United States Patent [19]

Porter et al.

[11] **3,754,605**

[45] **Aug. 28, 1973**

[54] **EARTH DRILLING MACHINE**

[75] Inventors: **Wilson B. Porter**, Seattle; **Harold T. Klein**, Bellevue, both of Wash.

[73] Assignee: **The Robbin Company**, Seattle, Wash.

[22] Filed: **Mar. 30, 1972**

[21] Appl. No.: **239,467**

Related U.S. Application Data

[62] Division of Ser. No. 75,020, Sept. 24, 1970, Pat. No. 3,695,364.

[52] **U.S. Cl.** **173/57**, 173/152, 173/163

[51] **Int. Cl.** **E21b 3/02**

[58] **Field of Search** 173/57, 152, 159, 173/163; 175/85, 53

[56] **References Cited**

UNITED STATES PATENTS

3,454,114	7/1969	Poage	173/152
2,595,401	5/1952	Moon	173/152

Primary Examiner—Ernest R. Purser
Attorney—John O. Graybeal

[57] **ABSTRACT**

A traveling support frame is mounted for up and down travel by two parallel guide columns secured at their lower ends to a base frame. A portion of the traveling frame projects laterally of the drive columns and supports two drive motors, two reducing gearing assemblies, a collector gearing assembly and drive head means. The traveling frame and equipment carried thereby are moved up and down by triangularly arranged thrust ram means, each comprising a downwardly opening, upwardly projecting, piston chamber having a lower mounting portion originally secured to the traveling frame and a downwardly directed piston having a lower mounting portion secured to the base frame.

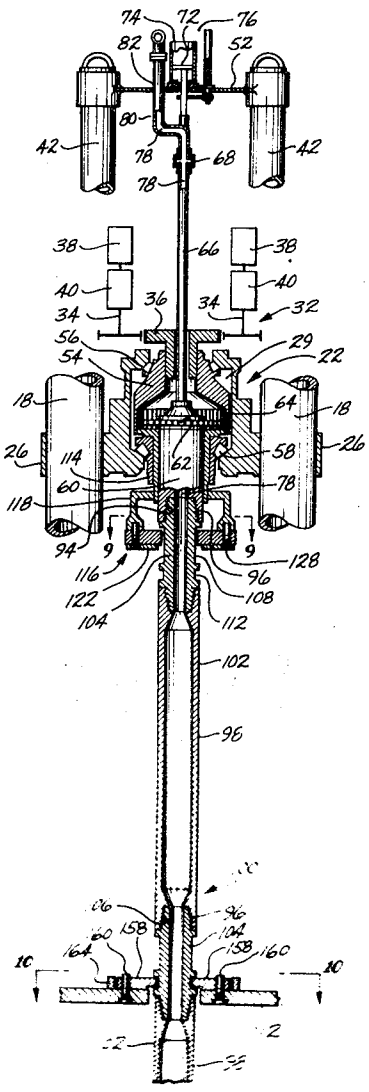
The drive head includes a breakout wrench having a plurality of laterally swinging wrench jaws moved in and out by linear fluid motors. The wrench jaws have radially inwardly directed wrench portions which are like spanner wrenches. The free end of each wrench jaw makes abutting contact with a shank portion of the adjacent wrench jaw, so that in use the wrench jaws brace each other and form a compression ring surrounding the engaged drill pipe.

The drill head includes a tool joint component which is movable axially a limited amount relative to the traveling cross frame. A connector rod connects this tool joint component to the piston of a linear fluid motor supported axially above the drill head. Fluid is introduced into the motor below the piston for the purpose of counterbalancing the weight of the drill head and any drill pipe connected thereto.

A holding wrench is located below the turning wrench. It comprises a plurality of wrench jaws pivotally mounted for lateral swinging movement, a surrounding control ring, and individual links interconnected between each wrench jaw and the control ring. The control ring is rotated by linear fluid motors. Rotation in one direction causes the links to move the wrench jaws radially inwardly into a position of engagement with holding wrench receiving portions on drill pipe, and movement in the opposite direction causes the links to move the wrench jaws radially outwardly in space relationship from the drill pipe.

