central bore extending through the shaft of the electric motor for the purpose of communicating drilling fluids to the tubular drill pipe driven by the power assembly. This requires that a conventional, off-the-shelf electric motor be modified by formation of a concentric fluid conducting bore through the motor shaft. The modification may invalidate the manufacturer's warranty for the motor and may also adversely affect the strength of the shaft.

The assembly described in the parent application also employs an hydraulic, shock loading or cushioning system to suspend the assembly from the traveling block. In some applications, a cushioning or support assembly having the high load capabilities of a hydraulic system is not required and a smaller, more direct mechanical cushioning system may be desirable.

SUMMARY OF THE INVENTION

The assembly of the present invention provides vertical, rotary and angular movement in tubular well pipes as required in the drilling and completion of petroleum wells. These needs are provided without the use of cumbersome rotary tables and slow, dangerous auxiliary equipment. In the present invention, a reversible,

electric motor with variable reduction gearing is mounted as a vertically and pivotably movable assembly in a well derrick and is employed to handle the tubular members employed in the drilling and production of a well.

Fluid communication with the rotating tubular drive at the output end of the assembly is provided directly without the need for fluid communication through the drive shaft of the electric motor. By eliminating the need for the bore in the electric motor shaft, the shaft strength is maintained and there is no invalidation of the equipment manufacturer's warranties due to modification.

A mechanical spring shock absorber is employed to suspend and cushion the assembly from the traveling block. A simple, low cost mechanical spring suspension is employed so that the assembly may be used in relatively low stress applications without the need for a hydraulic cushioning system.

The assembly of the present invention is equipped with increased gearing output ranges to provide greater versatility. Gear reductions of 6 to 1 and 36 to 1 are employed in different forms of the invention. In one form of the invention, a gear shift provision is employed so that the assembly may operate in either a 6 to 1 reduction range, or by activation of the hydraulically driven gear shift means, in a 36 to 1 reduction range. By this means, the need for an expensive, variable speed electric motor with high performance characteristics is eliminated while maintaining the desired output rotation ranges.

These and other features and advantages of the present invention will be better understood from the following specification, the related drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial vertical elevation schematically illustrating the rotary drive assembly of the present invention in a well drilling derrick;

FIG. **2** is a vertical elevation in quarter-section illustrating the preferred form of the rotary drive assembly of the present invention;

FIG. **3** is a horizontal cross-section taken along the line **3—3** of FIG. **2**;

FIGS. **4A** and **4B** are vertical elevations in quarter-section illustrating respectively the upper and lower portions of a modified form of the rotary drive assembly of the present invention; and

FIG. **5** is a horizontal cross-section taken along the line **5—5** of FIG. **4A**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, the rotary drive assembly of the present invention is indicated generally at **10** suspended from a derrick D by a traveling block B. Two vertically extending tubular guides G (only one is visible) project upwardly from a derrick floor DF to provide guidance to the assembly **10** and to prevent counter-rotation of the assembly. The assembly **10** is connected to the guide members G by sleeves S which slide along the guide members to permit vertical movement of the assembly as the block B is moved through the derrick G. An hydraulic piston assembly P extends between the block B and a connector arm A rigidly connected to a main housing **11** in the assembly **10**. Extension of the hydraulic cylinder P rotates the assembly **10** about dual pivotal mountings indicated generally at M (only one mounting is visible in FIG. 1) so that a tubular output drive shaft O extending from the base of assembly **10** is inclined with respect to the vertical. In FIG. **1**, the output drive shaft O has been inclined into the dotted position to be attached to a length of pipe L which is driven up to the end of the shaft O by any suitable means (not shown). The end of output shaft O is equipped with threads to threadedly engage a pipe or may also be equipped with movable gripping means for frictionally grasping and securing the tubular members to be handled. One such form of gripping means is described in the aforementioned application, Ser. No. 130,597. Flexible electric and hydraulic lines are made up into a cable E which extends to the assembly **10** to provide control signals and power which regulate the various tilting, rotational and grasping movements of the assembly. A second flexible cable F' connects directly into the output drive shaft O through a connector F to provide drilling fluids to a central flow passage into the output drive shaft O.

