United States Patent [19]

Hisey et al.

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[45] **Nov. 18, 1975**

[54] **ROTARY DRIVE AND JOINT BREAKOUT MECHANISM**

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[73] Assignee: **Gardner-Denver Company**, Dallas, Tex.

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[21] Appl. No.: **542,983**

Related U.S. Application Data

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[52] **U.S. Cl.** **173/164;** 175/85; 175/315; 175/320

[51] **Int. Cl.**[2] **E21B 3/00**

[58] **Field of Search** 173/164, 165; 175/315, 175/85, 320; 269/16; 81/57.16, 57.22; 64/23.5, 23.7

[56] **References Cited**

UNITED STATES PATENTS

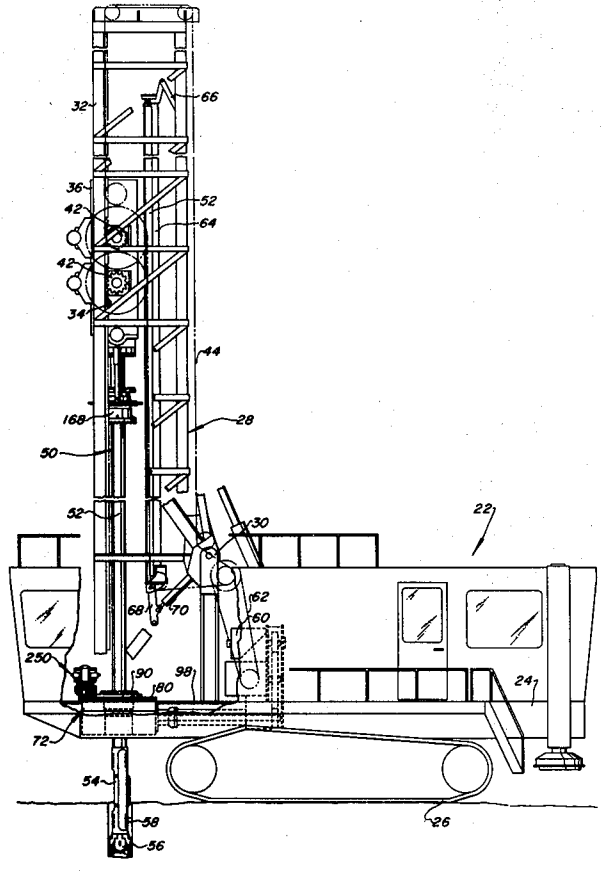
2,338,093	1/1944	Caldwell	64/23.5
2,784,942	3/1957	Peck et al.	175/195 X
3,446,284	5/1969	Dyer et al.	173/164
3,680,412	8/1972	Mayer et al.	81/57.16 X
3,695,364	10/1972	Porter et al.	173/164 X
3,844,547	10/1974	Lang et al.	173/164 X

Primary Examiner—Frank L. Abbott
Assistant Examiner—Richard E. Favreau
Attorney, Agent, or Firm—Michael E. Martin

[57] **ABSTRACT**

A rotary table drive for a blasthole drill has a pair of roller elements pivotally mounted in a table bushing and engageable with cooperative longitudinal flat sided recesses formed on the exterior of a heavy walled cylindrical drill pipe to form the rotary drive connection with the drill stem. Multiple sections of the drill pipe may be used to make up a drill stem. A pull-down traverse frame mounted for longitudinal movement along the rig mast includes a rotary coupling member connected to the top end of a drill pipe section. The traverse frame also includes a drive transfer mechanism which is engageable with the rotary table for transferring the rotary drive effort from the table through the coupling member to the drill stem when the top end of a drill pipe section is passed downward through the table bushing. The drive transfer mechanism can be nonrotatably locked to provide for breakout of the threaded joint between a drill pipe section and the coupling member. A deck mounted wrench for engaging a toothed flange on the rotary table together with a power operated holding wrench is also used to breakout drill stem connections.