5 Claims, 13 Drawing Figures

United States Patent [19] [11] **3,754,605**
Porter et al. [45] **Aug. 28, 1973**



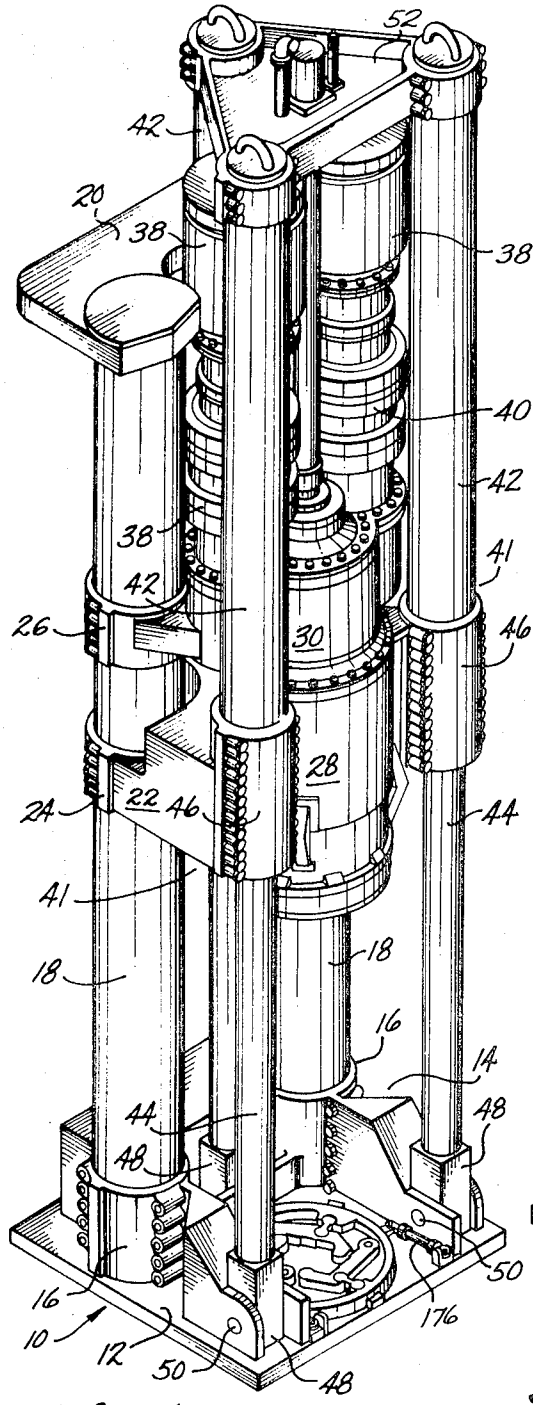

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Fig. 1.