Operation of the assembly **10** is controlled from a control panel C. Electric and/or hydraulic control lines CL extend from the control panel C and communicate with the cable E to convey control currents and power to a reversible electric motor (not visible) contained within the assembly **10.** By manipulation of the controls on the panel C, the electric motor in the assembly **10** may be caused to rotate to the right or left or to start or stop. Other controls carried in the line CL are employed to regulate expansion and contraction of the hydraulic cylinder P to thereby determine the angle of inclination of the output drive O, to control the vertical movement and position of the traveling block B, to control grasping and release of pipe gripping mechanisms carried by the drive O, and to control the flow of fluids through the line F'. In addition, the control panel C is equipped with visual indicators for showing the weight suspended from the assembly **10,** the rate of rotation of the shaft O, and the rate of penetration or rate of vertical movement of the assembly and other variables which must be monitored in the drilling operation.

When an additional length of pipe must be added during drilling operations, the assembly **10** is cocked over into the dotted line position to engage the upper end of the length of pipe L. Rotation of the output shaft O causes the shaft to threadedly engage the pipe section L and the block B is then raised while the output shaft means is moved into its vertical position. The lower, female end of the pipe section L (not illustrated) is positioned over the top of a drill string DS and rotated by the assembly **10** to threadedly engage the pipe L and the drill string. Subsequently, the entire drill string, including section L is supported from the assembly **10** which in turn is supported by the traveling block B. The electric motor in the assembly **10** is then activated to induce rotation of the output shaft O, attached pipe L and drill string DS to impart a rotary motion to a drill bit (not illustrated) secured to the bottom of the drill string. Other conventional operations including removing or replacing the entire drill string and positioning or removing production tubing may be performed by the assembly **10** by raising, lowering, rotating, or pivoting the pipe or tubing as required.

Details in the construction of the assembly 10 are illustrated in FIG. 2 of the drawings. The main housing **11** of the assembly is a substantially annular, hollow body which encases the upper end of the rotatable output shaft O and the reduction gears connected between the motor shaft and the output shaft. The upper end of the housing **11** is closed over by a circular, centrally apertured plate **12.** The housing **11** includes two radially extending suspension ears **14** and **15** positioned 180° from each other. With specific reference to the suspension ear **14** which is similar in construction to the ear **15,** an axially extending bore **17** formed through the ear **13** confines a metal coil spring **18** employed to cushion the assembly **10** in its suspension from the block B. A connecting rod **19** extends through the spring **18** and through a bore in the plate **12.** The spring **18** is maintained within the bore **17** between a threaded nut **20** engaging the lower end of the rod **19** and an internal shoulder **17*a*** formed at the upper end of the bore **17.** The upper rod end includes a clevis connection **21** through which a pin **22** is inserted to secure an arm **23** employed to secure the assembly to the block B. A similar arm **24** connected with a pin **25** inserted through a clevis connection **26** cooperates with the arm **23** to provide dual supports at opposite sides of the assembly **10.**

A reversible electric motor (not illustrated) encased within a motor housing **27** is employed to provide power in the form of rotary motion in a motor shaft **28.** A top plate **27*a*** is secured to the housing **27** by bolts **27*b*** and bolts **27*c*** secure the motor housing to the plate **12.** The upper end of the shaft **28** is mounted between radially supporting ball bearings **29** and the lower shaft end is threadedly engaged to a tubular gear support body **30.** The construction of the electric motor and its mounting within the housing **27** are conventional. A central spur gear **31** equipped with gear teeth **31a** is mounted on and locked to the support body **30** for rotation therewith. Suitable locking means such as the key **31b** fix the pinion gear **31** on the motor output shaft **28** to prevent the gear and mounting **30** from rotating with respect to the shaft **28.** O-ring seals **12*a*** and **12*b*** prevent debris from entering the housing **11.** The seal **12*a*** is adapted to slide along a smooth outer surface on the gear **31.** An annular bearing mount **32** encircles the gear **31** and supports an inner face member **33** on inclined roller bearings **34.** An outer race **35** for the bearings **34** is mounted concentrically within the circular path **12.** The roller bearings **34** are employed for preloading the rotatable drive assembly and provide both axial and radial friction reducing support.