4 Claims, 20 Drawing Figures



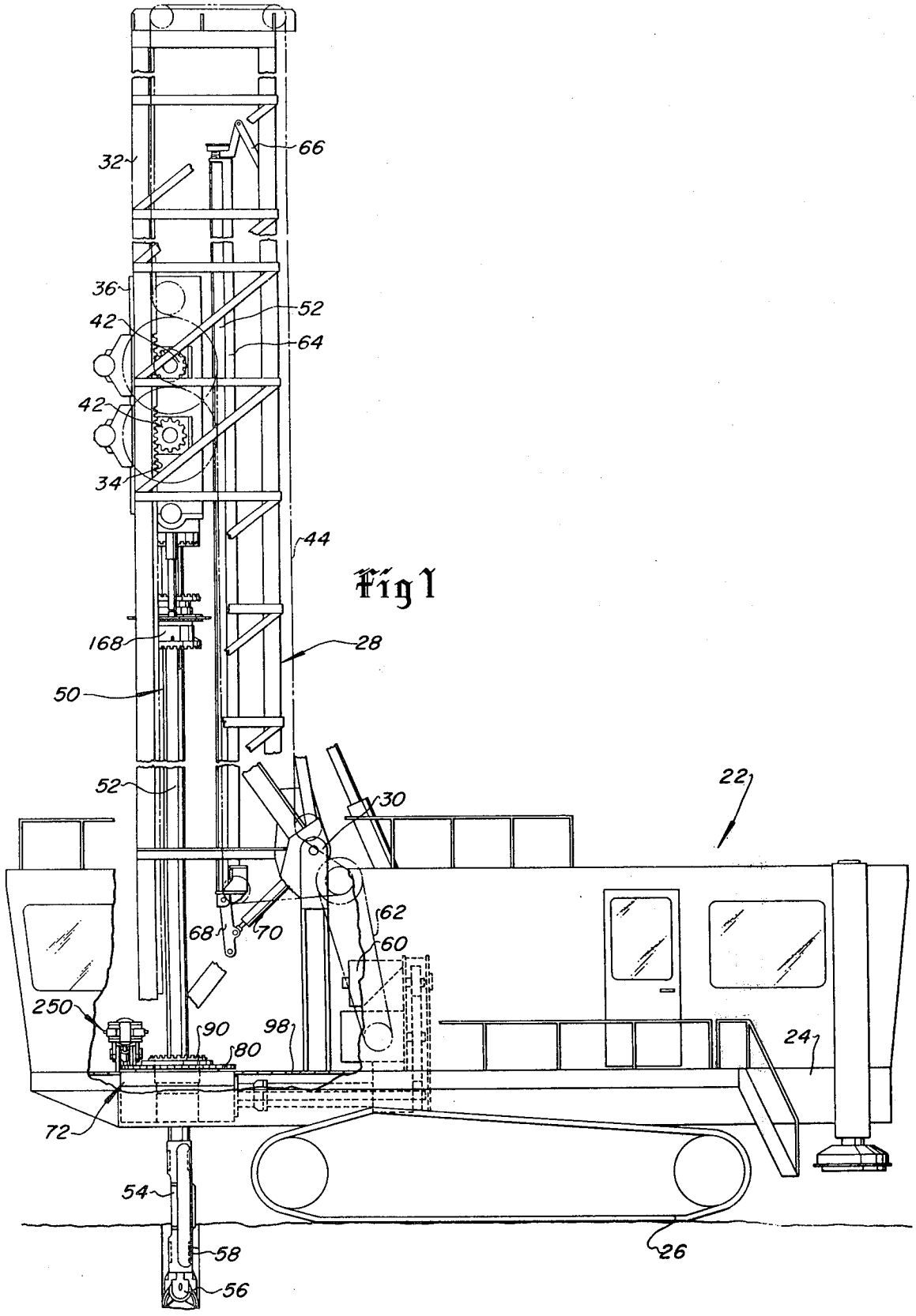

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Fig 1

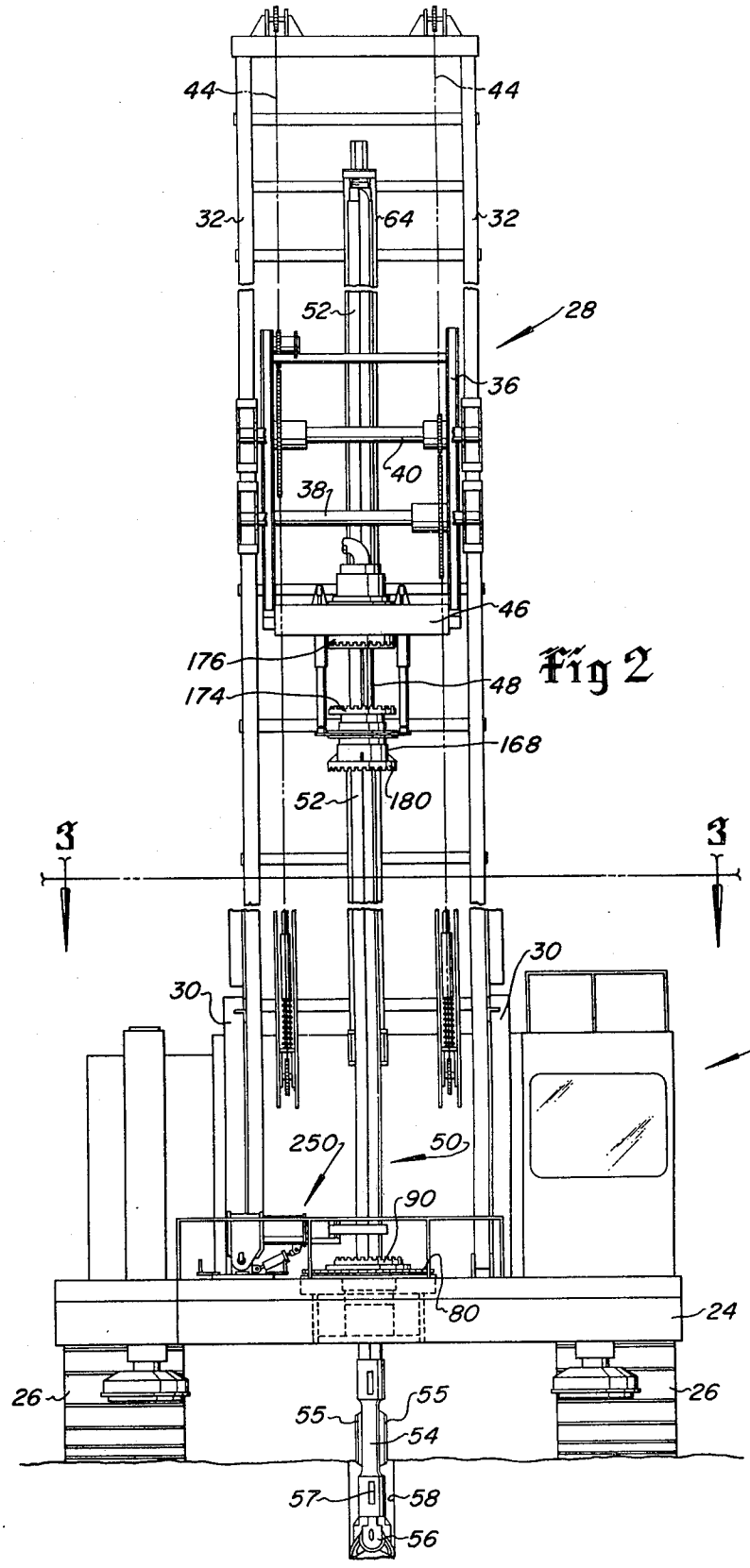

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Fig 2

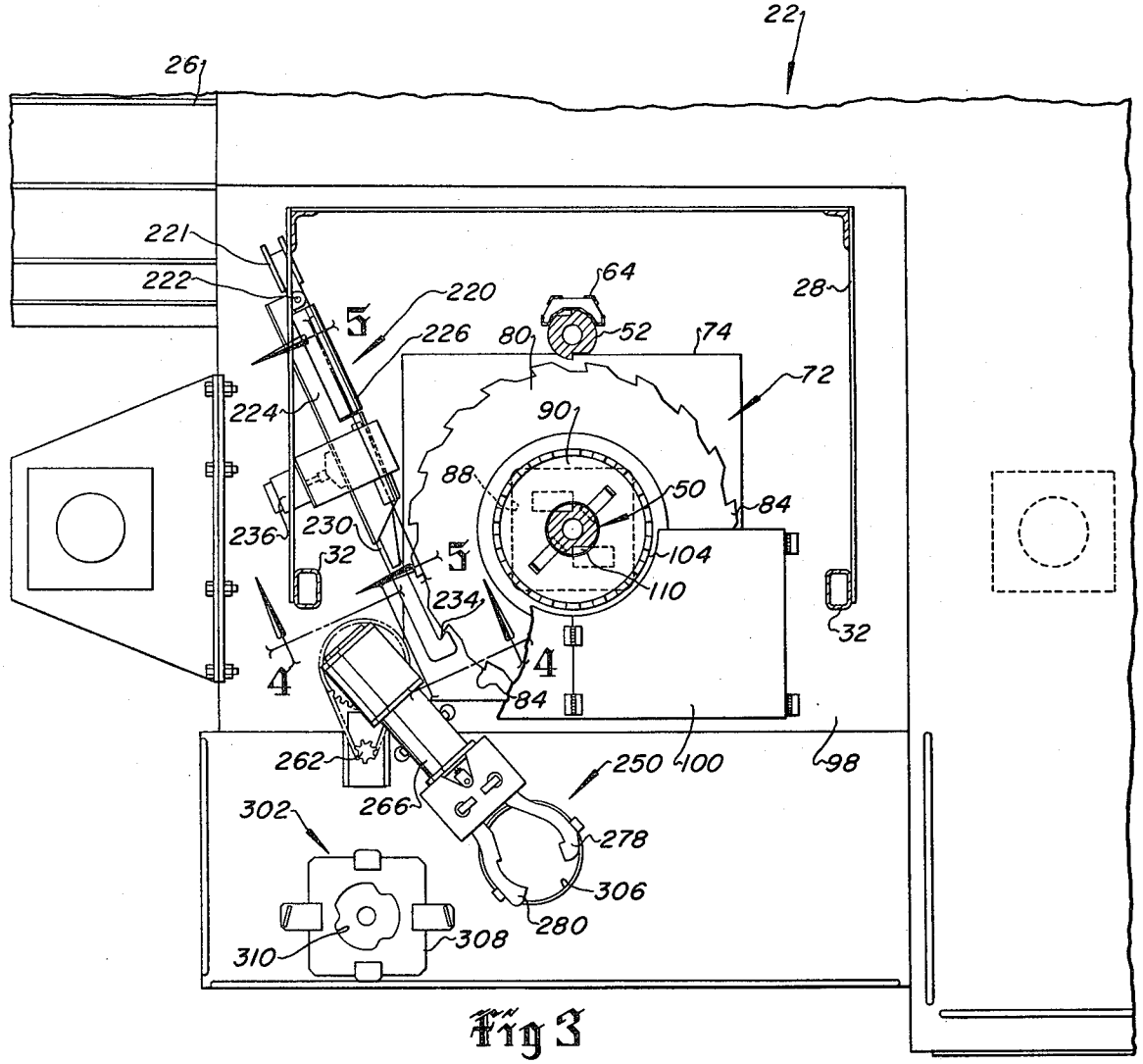


Fig 3

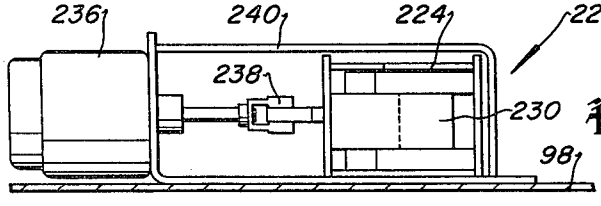


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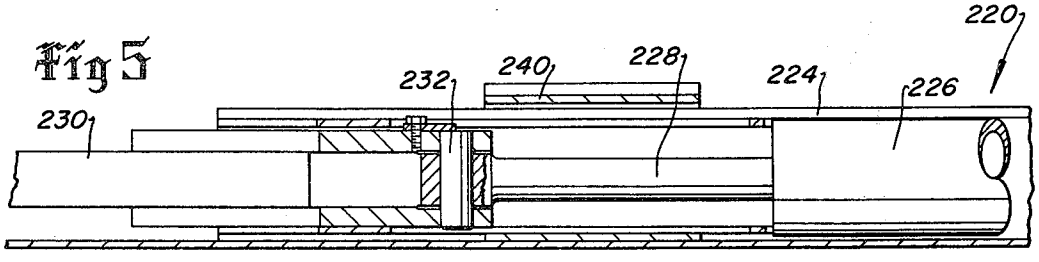


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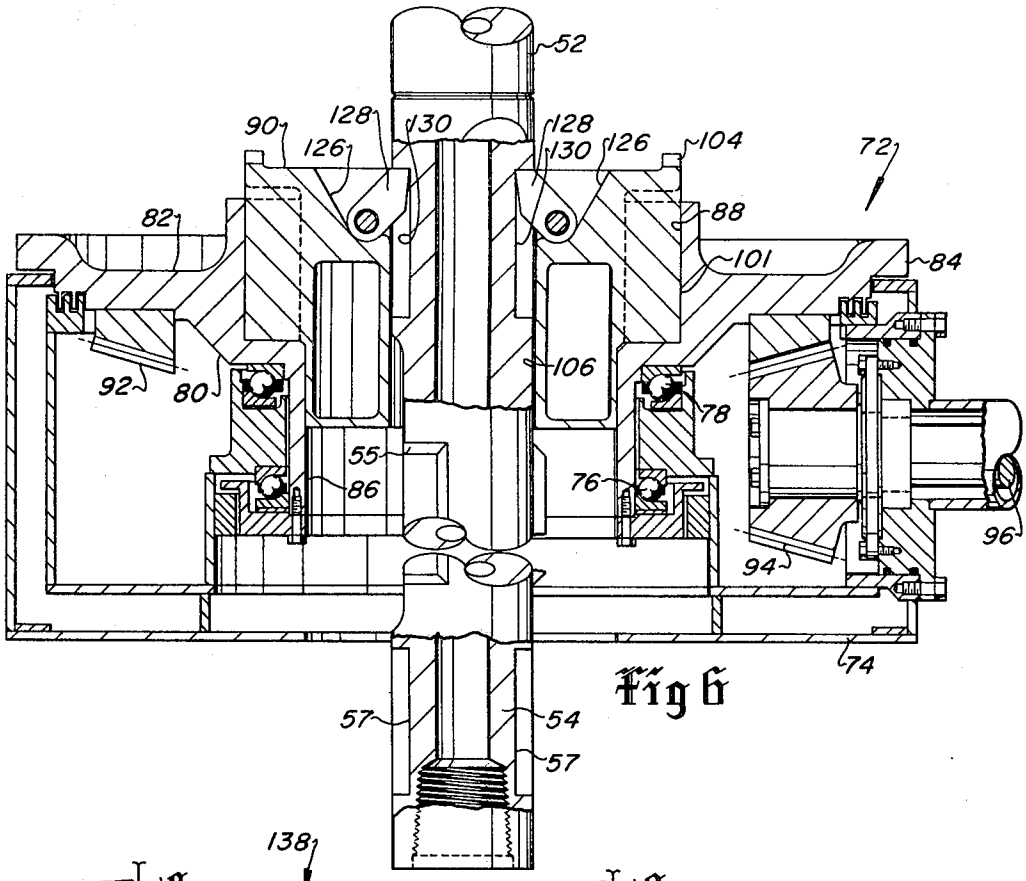