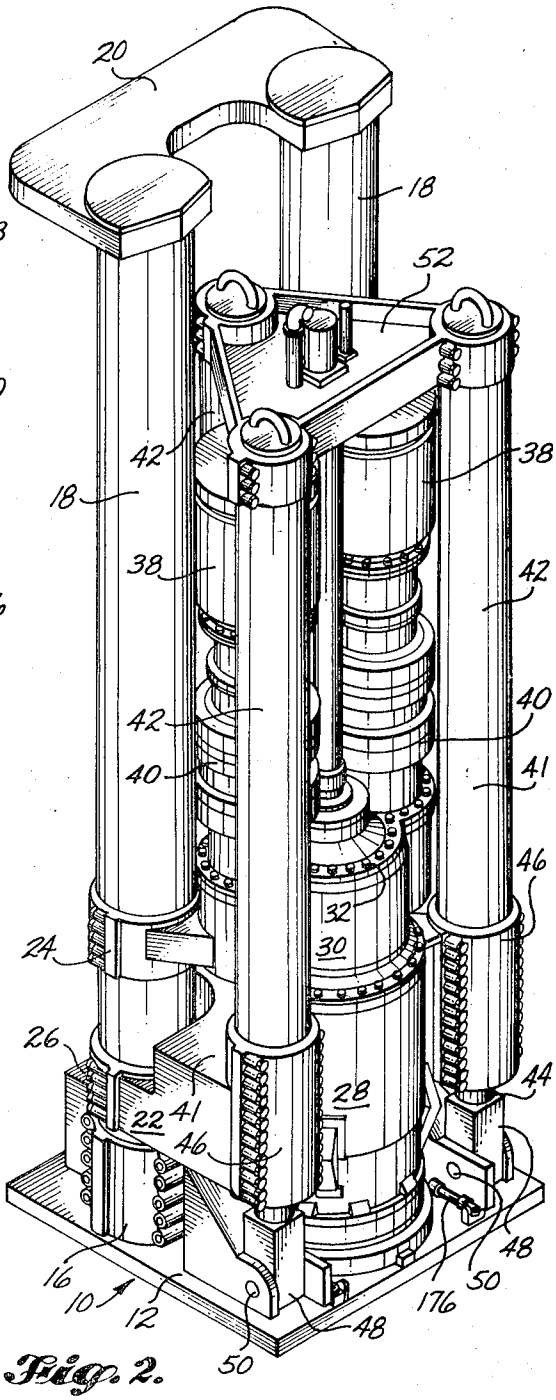

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Fig. 2.

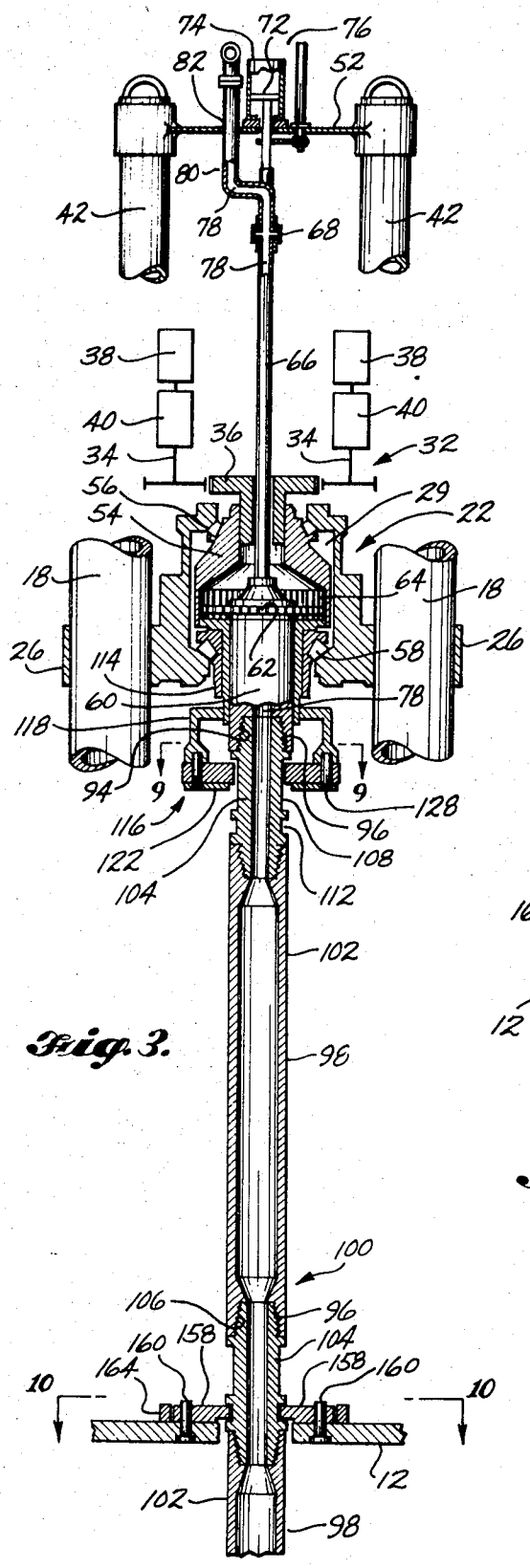

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Fig. 3.