With joint reference to FIGS. **2** and **3**, three planetary gears indicated generally at **36, 37** and **38** are mounted for rotary motion about shafts secured to a circular mounting head formed at the upper end of a tubular output drive shaft **39.** The lower end of shaft **39** forms the output drive shaft O. The centers of the gears **36–38** are positioned on the same radius and are spaced 120° from each other. The three gears **36–38,** which are the same will be described with specific reference only to gear **36.** The gear **36** includes a central shaft **40** which is mounted in a receiving recess **41** formed in the top surface of the mounting head on shaft **39.** Socket head bolts **42** hold the shaft **40** in firm engagement with the shaft **39** and ball bearings **43** mount an annular gear ring **44** about the shaft **40.** The ring **44** is equipped with external gear teeth **44*a*** which mesh with the gear teeth **31*a*** on the pinion gear **31** and also mesh with the gear teeth **45*a*** formed internally of a large ring gear **45**. The gear **45** is rigidly secured to the plate **12** by suitable socket head bolts **46**.

Rotary and axial support for the large weight which is to be suspended from the output drive shaft **39** is provided by tapered roller bearings **47** supported between lower and upper races **48** and **49**, respectively. The lower race **48** is supported on an annular H-beam collar **50** which in turn is supported on an internal shoulder formed in the housing **11**. A conventional strain gauge **51** is attached to the upstanding web connecting the upper and lower portions of the collar **50** and suitable electrical leads **51***a* extend to the control panel C to provide an input signal to a transducer which forms a visible indication of the weight being supported by the shaft **39**.

At the lower end of the housing **11**, shaft **39** is supported radially by roller bearings **52**. An annular fitting **53** secured to the base of housing **11** by bolts **54** mounts a resilient seal **55** adapted to bear against and seal with a rotatable sleeve **56** secured by bolts **56***a* to a restricted portion **39***a* of the output drive shaft **39**. The fluid connector indicated generally at F includes a tubular sleeve **57** which extends about the sleeve **56**. The connector F which is secured to the base of housing **11** by the bolts **54** employs upper and lower annular packing **58** and **59** to form a sliding, leakproof seal between the sleeves **56** and **57**. An input flow connector nipple **60** connects to the sleeve **57** and is equipped with a fluid conducting passage **60***a* which communicates with an annular passage **61** formed between the sleeves **56** and **57**. The passage **60***a* communicate with radial bores **62** extending through the sleeve **56** and into the tubular body of the drive shaft **39**. Upper and lower O-ring seals **63** and **64**, respectively prevent fluid leakage between the sleeve **56** and shaft **39**. The flow connector F is employed to convey drilling fluids from a stationary external supply point (not illustrated) to a rotatable, central flow passage **65** extending centrally through the tubular output drive shaft **39**.

An annular control line connector ring **66** secured to the base of the tubular body **57** by suitable bolts **67** cooperates with annular O-rings **68, 69** and **70** to provide sliding seals with the shaft **39** which isolate two separate fluid conducting paths **72** and **73**. The two flow paths **72** and **73** may be employed to convey hydraulic control fluid to automatic pipe gripping slips (not illustrated) or other automated assemblies connected to the end O of the output drive shaft.

Referring jointly to FIGS. **1, 2** and **3**, the pivotable mounts M include radially extending pins **74** projecting through bores carried at the ends of guide connecting arms **75**. The arms **75** extend to and connect with the guide sleeves S. Ball bearings **76** are mounted between the pins **74** and the receiving bores of the arms **75**. The two arms **75** cooperate with the sleeves S to provide a structure which permits pivoting and vertical movement of the assembly **10** while preventing rotation of the assembly caused by reaction to rotary motion of the output drive shaft **39**. A pin **77** extends through a clevis **78** to pivotably secure the lower end of the hydraulic cylinder P to an eye brace **79** extending from the housing **11**.