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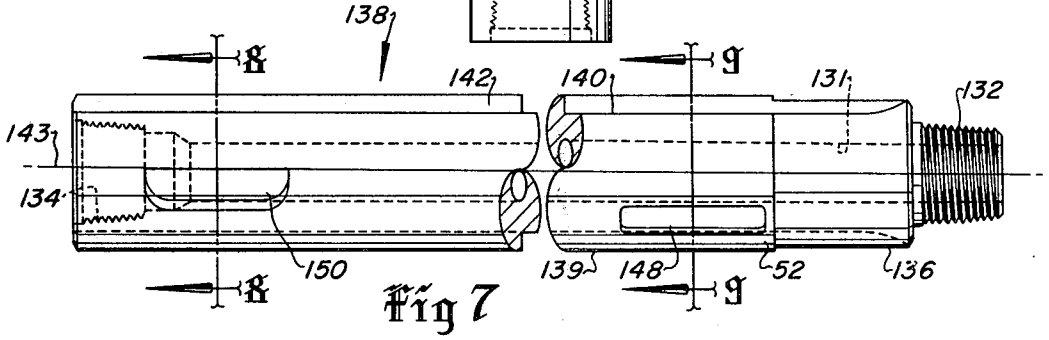


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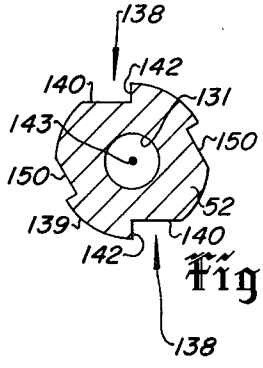


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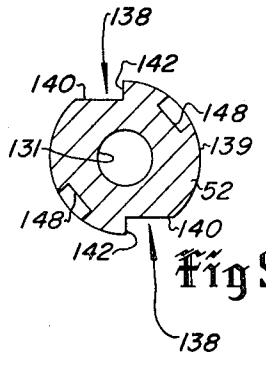


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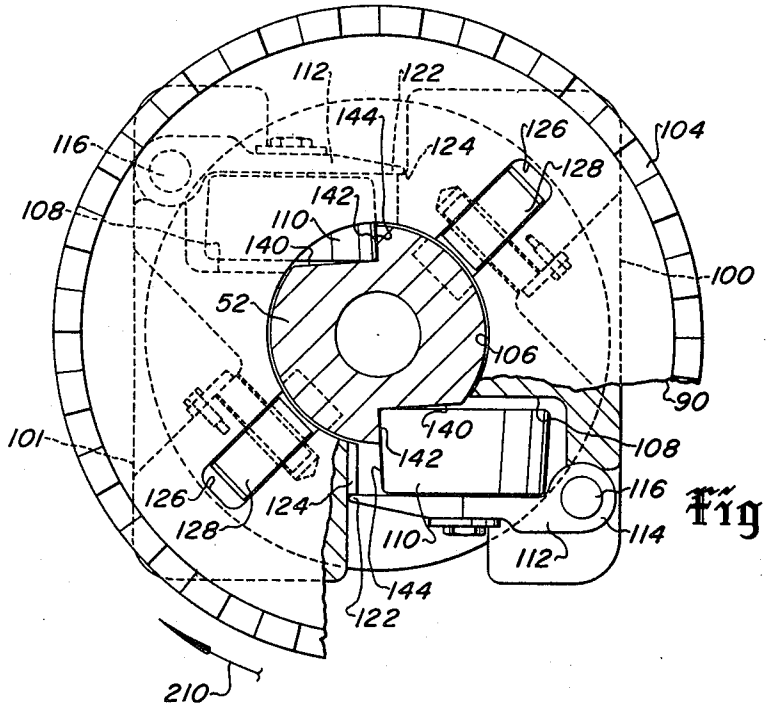

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Fig 10

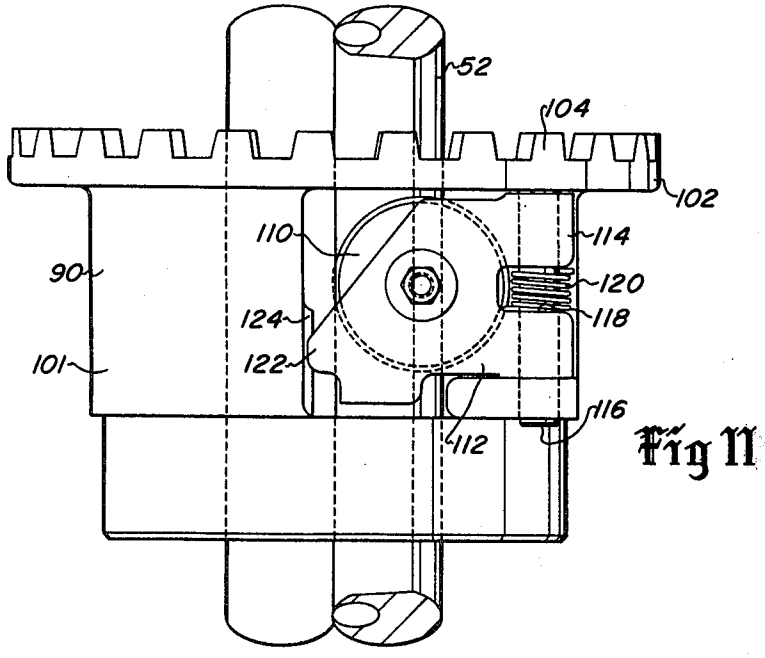

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Fig 11

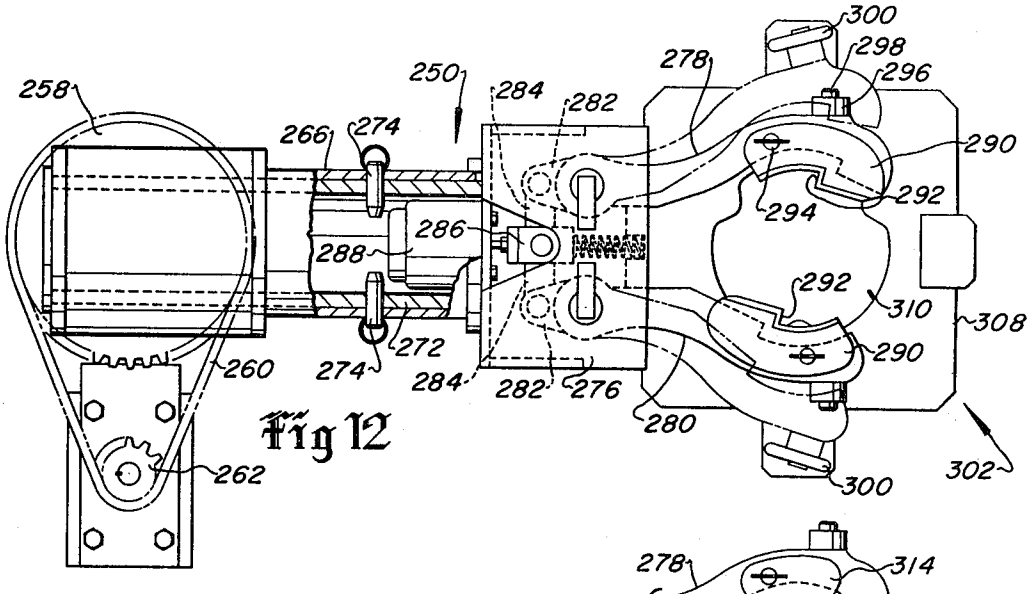


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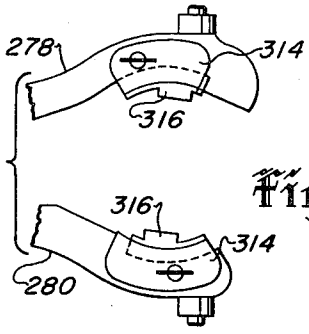