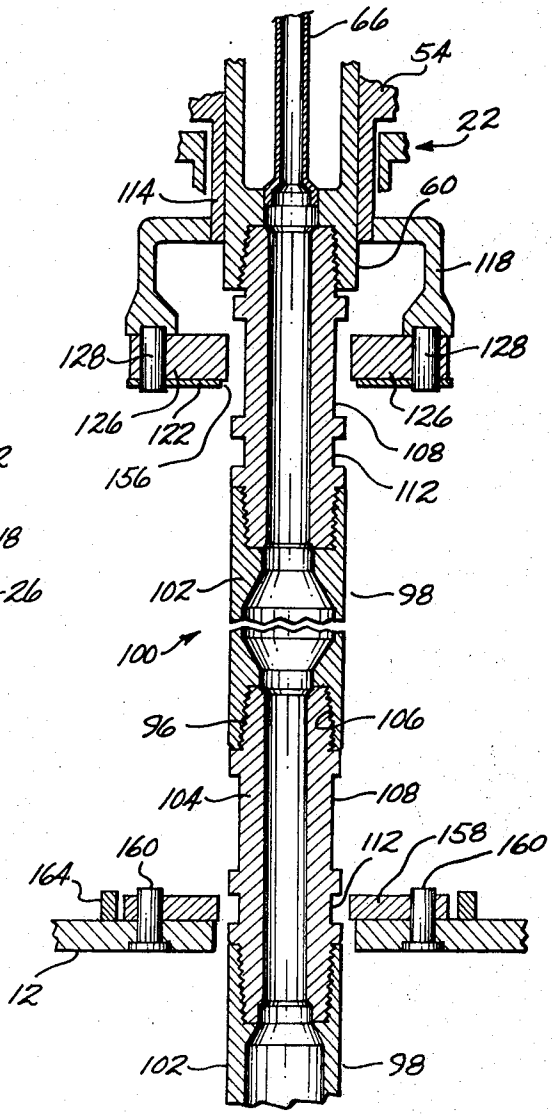

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Fig. 4.

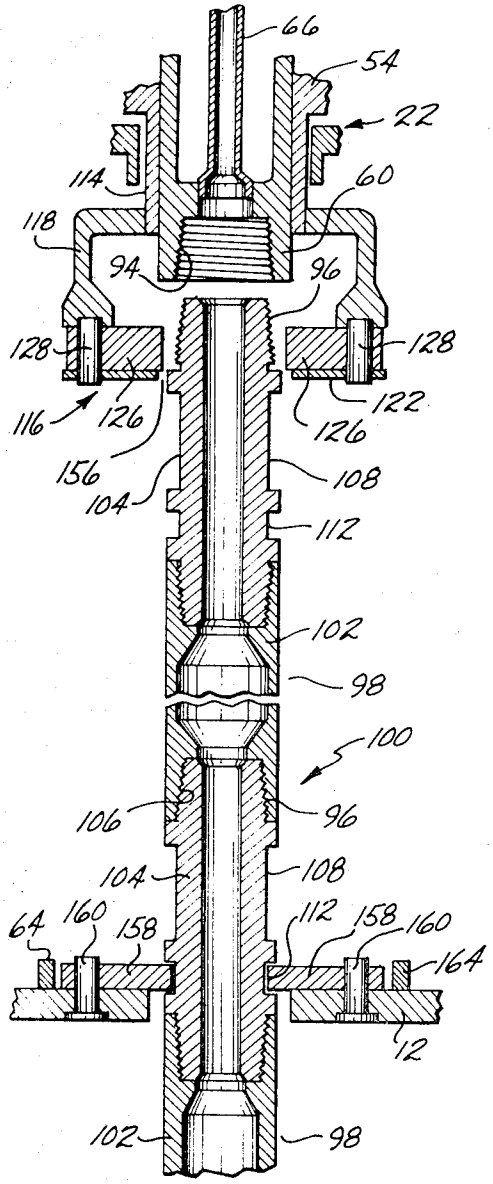

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Fig. 5.