OPERATION OF THE ASSEMBLY

When the output drive shaft end O is secured to a drill string, the weight of the string compresses the springs **18** between the shoulders **17***a* and the upper axial end of nut **20**. The springs **18** function to cushion and absorb sudden changes in vertical loading acting through the drive shaft **39** which may occur for example when the drill string is released from the assembly **10** or when the assembly is pulled downwardly away from the block B as the end O is threaded onto the top of the drilling string.

By appropriately moving controls on the control panel C, electrical energy is supplied through the cable E to the electric motor in the housing **27**. Depending upon the function being performed, the rotation of the motor may be in either a clockwise or counterclockwise direction. Rotation of the motor rotates the shaft **28** and the attached pinion gear **31**. As the gear is rotated, the meshing engagement of the gear teeth on the three planetary gears **36–38** with the teeth **31***a* and with the surrounding teeth **45***a* on fixed gear **45** causes the output shaft **39** to rotate within the housing **11**. Rotation of the shaft **39** is imparted to equipment or pipe strings attached to the output shaft end O. Six complete rotations of the motor shaft **28** are required to produce a single rotation in the output shaft **39** for a six to one reduction.

During conventional drilling operations, drilling fluid is supplied through the drill string to the bit. Drilling fluid entering the connector F communicates with the central flow passage **65** in the rotating output shaft **39** to provide the desired fluid flow.

MODIFIED ASSEMBLY

A modified drive assembly is depicted generally at **110** in FIGS. 4A and 4B. The assembly **110** is similar to the previously described assembly **10** except that the modified assembly is equipped with a 36 to 1 reduction capability whereas the assembly **10** is limited to a six to one reduction. In addition, the assembly **110** is equipped with provision for converting gearing ratios between 6 to 1 and 36 to 1 and also includes dual flow passages for both conveying drilling fluid to the drill bit and returning the fluid and fluid carried cuttings to the well surface. Load distributing means are also included in the modified assembly **110** for assisting in equally distributing forces acting in the assembly to improve smoothness of operation and prolong the life of the various moving components.

The assembly **110** includes a main housing **111** covered at its upper end by a centrally apertured, circular plate **112**. Dual suspension ears **114** and **115** are employed to suspend the assembly from the traveling block. With specific reference to the ear **114**, an axially extending bore **117** is formed through the housing **111** to receive a shock absorbing coil spring **118**. A connecting rod **119** projects upwardly through the bore **117** and connects to the suspension structure extending from the assembly **110** to the traveling block. A threaded nut **120** holds the spring **118** in place within the bore **117**. An eye member **121** is threadedly engaged to the upper end of the rod **119** and connects with a pin **122** passing through a clevis fitting **123**. A connecting rod **123***a* threadedly engaged to the clevis fitting **123** extends upwardly and meets with a second arm **124***a* connected to a clevis fitting **126** extending upwardly from the ear **115** at the opposite end of the assembly. The two suspension structures **123***a* and **124***a* meet at a single point (not illustrated) from which the assembly is suspended from the traveling block.

An electric motor housing **127** is bolted to the plate **112** and an electric motor (not illustrated) in the housing **127** rotates a central motor shaft **128.** The upper end of the shaft **128** is mounted for rotation in upper ball bearings **129** and the lower end of the shaft is threadedly engaged with a gear support **130** upon which an annular spur gear **131** is mounted and fixed. Inclined roller bearings **134** are used to align and preload the shaft **128.** Three planetary gears such as gear **136** are mounted in the upper surface of a circular mounting head formed at the top of a shaft **139.** It will be appreciated that the three gears similar to gears **136** are mounted and disposed in a manner similar to that of gears **36–38** illustrated in FIG. **3.** The gears of assembly **110** differ from those in the assembly **10** in that the former are equipped with load equalizing means to be hereinafter described. The gear **136** includes a gear shaft **140** encircled by ball bearings **143** which rotatably mount a circular gear **144.** External gear geeth on the gear **144** mesh with gear teeth **145*a*** formed along the internal surface of a large annular ring gear **145.** The gear **145** is mounted in upper and lower ball bearings **145*b*** and **145*c***, respectively, for rotation within the housing **11.**