Fig 14

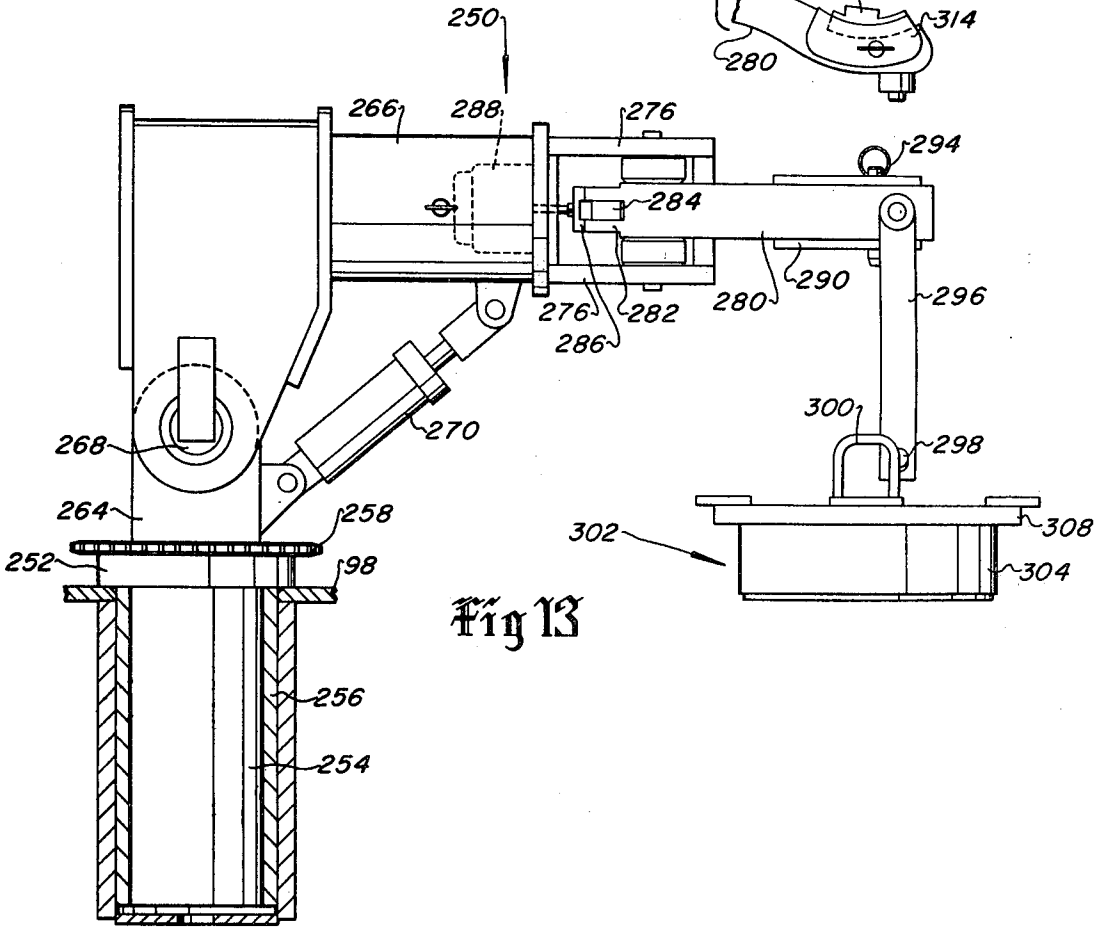


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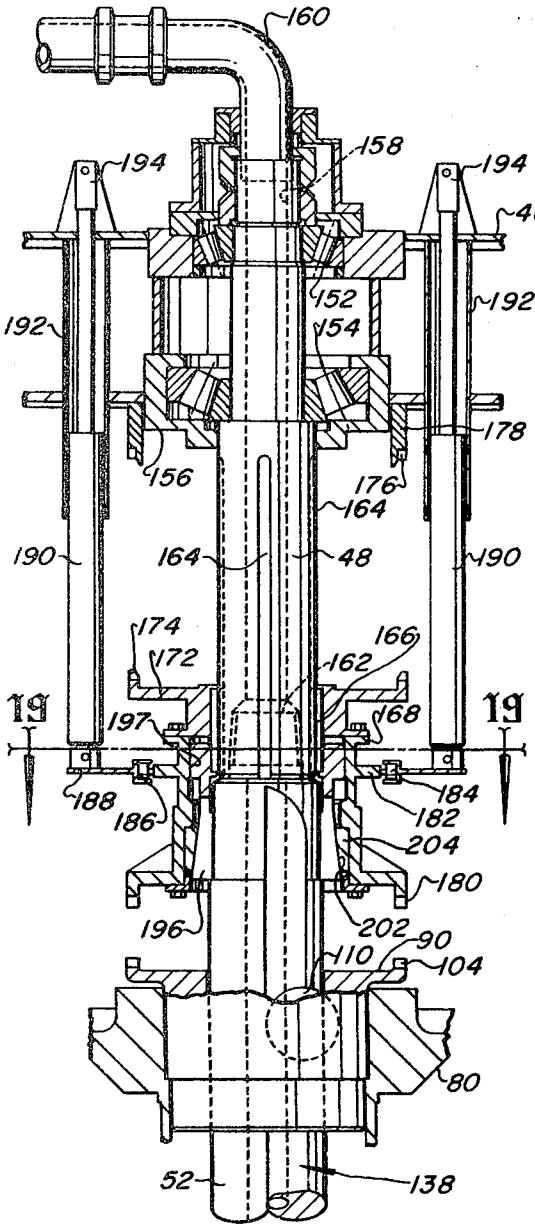
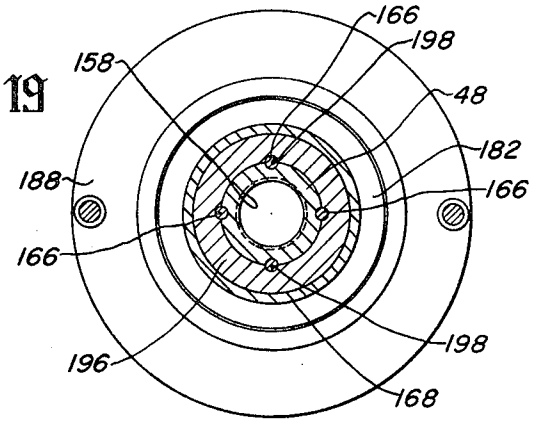