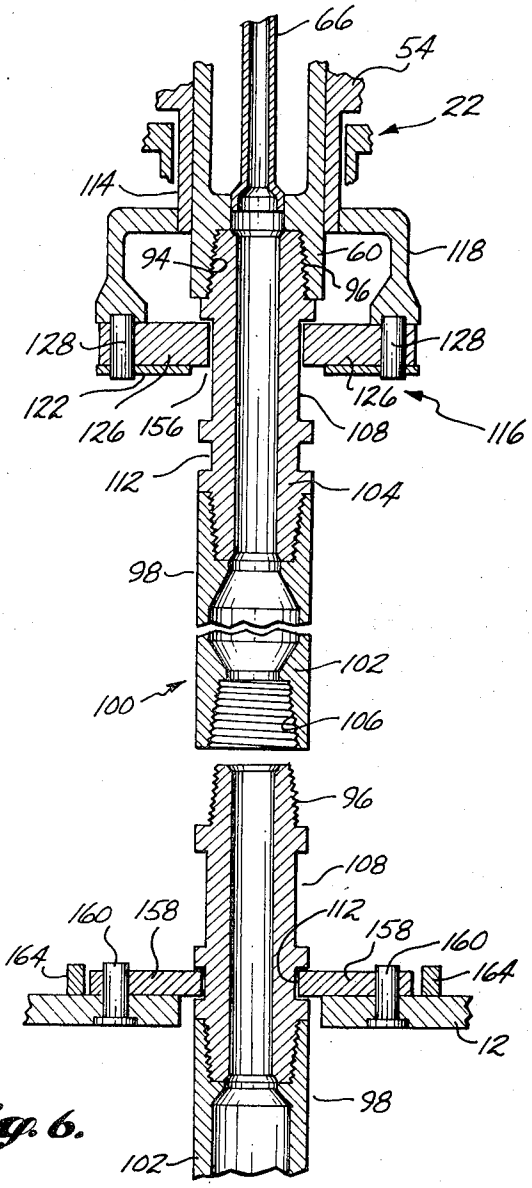

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Fig. 6.

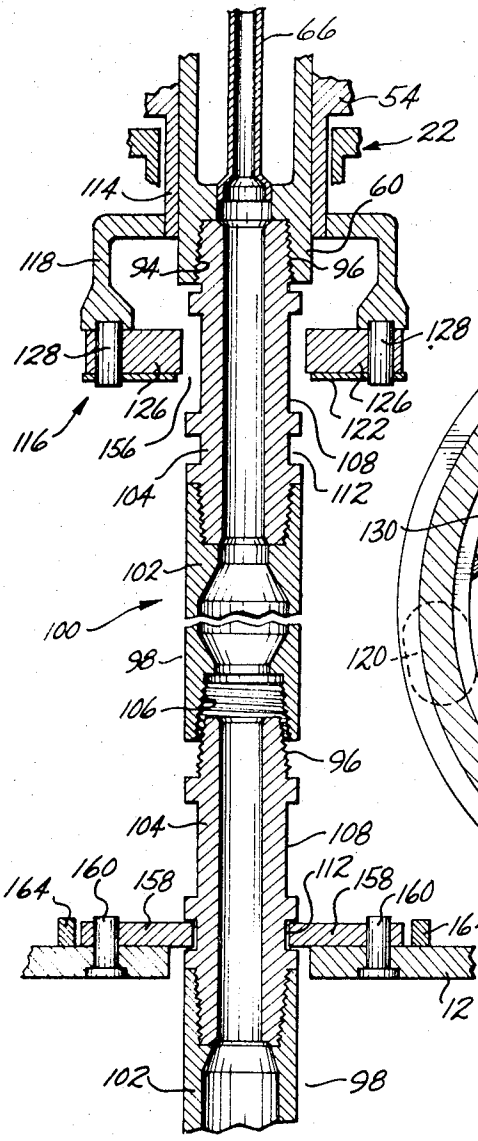


Fig. 7.