As will be seen, rotation of the electric motor shaft **128** acts through a variable gear reduction system to impart rotation to a lower tubular output drive shaft **139*a***. Tapered roller bearings **147** support and align the shaft **139*a*** for rotation within the housing **111.** The bearings **147** are supported in an annular H-beam collar **150** equipped with a strain gauge **151.** Output leads **151*a*** connected with the strain gauge **151** connect to the control panel (not illustrated) to provide a visual indication of the total weight suspended from the assembly **110.** Roller bearings **152** align and radially support the shaft **139*a*** for rotation within the lower portion of the housing **111.**

Referring to FIG. 4B, a fluid input assembly F′ is formed by a tubular connecting sleeve **157** which surrounds the lower portion of the output drive shaft **139*a***. Upper and lower packing **158** and **159** respectively, is positioned between the tubular connector body **157** and the cylindrical outer surface of the drive shaft **139*a*** to provide a leakproof seal between the stationary fluid input connector F′ and the rotating output drive shaft **139*a***. The assembly F′ is secured to a return connector R′ by suitable bolts **157*a***. The connector R′ includes a tubular sleeve portion **157′** which encircles the drive shaft **139*a***. Upper and lower packing **158′** and **159′** respectively is positioned between the sleeve **157′** and the shaft **139*a*** to provide a sliding, leakproof connection between the stationary connector R′ and the rotating shaft **139*a***. Upper and lower ball bearing and seal assemblies indicated generally at **157*a*′** and **157*b*′** respectively assist in supporting the shaft **139*a*** for rotation within the stationary structures F′ and R′ .

Openings **160*a*** extend through input flow connector nipples **160** which communicate with radial bores **162** formed through the wall of the drive shaft **139*a*** to convey drilling fluid into an axially extending, annular flow passage **165.** Drilling fluids entering the nipples **160** flow in the direction of the arrows shown in the flow paths **160*a*** through the radial ports **162** and into the annular input flow passage **165** where they are conducted downwardly to a drill bit (not illustrated) suspended from the assembly **110.** Drilling fluid and fluid borne cuttings are returned up to the wellhead through a return flow passage **165*a*** provided by a tubular conduit **165*a*′** carried within the tubular shaft **139*a***. The conduit **165*a*** extends down through a drill string DS′ threadedly engaged with the threads **139*a*′** at the output end O′ of the assembly **110.** The tubular conductor **165*a*′** is secured to the drive shaft **139*a*** by suitable bolts **139*b*** for rotation with the shaft **139*a***. Packing **139*c*** between the inner conduit **165*a*′** and the shaft **139*a*** provides a leakproof connection between the two members to isolate the input flow passage **165** from the return flow passage **165*a***. Fluid and returns flowing in the return passage **165*a*** flow through radial openings **162*a*** formed in the walls of the shaft **139*a*** and enter an output passage **162*a*′** extending through return flanges **162*b*** in connector R′.

Referring back to FIG. 4A, two pins such as the pin **174** extend through openings provided in connecting arms **175** which are secured to guide sleeves (not illustrated). Ball bearings **176** are disposed between the arms **175** and the pins **174** to permit pivoting of the assembly **110.**

The gearing connection between the motor shaft **128** and the output drive shaft **139*a*** is provided by the three planetary gears such as the gear **136,** already described, acting in cooperation with an additional set of planetary gears indicated generally at **180, 181** and **182.** With joint reference to FIGS. **5** and **4A**, the gears **180–182** are similar to the three gears (such as the gear **136**) mounted in the mounting plate at the upper end of the shaft **139.** With specific reference to the gear **180,** gear teeth **180*a*** mesh with gear teeth **183*a*** formed along the internal surface of a stationary ring gear **183.** The gear **183** is secured to the housing **111** by bolts **184.** The gear teeth **180*a*** also mesh with gear teeth **139*e*** formed along the lower portion of the shaft **139.** The gears **180–182** are mounted in the shaft **139*a*** so that rotation of the shaft **139** acts through the gears **180–182** to impart a rotary motion to the shaft **139*a***. Suitable ball bearings **186** support the shaft **139** for rotary motion within the housing **111.** Upper shaft supports **187** assist in mounting and aligning the central shafts of gears **180–182.**