Fig 15

Fig 19



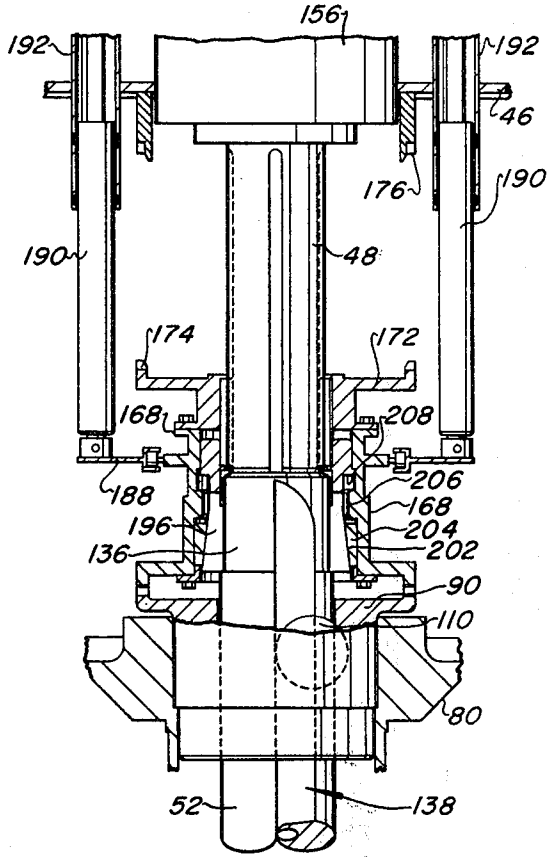


Fig 16

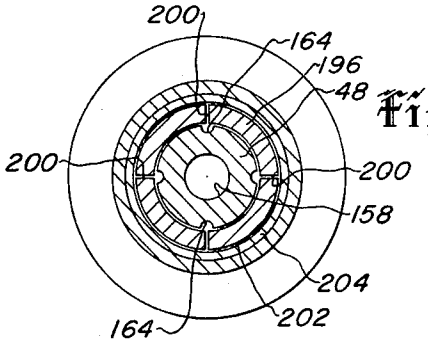


Fig 20

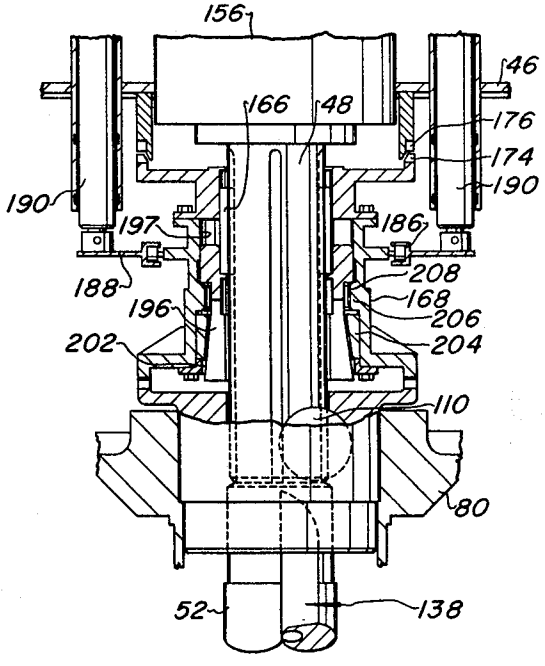


Fig 17

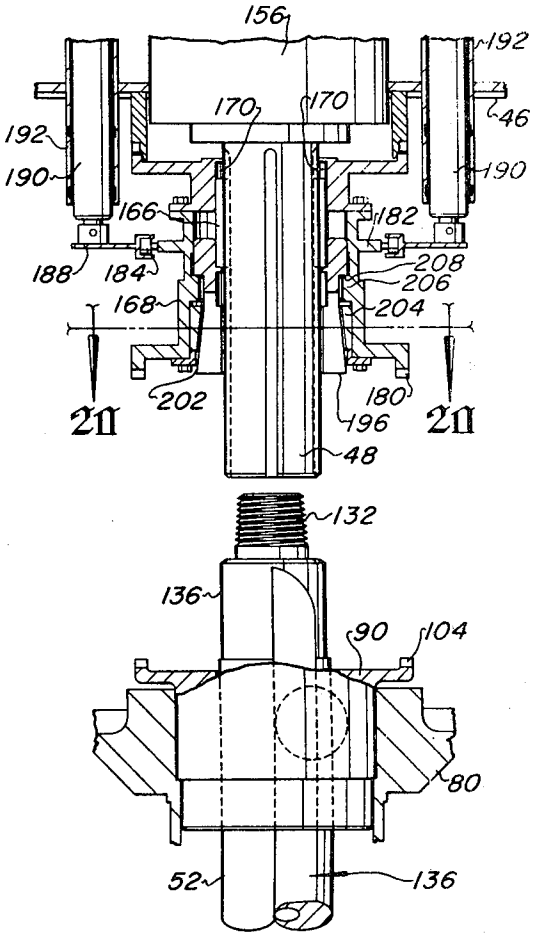


Fig 18

ROTARY DRIVE AND JOINT BREAKOUT MECHANISM

This is a division of U.S. Pat. application Ser. No. 379,664, filed July 16, 1973, now U.S. Pat. No. 3,874,196.

BACKGROUND OF THE INVENTION

Rotary table drives for earth drilling rigs hold certain advantages over so-called top drive arrangements in that the weight of the rotary drive mechanism is not required to be supported by the drill rig mast or derrick and the reaction torque from the drill stem rotative effort can be transferred directly to the main frame of the drill rig instead of being imposed on the mast structure. These advantages simplify the structural requirements of the mast itself. Additionally, the power transmission system is more compact and easily arranged for a rotaty table drive and often a portable drill rig may require a total of only one or two drive motors for propelling the rig, pulldown and hoisting of the drill stem, and rotation of the drill stem.

A longstanding problem in the use of rotary table drives for large earth drilling rigs for drilling blastholes and other relatively shallow holes in hard rock is that the use of a conventional noncylindrical cross section drill pipe or kelly for transmitting rotary motion from the table to the drill stem does not provide a suitable annular area in the drill hole for effective removal of the drill cuttings by the hole cleaning fluid. In order to provide suitable annular areas for drill cutting removal a flat sided drive member is required to be so large that the corners formed by the intersections of the sides of the member are disposed closely adjacent the side wall of the drill hole and are subject to severe wear from unavoidable rubbing against the side wall. Additional severe wear which tends also to "round off" the corners and the flat sides of a conventional drive member is caused by abrasion from the constant stream of drill cuttings passing upward during drilling around the exterior of the drill stem portion which is in the hole. In a short time an unsuitable driving connection is formed between the socket or complementary opening in the rotary table and the drive member due to wear which changes the cross sectional shape of the drive member itself.

Furthermore, if a square cross section or otherwise special rotary drive member or kelly is used together with cylindrical cross section drill pipe, then the process of adding and removing drill stem sections is somewhat more complex and time consuming. Since the drive member or kelly is the only drill stem member which can be driven by the rotary table the kelly itself must be disconnected from the drill stem and set aside in the mast or placed down an auxiliary hole while additional drill pipe sections are added to or removed from the drill stem and then the kelly must be reconnected to the drill stem and reinserted in the rotary drive bushing when rotation of the stem is desired. Conversely, if the drive member or kelly is retained in connection with the hoisting mechanism and over the drill hole centerline, then the mast height must be sufficiently great to hoist the length of the kelly and at least one section of drill pipe up out of the table.

Accordingly, it is desirable to provide a rotary table drive for earth drill rigs in combination with a drill stem which will provide for use of the drill pipe members making up the drill stem to be used as drive members

engaged with the table drive itself. Such drill stem members are also desirably of a configuration which will provide an annular area in the drill hole between the drill pipe exterior and the side wall of the hole which will be of the proper size to permit effective drill cutting removal from the bottom of the hole without using unnecessarily large quantities of hole cleaning fluid. It is further desirable in large rotary blasthole drills to be able to use relatively thick walled cylindrical drill pipe which can be driven directly by a rotary drive mechanism because such pipe configurations are capable of withstanding large axial pulldown forces without being susceptible to bending or kicking.

SUMMARY OF THE INVENTION

The present invention provides an improved rotary drive arrangement for an earth drilling rig wherein a novel rotary table drive mechanism is used in combination with novel drill pipe or stem components which are adapted to be driven directly by the rotary table without the use of a special drill stem drive section. The rotary table drive mechanism of the present invention provides for driving a drill stem made up of one or more substantially cylindrical drill pipe sections adapted to engage driving members mounted in the rotary table. The rotary table drive mechanism of the present invention also includes drill stem driving members which provide positive and low friction driving engagement with the drill stem and are mounted in such a way that they are drivingly engageable with each drill pipe section which is added to the drill stem as the drill pipe sections pass through the rotary table. With the rotary table drive arrangement of the present invention cylindrical cross section or tubular drill pipe in a modified form is advantageously used as sectional drill stem members which are directly driven by an improved rotary table drive mechanism wherein wear on the pipe itself does not have harmful effects on the drive connection with the rotary table.

The present invention also provides a rotary drive transfer mechanism for use with a rotary table drive in an earth drilling rig wherein sectional drill stem members may be rotatably driven while the end portions thereof are passed through the rotary table. The rotary drive transfer mechanism of the present invention is particularly advantageous for use with a rotary table drive which includes members engageable with cooperating drive surfaces on a drill stem member and wherein positive driving engagement between the table and the drill stem member cannot be provided when an end portion of a drill stem member is passed through the table during drilling operations.

The rotary drive transfer mechanism of the present invention also includes means for nonrotatably locking a rotary coupling between a drill stem and a pulldown traverse frame whereby the drill stem members may be easily disconnected from the traverse frame.

The present invention further includes improved means for breaking out threaded joints between sectional drill stem members and between a drill stem member and a drill bit portion. The joint breakout means of the present invention includes a power operated wrench for holding a drill stem member during breakout operations and which also provides for handling the detachable drill bit portion in a fast and work saving manner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal side elevation of an earth drilling rig including the rotary drive and joint breakout mechanisms of the present invention;

FIG. 2 is a front elevation of the drill rig of FIG. 1;

FIG. 3 is a plan view of the rotary table of the present invention taken from line 3—3 of FIG. 2;

FIG. 4 is a view from line 4—4 of FIG. 3;

FIG. 5 is a section view taken along line 5—5 of FIG. 3;

FIG. 6 is a sectional elevation of the rotary table and drive bushing;

FIG. 7 is a longitudinal view of a section of drill pipe in accordance with the present invention;

FIG. 8 is a section view taken along line 8—8 of FIG. 7;

FIG. 9 is a section view taken along line 9—9 of FIG. 7;

FIG. 10 is a plan view of the rotary drive bushing of the present invention;

FIG. 11 is an elevation view of the rotary drive bushing shown in FIG. 10;

FIG. 12 is a plan view of a power operated holding wrench and bit handling tool;

FIG. 13 is a side elevation of the power operated holding wrench and bit handling tool of FIG. 12;

FIG. 14 is a view of a pair of removable shoes for use with the power operated holding wrench of FIGS. 12 and 13;

FIGS. 15 through 18 are views of the rotary drive transfer and breakout mechanism showing the operation thereof;

FIG. 19 is a section view taken along line 19—19 of FIG. 15; and,

FIG. 20 is a section view taken along line 20—20 of FIG. 18.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The rotary table drive and joint breakout mechanism of the present invention is particularly suitable for use with relatively large rotary blasthole drills which are designed for drilling holes to a maximum depth usually in the range of 100 to 150 feet. Such types of drills are characterized by mechanism for exerting a heavy axial down thrust or pulldown force on the drill stem and bit portion while the drill stem including the bit is rotated to provide for localized crushing and grinding of the rock and earth to form the drill hole. However, since the mode of drilling is generally similar to that practiced with other types of drilling rigs such as oil and water well drilling equipment it is contemplated that the present invention could be utilized with these as well as other rotary drilling devices.