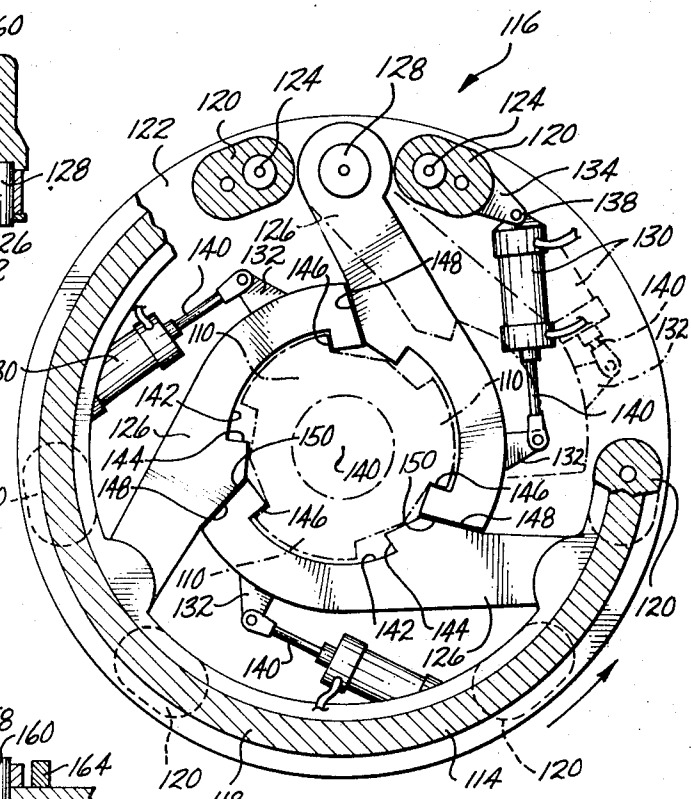


Fig. 9.

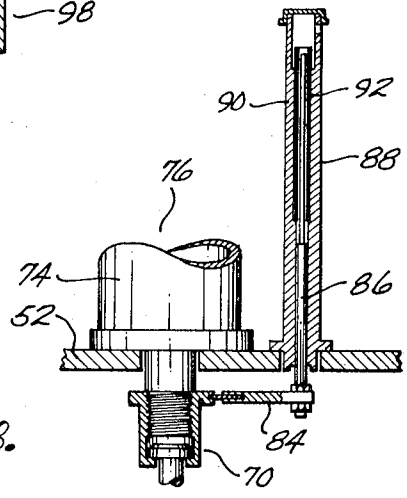


Fig. 8.

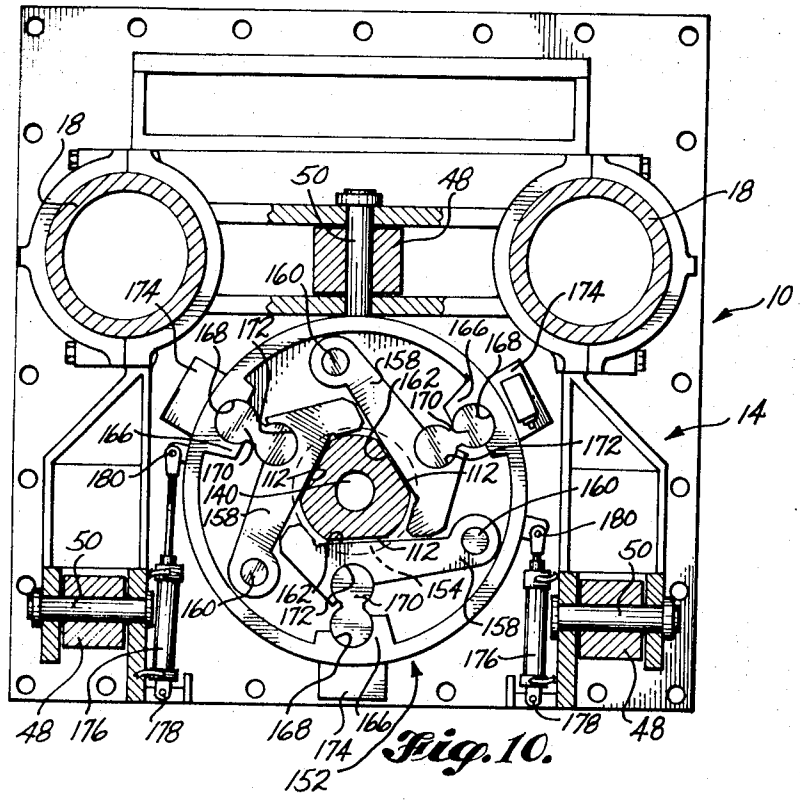


Fig. 10.

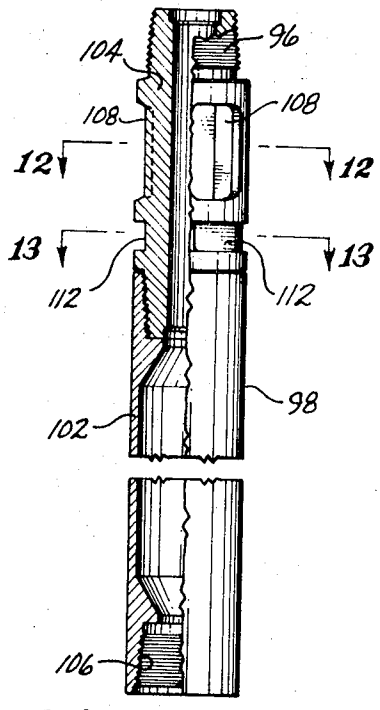


Fig. 11.