A load distributing means **188** is connected by arms to the central shafts in each of the gears **180–182.** The load distributing mechanism includes a circular plate member **188*a*** through which three slots **188*b*** are provided. Axially extending pins **188*c*** connected to the ends of arms **188*d*** extend downwardly through the slots **188*c***. The opposite ends of the arms **188*d*** fit over hubs **188*e*** formed on the lower ends of the shafts on which the gears **180–182** are mounted. The hubs **188*e*** are eccentric with respect to the center of the central shafts and any unequal load distribution on any one of the three shafts is transmitted through the arms **188*d*** to the plate member **188*a*** and to the shafts in either of the other two gears to distribute the load equally about the assembly. A similar load distributing mechanism **188′** is employed with the three gears driven by the spur gear **131.**

Provision for shifting or altering the gear reduction ratio between a maximum of thirty-six to one to a lower six to one ratio is provided by a gear shift assembly indicated generally at **190.** The assembly **190** is carried in a centering plate **190′** and includes a fluid driven piston **191** which is raised or lowered in a bore **191**a by fluid pressure applied through hydraulic lines **192** and **193.** The piston **191** connects to a locking member **194** which is equipped with teeth **194***a* and **194***b*. The teeth **194***a* are adapted to engage gear teeth **195** formed along the outer edge of the circular mounting head at the upper end of the shaft **139** and the teeth **194b** are adapted to engage gear teeth **196** carried on the ring gear **145** and teeth **183***b* extending inwardly from the inner wall of the fixed gear ring **183**. The teeth **195**, **196** and **183***b* extend along the entire circumference of the members from which they project. In its lower position, the member **194** locks with teeth **196** and **183***b* to prevent rotation of the gear **145**. In its upper position, the member **194** locks with teeth **195** and **196** and is free of the ring gear **183** so that gear **145** may be rotated. The member **194** is rotatably mounted on rollers **191***a* which ride on a radial lip **191***b* extending outwardly from a support ring **191***c*. A connecting rod **191***d* extends from the piston **191** to the ring **191***c* to raise and lower the ring as the piston is raised and lowered.

OPERATION OF THE MODIFIED ASSEMBLY

The tilting and shock absorbing suspension of the assembly **110** is similar to that described for the assembly **10.** Other functions are also similar except that the assembly **110** is capable of providing either a 36 to 1 gear reduction or a 6 to 1 reduction depending upon placement of the member **194** in the shifting assembly **190.** In addition, the assembly **110** is designed to conduct drilling fluid to the drill bit and return fluid and cuttings through a return passage formed internally of the drill string. Conventionally, returns are brought to the well surface through the annular space between the drill pipe and the surrounding well bore.

With the member **194** in its lower position, rotation of the drive shaft **128** acts through the three gears (such as gear **136**) and the stationary ring gear **145** to induce rotation in the shaft **139**. Rotation of the shaft **139** in turn, rotates the gears **180–182** against the stationary ring gear **183** causing the lower shaft **139***a* to rotate. The gear reduction between the shaft **128** and the shaft **139** is 6 to 1 and the reduction between the shaft **139** and the shaft **139***a* is also 6 to 1 for an overall reduction between the shaft **128** and the shaft **139***a* of 36 to 1.

When six to one reduction between the shaft **128** and the output shaft **139**a is desired, the fluid control line **193** is pressured up to push the piston **191** upwardly which in turn causes the member **194** to lock the teeth **195** on the shaft **139** with the teeth **196** on the gear **145.** Rotation of shaft **128** causes the gear **145** to rotate in the housing **111.** The member **194** rotates about the lip **191***b* to keep the shaft **139** and gear **145** locked together. By this means, the rotation of shaft **128** is imparted on a one-to-one basis to the shaft **139.** Rotation of the shaft **139** is then reduced by the gears **180–182** and cooperating fixed ring gear **183** to provide a six to one reduction between the rate of rotation of the shaft **128** and the rate of rotation of the shaft **139***a*.