Referring to FIGS. 1 and 2 a portable rotary blasthole drilling rig is illustrated and generally designated by the numeral 22. The drill rig 22 is characterized by a frame 24 which is mounted on spaced apart crawlers 26. The frame 24 supports an elongated mast 28 which is mounted on support means 30 for pivotal movement between the erect or working position shown and a substantially horizontal position when the rig is being propelled from one drilling site to another. The mast 28 includes two spaced apart longitudinal posts 32 on which are formed gear racks 34. The mast 28 is adapted to support a longitudinal traverse frame 36 which includes a pair of spaced apart rotatable shafts 38 and 40 each having pinions 42 mounted thereon and engaged with the racks 34. Suitable flexible drive means such as endless chains designated by numeral 44 are supported by the mast 28. The drive chains are suitably engaged with the shafts 38 and 40 for rotating the shafts to advance the traverse frame reversibly along the mast.

The traverse frame 36 includes a transverse yoke member 46 including means for rotatably supporting a coupling member 48 for connecting the traverse frame to a drill stem generally designated by numeral 50 and made up of one or more elongated drill pipe sections 52. The drill stem 50 also includes a stabilizing sub 54 and a rotary bit 56 connected to the lower end thereof for forming a drill hole 58. The traverse frame 36 is reversibly driven along the mast 28 by the chains 44 to exert an axial feed or pulldown force on the drill stem 50 and to hoist the drill stem components out of the drill hole. A drive motor and transmission unit 60 mounted on the rig 22 is connected by drive means 62 to the endless flexible chains 44 for driving the traverse frame 36 along the mast. A more detailed description of the pulldown traverse frame 36 and its associated drive means is disclosed in U.S. Pat. No. 3,867,989.

In many applications of the rig 22 a single traversal of the frame 36 down the mast will be sufficient to cause the formation of a drill hole of desired depth. However, when it is desired to form a hole depth greater than that provided for by one pass of the frame 36, additional drill pipe sections must be added to the drill stem. Accordingly, the drill rig 22 is provided with a storage rack 64 for holding a second drill pipe section 52. The storage rack may take various forms and may be adapted to hold a plurality of drill pipe sections. The rack 64 is exemplary and is of the type which is mounted in the mast 28 on pivotal linkage members 66 and 68 adjacent the top and bottom of the rack, respectively. A pressure fluid operated cylinder and piston device 70 is connected to the member 68 for moving the rack 64 from the retracted position shown in FIG. 1 into a position whereby the pipe section 52 held by the rack is in line with the longitudinal axis of the drill stem 50.

Referring to FIGS. 1 through 3 and FIG. 6 the drill rig 22 is characterized by a rotary table drive mechanism for imparting rotary motion to the drill stem 50. The rotary table drive mechanism of the present invention is generally designated by numeral 72 and includes a boxlike housing 74 mounted on the frame 24. The housing 74 includes bearings 76 and 78 mounted therein for supporting a rotating table member 80. The table member 80 is characterized by a circular flange 82 having radially projecting teeth 84 formed on the periphery thereof. An axial opening 86 through the table member 80 includes a square or flat sided portion 88 which forms a socket for receiving a removable rotary drive bushing 90. The table member 80 also includes a bevel gear 92 fixed on the underside of the flange 82 and engaged with a bevel pinion 94 rotatably mounted in the housing 74. The pinion 94 is connected to a shaft 96 which in turn is drivenly connected to the drive motor and transmission 60. The table housing 74 is mounted on the frame 24 so that the table member 80 extends slightly above the deck or platform 98, FIG. 1. A hinged cover 100 is shown in FIG. 3 for partially covering the table member 80 in the vicinity where drill operating personnel normally work when making up and breaking out threaded connections between the bit, stabilizing sub, and drill pipe sections.

The rotary table drive of the present invention includes the improved drive bushing **90** which in combination with the drill pipe sections **52** shown in FIGS. **7** through **9** provides for use of sectional drill stem members as the rotary driven member or what is sometimes referred to as the kelly. Referring to FIGS. **6** through **11**, the rotary drive bushing **90** is characterized by a flat sided and square depending portion **101** which is removably fittable in the complementary socket portion **88** in the table **80.** A circular flange **102** formed on the bushing includes a plurality of circumferentially spaced teeth **104** which project axially upwardly when the bushing is fitted in the table. The bushing **90** also includes a central opening **106** through which the drill pipe sections **52** pass during drilling and hoisting operations. Recesses **108** are formed in two opposed sides of the portion **101** and intersect the opening **106.** The recesses **108** are formed to accommodate a pair of drive rollers **110** which are mounted to be substantially parallel to each other and to project partially into the opening **106.** The rollers **110** are each rotatably mounted on a support plate **112** having a hub portion **114** for mounting the rollers to swing about a substantially vertical pivot formed by pins **116** projecting through the hub portion of each support plate. The pins **116** are suitably retained on the bushing **90.** The hub portions of the support plates **112** each include a recess **118** in which is positioned a torsion coil spring **120** surrounding the pin **116** and engaged with the support plate for biasing the roller **110** inwardly toward the center of the opening **106.** The support plates **112** also include projecting tabs **122,** as shown in FIGS. **10** and **11,** which engage projections **124** formed on the bushing **90** so as to limit the inward swinging movement of the rollers toward the center of the opening **106.** The bushing **90** also includes a pair of recesses **126** located adjacent to the opening **106** and opposed to each other along a line through the center of the opening as shown in FIGS. **6** and **10.** The recesses **126** have disposed therein pivotally mounted dogs **128** which may be pivoted to project into the opening **106** for engaging holding slots formed in a drill stem member such as the pair of slots **130** in the stabilizer **54** as shown in FIG. **6.** When not required for holding a drill stem member the dogs **128** may be swung away from the opening **106** to lie along the sloped surfaces of the recesses **126.**

Referring to FIGS. **7** through **9** a drill pipe section **52** is illustrated which is adapted to be used as the member rotatably driven by the rotary table bushing **90** and which may be used as part of the drill stem disposed in the drill hole without suffering wear which would be harmful to the driven surface portions engaged with the rollers **110.** The drill pipe section **52** is basically a cylindrical thick walled steel tube having a central longitudinal passage **131** for conducting hole cleaning fluid through the drill stem to the bottom of the drill hole. The drill pipe section **52** includes an externally threaded portion or pin **132** at one end and an internally threaded portion **134** or box at the opposite end. The threaded portions **132** and **134** will be assumed to be of the "right hand" for purposes of this disclosure. A slightly reduced diameter portion **136** is formed at the pin end of the section **52.** The drill pipe section **52** also includes a pair of longitudinal recesses **138** formed in the outer cylindrical wall surface **139.** The recesses **138** extend over a major portion of the drill pipe section **52** and include parallel and opposed surface portions **140.** The surfaces **140** are each intersected by a surface **142,** which intersection is such that the surfaces **140** and **142** of each groove **138** are substantially perpendicular to each other. The surfaces **142** are formed to be coplanar and lie in a longitudinal plane which passes through the longitudinal rotational axis **143** of the drill pipe section **52.**

As shown in FIG. **10** the surfaces **142** of the grooves **138** are disposed to be engaged by the rollers **110** whereby rotation of the bushing **90** will impart rotation to the drill pipe section **52.** As may be seen in FIG. **10** the drive faces **144** of the rollers are provided with a taper or slope with respect to the axis of rotation of the rollers which provides for clearance along the surface **140** of the grooves **138** with respect to the sides of the rollers when the rollers are drivingly engaged with the surfaces **142.** As may be noted also from FIG. **10** the location of the pivot pins **116** for the roller support plates are radially further from the rotational axis of the drill pipe section **52** than the drive surfaces **142** which engage the rollers **110** and are positioned such that when the rollers are driving the drill stem rotatably a force couple is formed about the pivot pins **116** which tends to swing the rollers inwardly toward the center of the opening **106** to assure maximum engagement of the surfaces **142** with the roller drive faces **144.** With the arrangement of the rollers **110** and drive surfaces **142** as provided on the drill pipe section **52** the drill pipe can be easily proportioned to be of the proper size to provide the desired annular area in the drill hole for effective drill cuttings removal and furthermore the drive surfaces **142** are not affected by rubbing of the drill pipe against the side wall of the hole or by abrasion from the drill cuttings passing upward out of the hole around the drill stem. Moreover, by providing the drill pipe section **52** with surfaces **142** which are substantially flat and radially extended with respect to the longitudinal axis of the pipe section the direction of the driving force transmitted from the rollers **110** to the drill pipe section **52** is more effective for turning the drill stem **50.** Accordingly, a more positive and long lasting drive connection may be maintained with the rotary drive disclosed herein.