Fig. 12.

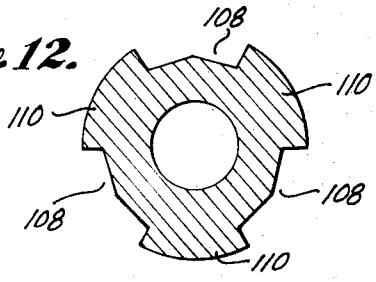
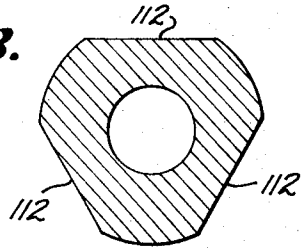


Fig. 13.



EARTH DRILLING MACHINE

This is a division, of application Ser. No. 75,020, filed Sept. 24, 1970 now U.S. Pat. No. 3,695,364.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to earth boring or drilling machines. It particularly relates to mechanism for counterbalancing the weight of the drill stem and other rotary components, to turning and holding breakout wrenches, and to mechanism for supporting and vertically moving the rotary drilling equipment.

2. Description of the Prior Art

The present invention relates to an earth boring or drilling machine of the same basic type as disclosed in U.S. Pat. No. 3,220,494, granted on Nov. 30, 1965 to Robert E. Cannon et al, in U.S. Pat. No. 3,454,114, granted July 8, 1969 to Leland B. Poage, in U.S. Pat. No. 3,490,546, granted Jan. 20, 1970 to John S. Hattrup et al., and in U.S. Pat. No. 3,463,247, granted Aug. 26, 1969 to Harold T. Klein. In other words, like each of the machines of the above-identified patents, the machine of the present invention is a precision earth drilling machine which includes rotary drilling equipment mounted for precision movement up-and-down along a plurality of elongated base supported guide columns by traveling cross frame which is hydraulically raised and lowered. The machine of the present invention is a larger capacity machine, adapted for delivering much higher torque than any of the machines shown by the aforementioned patents.

Drilling machines of the present invention are characterized by high torque breakout apparatus for the sectional drill stem which is used with the machine, and by drilling equipment which includes hydraulic means for counterbalancing the weight of the drill stem and certain components of the drilling equipment.

Known but quite different systems for decoupling threaded sections of a drill stem are shown by U.S. Pat. No. 3,181,630, granted May 4, 1965 to Robert S. Coburn; by U.S. Pat. No. 3,239,016, granted Mar. 8, 1966 to Emmett L. Alexander; by U.S. Pat. No. 3,291,225, granted Dec. 13, 1966 to Charles D. Foran; by U.S. Pat. No. 3,446,284, granted May 27, 1969 to Norman D. Dyer and Roy L. Van Winkle; and by U.S. Pat. No. 3,460,638, granted Aug. 12, 1969 to Stuart C. Millsapps, Jr.

Known prior but quite different systems for hydraulically counterbalancing the weight of a drill stem are shown by U.S. Pat. No. 1,781,707, granted Nov. 18, 1930 to Waldo Sheldon, and by U.S. Pat. No. 3,151,686, granted Oct. 6, 1964 to Archer W. Kammerer.

SUMMARY OF THE INVENTION

The drill stem weight counterbalancing equipment of the present invention includes a linear fluid motor which is mounted on a frame portion of the drilling machine substantially in line with the drilling axis. A tension member is interconnected between the piston of such motor and a floating drill head which is threadable to the sections of drill pipe. This drill head and a power drive mechanism therefore are carried together on a traveling cross frame.

According to the invention, the drill head is surrounded by a remotely controllable breakout wrench

adapted to grip each section of drill pipe at a location axially inwardly of the drill pipe from its threaded connection with the drill head. The drilling equipment also includes a holding wrench located at a wrench table spaced axially from the drill head on the drilling axis. In use the pipe section second from the drill head is held by this holding wrench mechanism and the drill head is rotated in reverse for "breaking", i.e. "loosening", the threaded joint between the first and second sections of pipe. If the threaded joint between the first section of pipe and the drill head breaks first, the breakout wrench is activated to engage the first section of pipe and the drill head is again reversed for loosening the threaded connection between the first two sections. In addition to counterbalancing the weight of the drill stem and portions of the drilling equipment the linear fluid motor automatically moves the floating drill head axially in response to thread travel during the breakout procedure.