With reference to FIG. 4B, drilling mud or other well fluids are introduced into the drill string through the nipples **160** in the stationary connector assembly F′. The input fluid flows through the openings **160***a* through the bores **162** and down the annular passage **165** to the drill bit. A negative pressure is maintained at the return connector R′ so that fluids and fluid borne cuttings at the bottom of the well bore are drawn into the central conductor **165***a′* and elevated through the passage **165***a*. The fluid and returns in the passage **165***a* flow through the radial openings **162***a* and into the flow passages **162***a′* to be carried to a remote location where the cuttings are separated from the fluid and the fluid is recirculated.

While the foregoing invention has been described with specific reference to the use of an electric motor as the drive means, it will be appreciated that other suitable drives may be employed. Thus, hydraulic motors, pneumatic motors, internal combustion engines or other powering devices may be employed to impart the desired rotary motion to the output drive shaft. In addition, while 6 to 1 and 36 to 1 gearing ratios have been shown, different reduction ratios may be employed without departing from the spirit of the present invention. In addition, although hydraulic pivot means have been described for pivoting or tilting the assembly, it is apparent that other means such as electrically powered drives, or other suitable drives may be employed to provide the desired tilting function.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. In a rotary drilling system including a derrick, a vertically movable traveling block and a source of drilling fluids, a rotary drive assembly comprising:

a. a reversible, electrical motor supported from said traveling block and movable vertically therewith, said motor including a rotatable drive shaft;

b. gearing means connecting said drive shaft with a rotatable output drive means for providing a rate of revolution of said rotatable output drive means different than that of said rotatable drive shaft;

c. fluid connecting means between said drilling fluid source and said output drive means for conveying drilling fluids directly from said source to a fluid conductor carried by said rotatable output drive means;

d. telescoping tubular drive members included in said output drive means for forming separate, rotatable, fluid conducting passages; and

e. connecting means between said rotatable passages and non-rotating, external connection points.

2. In a rotary drilling system as defined in claim **1,** gear shift means for altering the rate of rotation of said output drive means for a substantially constant drive shaft rotation rate.

3. In a rotary drilling system as defined in claim **1,** said gearing means including automatic load distributing means.

4. In a rotary drilling system as defined in claim **1,** cushioning means connecting said assembly with said traveling block for cushioning sudden changes in vertical forces resulting between said assembly and said traveling block.

5. In a rotary drilling system as defined in claim **4,** said cushioning means including steel spring means.

6. In a rotary drilling system as defined in claim **1,** pivot means for pivoting said output drive means with respect to the vertical for aligning non-vertically disposed members with said output drive means for connection thereto.

7. In a rotary drilling system as defined in claim 6, backup means for preventing rotation of said traveling block as said output drive means is rotated.

8. In a rotary drilling system as defined in claim 7, said gearing means including automatic load distributing means.

9. In a rotary drilling system as defined in claim 7, control panel means for controlling movement of said rotary drive assembly.

10. In a rotary drilling system as defined in claim 9, said control panel means including:

a. control means for regulating the raising or lowering of said assembly;

b. control means for regulating the onset and termination of rotation of said output drive means; and

c. control means for regulating the angular disposition of said output drive means.

11. In a rotary drilling system as defined in claim 10, said control panel means including load indicator means for forming a visual representation of the load on said assembly.

12. In a rotary drilling system as defined in claim 1, said gearing means including:

a. first gear means connected with said drive shaft means for rotation therewith;

b. second gear means for meshing engagement with said first gear means and movable by rotation of said first gear means; and

c. drive linkage means operatively connected between said telescoping drive member and said second gear means for imparting rotary motion from said second gear means to said drive member, said second gear means including a plurality of planatary gear means rotatable about gear axes fixed relative to said drive linkage means and said planatary gear means operatively meshing with a surrounding third gear means whereby rotation of said first gear means acts through said planatary gear means against said surrounding third gear means to rotate said drive linkage means.

13. In a rotary drilling system as defined in claim 12, said gearing means further including:

a. third gear means operable by gear shift means for connection with said drive shaft means for rotation therewith;

b. fourth gear means for meshing engagement with said third gear means and movable by rotation of said third gear means; and

c. second drive linkage means selectively connected between said drive members and said fourth gear means by said gear shift means for imparting rotary motion from said fourth gear means to said drive member.

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