The drill pipe section **52** also includes a pair of slots or recesses **148** in the outer wall surface near the pin end which recesses are for engagement with the dogs **128** in the rotary bushing for holding the drill pipe section in the bushing during joint makeup and breakout operations. The drill pipe section **52** also is characterized by a pair of opposed grooves **150** disposed near the lower end which are cooperable with a pair of jaws of a holding wrench to be described herein. If multiple pass drilling is performed by the drill rig **22** all of the drill pipe sections may be of the same configuration as the section **52** shown in FIGS. **7** through **9.** As shown in FIG. **7** and FIGS. **15** through **18** the grooves **138** are formed such that the surfaces **140** are sloped radially outwardly with respect to the longitudinal axis of the drill pipe section toward the outside wall surface at the reduced diameter portion **136.** This flaring out of the grooves **138** provides for the rollers **110** to be urged to swing outwardly away from the center of the opening **106** as the end portion of the drill pipe section **52** passes down through the opening whereby the lower end of the next drill pipe section added to the drill string may be initially passed into the opening **106** regardless of any longitudinal misalignment of the drive surfaces **142** on one drill pipe section with the corresponding surfaces on the adjacent drill pipe section.

When the pipe sections are being removed from the drill hole the table **80** may be rotated in the reverse or nondriving direction slightly to cause the rollers **110** to swing outwardly with respect to the opening **106** so as not to engage or catch on the transverse end faces of the pipe sections as they are withdrawn from the hole. If single pass drilling only is to be performed the grooves **138** may be formed to extend entirely the length of the pipe section **52** to thereby provide driving engagement of the rollers **110** throughout the entire length of the section. With the drive transfer mechanism disclosed herein it is advantageous to form the grooves **138** as shown in FIG. **7** since the rollers are not drivingly engaged with the drill pipe at the end portion **136** anyway.

For drilling operations wherein more than one section of drill pipe is to be used to increase the length of the drill stem for drilling deeper holes a drive transfer mechanism may be advantageously used with the rotary table drive mechanism of the present invention so that the grooves **138** of one drill pipe section **52** are not required to be longitudinally aligned with the corresponding grooves on an adjacent drill pipe section in the drill stem. Referring to FIGS. **1, 2** and **15** through **20** the rotary drive transfer mechanism of the present invention includes the rotary coupling member **48** which is rotatably supported in bearings **152** and **154** mounted in a housing **156** on the yoke **46.** The member **48** includes an internal passage **158** in communication with a drill hole cleansing fluid conduit **160.** The lower end of the member **48** is characterized by an internally threaded portion **162** for receiving the pin end **132** of a drill pipe section **52.** The member **48** also includes a plurality of longitudinal keyways **164** in which are slidably fitted keys **166.** The drive transfer mechanism further comprises a coupling sleeve **168** having complementary grooves **170,** FIG. **18,** in which the keys **166** are disposed to form a rotary driving connection between the sleeve and the member **48.** The sleeve **168** includes a flange **172** at one end having a ring of circumferentially spaced and axially projecting teeth **174** which are engageable with complementary teeth **176** formed on a collar **178** fixed to the yoke **46.** The lower end of the sleeve **168** also includes circumferentially spaced teeth **180** which project axially downwardly and are operable to be interfitted with the teeth **104** on the bushing **90** to form a driving connection between the bushing and the sleeve. The sleeve **168** also includes a flange **182** which has disposed on its circumference a plurality of rollers **184.** The rollers **184** are disposed in a radially inward facing channel **186** formed on a circular plate **188.** The plate **188** is attached to the ends of a pair of pressure fluid cylinder and piston type actuators **190.** The cylinders **190** are slidably guided in tubular sleeves **192** disposed on the yoke **46.** The distal ends of the cylinder piston rods **194** are suitably fixed to the yoke **46** as shown in FIG. **15.**

The drive transfer mechanism also includes a second sleeve member **196** disposed in a bore **197** in the sleeve **168** and adapted to surround and frictionally grip the reduced diameter portion **136** of a drill pipe section **52** as shown in FIGS. **15** and **16.** The sleeve **196** includes keyways **198,** FIG. **19,** in which are disposed the keys **166** to form a driving connection with the member **48.**

As shown in FIG. **20** the sleeve **196** includes a plurality of slots **200** which extend longitudinally a portion of the length of the sleeve along which portion the exterior surface **202** of the sleeve is also sloped and is engageable with a correspondingly sloped collar **204** as shown in FIGS. **15** through **18.** The collar **204** is suitably retained in the interior of the sleeve **168** and is engageable with an inwardly projecting shoulder portion **206.** The sleeve **196** also includes a shoulder portion **208** engageable with the shoulder portion **206** on sleeve **168,** as shown in FIGS. **17** and **18.** The drive transfer mechanism provides for rotatably driving the drill stem **50** when an end portion of a drill pipe section **52** is passed through the rotary bushing **90** so that sufficient hole depth is achieved to permit the addition of a drill pipe section to the drill stem and engagement of the rollers **110** with the grooves **138** of the section added to the drill stem at the onset of drilling after the section has been added. The drive transfer mechanism also is adapted to be used to break out the threaded connection between the member **48** and a drill pipe section.

An operating sequence of the drive transfer mechanism will now be described in connection with viewing FIGS. **15** through **18.** During drilling operation, with the rotary drive being imposed on the drill stem **50** by the driving connection between the rollers **110** and a drill pipe section **52,** the cylinders **190** are extended as shown in FIG. **15** to cause the collar **204** to compress the sleeve **196** to grip the reduced diameter portion **136** of a drill pipe section. This prevents the right-hand thread connection between the member **48** and the drill pipe section **52** from breaking loose due to the rotary driving effort imposed on the drill string which is in the direction of the arrow **210** in FIG. **10.**

As the pulldown traverse frame **36** feeds the drill stem downwardly to the position shown in FIG. **16,** the complementary teeth **180** and **104** on the sleeve **168** and bushing **90** become engaged and rotary driving effort is transferred from the bushing **90** to the coupling member **48** by way of the sleeve **168.** Accordingly, rotation of the drill stem **50** is now no longer dependent on the rollers **110** driving against the surfaces **142** on the drill pipe section. Continued axial down thrust by the traverse frame will result in axial sliding movement of the member **48** downward, viewing FIGS. **16** and **17,** with respect to the sleeve **168** which will also cause the sleeve **196** to move downward with respect to the collar **204.** The sleeve **196** will, upon moving free of the radial inward wedging action of the collar **204,** release its grip on the portion **136** of the drill pipe section **52,** as shown in FIG. **17.** The rotary drive now being from the member **48** to the drill pipe section **52** will, of course, tend to tighten a right-hand threaded connection therebetween. The cylinders **190** will be allowed to telescope into the sleeves **192** as the traverse frame **36** moves downward from the FIG. **16** position to the FIG. **17** position. As shown in FIG. **17** the top end of a drill pipe section **52** is now below the rollers **110** and a drill pipe section to be added to the drill stem could be lowered into the opening **106** so that the rollers could engage the drive surfaces **142.** Prior to adding a drill pipe section the threaded connection between the member **48** and the upper end of a drill pipe section **52** must be broken out. To accomplish this the traverse frame **36** is reversed to hoist the drill pipe section **52** up through the bushing **90** until the dogs **128** can be pivoted into position in the recesses **148** to hold the drill pipe section in the position shown in FIG. **18** and in the same manner as shown for the stabilizer **54** in FIG. **6.** The cylinders **190** are then actuated to move the sleeve **168** upward until the teeth **174** are interfittingly engaged

with the teeth **176** as shown in FIG. **18** whereby the sleeve **168** and member **48** are nonrotatably locked. The rotary table **80** is then driven in the direction of the arrow **210** of FIG. **10** to rotate the pipe section **52** with the rollers **110** as well as the dogs **128** drivingly engaged in their respective recesses until the pipe section **52** is disconnected from the member **48.** After moving the traverse frame **36** up the mast **28** an additional drill pipe section **52** can be added by positioning a suitable storage rack such as the rack **64** over the axis of the drill stem and rotating the table **80** in reverse to make up a threaded connection between the drill pipe section supported in the table and the section being added. The traverse frame **36** is then lowered to engage the coupling member **48** with the section added to the drill stem whereby further reverse rotation of the table would thread the pin end **132** of a drill pipe section into the threaded portion **162** on the coupling member. The cylinders **190** are extended after the coupling member is reconnected to the drill string to unlock the sleeve **168** and to cause the sleeve **196** to be lowered into frictional gripping engagement with the top portion of the drill pipe section now connected to the coupling member **48.**

If a drill pipe section is to be removed from the drill stem **50** the threaded connection between a drill pipe section **52** and the coupling member **48** would be broken loose generally in accordance with the above described procedure. Then, prior to complete separation of the coupling member **48** from the drill pipe section, the traverse frame **36** is raised up the mast to pull the pipe section to be removed from the drill stem up through the table bushing **90** until the upper portion of the drill pipe section which is below the one to be removed is in position to have the recesses **148** engaged by the dogs **128** and the recesses **138** engaged by the rollers **110.** With the drill pipe storage rack in position to receive the pipe section being removed from the drill stem or an auxiliary hoisting line connected thereto, the table **80** is rotated forward, the direction of arrow **210** in FIG. **10,** until the coupling member **48** is separated from the pipe section being removed. Then a suitable holding wrench such as the wrench described hereinbelow is engaged with the grooves **150** of the pipe section being removed from the drill string while the table **80** again is rotated forwardly to break out the joint between the section being removed and the section supported in the table bushing **90.**

The rotary drive and joint breakout mechanism of the present invention includes improved auxiliary breakout and drill stem component handling devices. Referring to FIGS. **3** through **5** a rotary table turning device, generally designated by numeral **220,** is disposed on the deck **98** and is connected to a bracket **221** for limited swinging movement about a vertical pivot **222.** The table turning device **220** includes a rectangular tubular frame **224** upon which is supported a hydraulic cylinder actuator **226.** One end of the cylinder **226** is connected to the frame **224,** and a piston rod **228** extending from the opposite end of the cylinder is connected to an arm **230** by means of a pin **232.** The arm **230** is supported for sliding movement in the frame **224** and includes a hook **234** formed on the end which is opposite the end connected to the piston rod **228.** The frame **224** is suitably connected to a pressure fluid actuator **236** by way of a member **238** whereby in response to operation of the actuator the device **220** may be pivoted into the position shown in FIG. **3** and held for engagement of the hook **234** with one of the radially projecting teeth **84** on the table **80.** The actuator **236** is mounted on a bracket **240** which is disposed on the deck **98** and which also partially supports the frame **224.** With the hook **234** positioned to engage a tooth on the table **80** the cylinder **226** may be actuated to retract the piston rod **228** so as to rotate the table **80** with great force a small portion of a revolution for breaking out drill string connections which cannot be loosened with the turning effort available from the motor and transmission **60** through the table drive gears **92** and **94.** When the breakout device **220** is not in use the actuator **236** is energized to pivot the frame **224** so that the hook **234** is moved radially away from the table **80.**

Referring to FIG. **3** and FIGS. **12** through **14** the drill rig **22** includes a drill stem holding wrench **250** which is also adapted to handle a drill bit for adding and removing the same with respect to the drill stem **50.** The wrench **250** includes a power rotated base **252** having a shaft portion **254** rotatably mounted in a bearing sleeve **256** supported on the rig substantially below the deck **98.** The base **252** includes a sprocket **258** fixed thereon and engaged with a chain **260** which is drivenly connected to a sprocket **262** mounted on the shaft of a suitable drive motor, not shown. The base **252** includes an upstanding part **264** upon which a boom **266** is mounted for movement about a horizontal pivot **268.** A hydraulic cylinder **270** is connected between the boom **266** and the part **264** for raising and lowering the boom about the pivot **268.** The boom **266** is adapted to receive a partially tubular member **272** which is secured against rotation with respect to the boom by a pair of removable pins **274.** The member **272** includes a portion formed in part by two spaced apart plates **276.** A pair of holding jaws **278** and **280** are mounted between and supported for pivotal movement with respect to the plates **276.** Each jaw includes a short arm portion **282** which is connected by means of a link **284** to a clevis **286.** The clevis **286** is connected to a piston rod portion of a linear pressure fluid actuator **288** mounted on the member **272** for moving the jaws between the closed position shown by the solid lines in FIG. **12** and the open position shown by the dashed lines. The holding jaws **278** and **280** have removable shoes **290** secured on the jaws by pins **294.** The jaws **278** and **280** each also includes a depending member **296** having a projection **298** formed on the lower end thereof, viewing FIG. **13,** which is engageable with a bail **300** mounted on a bit holding fixture **302.**

The bit holding fixture **302** is characterized by a cylindrical portion **304** which is adapted to be retained in suitable receptacles **306,** one shown in FIG. **3,** in the deck of the rig **22.** A flat sided flange **308** is attached to the portion **304** and is adapted to fit in the socket or opening **88** of the table **80** in place of the bushing **90.** The flange **308** also has a socket opening **310** formed to closely fit around the integral legs of a roller type rotary bit such as the bit **56** in FIGS. **1** and **2,** whereby with the fixture disposed in the table **80** and surrounding the bit the table may be rotated to make up or break out a connection between the bit and the stabilizer **54.**

The process of changing bits on the drill rig **22** may be performed by raising the traverse frame **36** and drill stem up the mast **28** until the lower end of the bit **56** is pulled up through the table **80** and above deck level sufficiently to permit swinging the holding wrench **250** from a retracted position, as shown in FIG. **3,** with a fixture **302** attached thereto into position over the table.

The fixture **302** is then lowered into the opening by operation of the cylinder **270** and the jaws **278** and **280** are at least partially closed to disconnect the members **296** from the bails **300.** When the drill string is removed from the hole the flutes **55,** see FIG. **6,** on the stabilizer **54** engage the bushing **90** and carry it upwardly out of the table **80** to provide for accommodation of the fixture **302** in the table opening **86.** After placement of the fixture **302** in the table **80** the bit **56** is lowered into the socket **310** and the jaws **278** and **280** with modified shoes **314,** as shown in FIG. **14,** disposed thereon are closed so that projections **316** on the shoes **314** are engaged with the sides of grooves **57** in the stabilizer. The table **80** is then rotated, while the stabilizer **54** is prevented from rotation, to break a threaded connection between the bit and stabilizer. The bit fixture **302** with a bit disposed therein may then be removed from the table by the wrench **250** and deposited in a receptacle **306,** and a similar fixture and bit can then be picked up and swung into place in the table opening. With the new bit disposed in the table the drill stem and stabilizer are lowered and the table rotated in reverse to make up a joint between the bit and stabilizer. The wrench **250** may be used to hold the stabilizer nonrotatably while the joint is being made up. The drill stem including the new bit is then raised to remove the bit from the fixture **302** and after retraction of the wrench **250** and fixture to the stored position the drill stem is lowered into the table and the bushing **90** returned into the opening **88** preparatory to a drilling operation.

The wrench **250** is also used to hold a drill pipe section **52** while threaded joints between sections are made up or broken loose. By rotation of the base **252** and operation of the boom cylinder **270** the wrench may be moved when desired into a position with the jaws **278** and **280** surrounding the drill stem **50.** The shoes **290** shown in FIG. **12** include surfaces **292** engageable with the sides of the grooves **150** for holding a drill pipe section **52** while the table is rotated to break one section loose from another.

The wrench jaws **278** and **280** may also be inverted by removing the pins **274,** rotating the member **272** in the boom **266,** and then reinserting the pins. This inversion of the jaws **278** and **280** may be performed so that the shoes **290** can be engaged with the surfaces **142** to hold one drill pipe section from rotating while the table **80** is rotated in reverse, with another drill pipe section or stabilizer **54** supported therein by the dogs **128,** to tighten a joint.

As may be appreciated from the foregoing description the present invention provides improved rotary drive means for rotating a drill string in a rotary earth drilling rig. The rotary drive means of the present invention together with a novel drive transfer mechanism and the holding wrench and bit handling device **250** provides for more rapid and efficient drilling operations on rotary drill rigs than was heretofore known.

What is claimed is:

1. In a rotary drive arrangement for rotating a drill stem on an earth drilling rig:

a rotary table having a housing supporting a rotatable table member;

a bushing removably fitted on said table member to be rotatably driven by said table member and including an opening in which said drill stem is disposed for longitudinal movement with respect to said table member;

said drill stem comprising at least one elongated drill pipe section having recess means formed in the outer wall surface thereof, said recess means including drive surface means extending longitudinally over a major portion of said drill pipe section;

means disposed on said table member for engagement with said drive surface means for rotating said drill pipe section in response to the rotation of said table member;

said drill stem includes a rotary bit threadedly connected to the lower end of said drill stem;

said drilling rig including a fixture removably mountable on said table member for engagement with said bit to rotate said bit in response to the rotation of said table member; and,

said drilling rig further including a power operated holding wrench for engagement with said drill stem to hold said drill stem nonrotatable while said bit is rotated by said fixture to release the threaded connection between said bit and said drill stem.

2. The invention set forth in claim **1** wherein:

said holding wrench comprises a base pivotally mounted on said drilling rig for moving said holding wrench from a retracted position to a position for engaging said drill stem, and said holding wrench includes a pair of power operated movable jaws for engagement with said drill stem to hold at least a portion of said drill stem nonrotatably.

3. The invention set forth in claim **2** wherein:

said holding wrench includes means for engaging said fixture for moving said fixture on and off said rotary table.

4. In a rotary drive arrangement for rotating a drill stem on an earth drilling rig:

a rotary table having a housing supporting a rotatable table member including a radially extending flange having toothlike projections thereon;

a bushing removably fitted on said table member to be rotatably driven by said table member and including an opening in which said drill stem is disposed for longitudinal movement with respect to said table member;

said drill stem comprising at least one elongated drill pipe section having recess means formed in the outer wall surface thereof, said recess means including drive surface means extending longitudinally over a major portion of said drill pipe section;

means disposed on said table member for engagement with said drive surface means for rotating said drill pipe section in response to the rotation of said member;

a drill stem holding wrench mounted on said drilling rig and engageable with said drive surface means for holding said drill pipe section nonrotatable; and,

an arm including a hook portion for engaging one of said projections on said flange and pressure fluid cylinder and piston means connected to said arm for moving said arm to rotate said table member.

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