In addition to new and improved breakout system, and to unique apparatus for counterbalancing drill stem and drilling equipment weight, the present invention relates to an improved high torque breakout wrench and an improved high torque holding wrench. It also relates to improvements in the hydraulic thrust ram system used for raising and lowering the traveling cross frame which carries the rotary drilling equipment.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing like letters and numerals refer to like parts, and:

FIG. 1 is an isometric view taken from above and looking towards one side and the front of a drilling machine constructed according to the present invention, showing the drilling apparatus in a partially raised position;

FIG. 2 is a view like FIG. 1, but showing the drilling apparatus in a lowered position;

FIG. 3 is a fragmentary, somewhat schematic front elevational view of a breakout mechanism for the drill pipe and a fluid motor type counterbalancing system for the drill head and drill pipe.

FIG. 4 is an enlarged scale view partially in section and partially in elevation of the breakout apparatus shown by FIG. 3, with both the holding and driving wrenches in retracted positions;

FIG. 5 is a view similar to FIG. 4, but showing the holding wrench engaging the second section of pipe from the drill head and the drill head uncoupled from the tool joint at the upper end of the upper drill stem section;

FIG. 6 is a view similar to FIGS. 4 and 5, but showing the turning wrench engaged with the upper section of drill pipe, and the threaded tool joint at the lower end of the upper length of pipe decoupled;

FIG. 7 is a view similar to FIGS. 4–6, but typifying a situation wherein on reverse rotation of the drill head, for random breaking of the threaded joints, the lower threaded joint breaks first, such view showing the lower joint completely coupled;

FIG. 8 is an enlarged scale elevational view, with some parts in section, of the counterbalancing fluid motor and an internal parts position indicating mechanism associated therewith;

FIG. 9 is a cross-sectional view taken through the drill head above the turning wrench, substantially along line 9—9 of FIG. 3;

FIG. 10 is a cross-sectional view taken through the machine immediately above the holding wrench, substantially at the level indicated by line 10—10 in FIG. 3;

FIG. 11 is a view partially in elevation and partially in longitudinal section of a length of drill pipe;

FIG. 12 is a cross-sectional view taken through the recesses formed in the drill pipe for receiving portions of the turning wrench jaws; and

FIG. 13 is a cross-sectional view taken through the holding wrench flats, substantially along line 13—13 of FIG. 11.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more specifically to the several figures of the drawing, the illustrated embodiment is shown to comprise a lower or base frame assembly **10** including a base plate **12** and a generally U-shaped main frame **14** upstanding from the plate **12.** Frame **14** includes upstanding wall portions forming a pair of sockets **16** which occupy near corner positions on the plate **12.** The lower end portions of a pair of parallel guide columns **18** are received in the sockets **16** and are rigidly secured to the base frame thereby. A fixed cross frame **20** rigidly interconnects the upper ends of the guide columns **18.**

The guide columns **18** support and guide a movable or traveling cross frame **22.** Traveling cross frame **22** includes vertically spaced apart upper and lower guide sleeves **24, 26** which surroundingly engage the columns **18.** A lower portion of the traveling cross frame **22** extends laterally from the sleeves **26** into a position over the base frame assembly **10.** It includes wall means **28** forming a housing for a bearing assembly (FIG. **3**). A second housing **30** extends laterally from the upper guide sleeves **24** into a position above the housing **28.** Housings **28, 30,** sleeves **24, 26** and the interconnecting parts of traveling cross frame **22** are structurally integrated into a single rigid frame assembly.

The upper housing **30** contains collector gearing **32** having a pair of inputs **34** and a single output **36.** A pair of drive motor assemblies are bolted to the housing **30,** and each has an output shaft which is coupled to one of the inputs of the collector gearing. In preferred form the motor assemblies comprise an electric motor **38** and a planetary type reduction transmission **40,** such as the type shown by FIG. **7** of the aforementioned U.S. Pat. No. 3,454,114.

Traveling cross frame **22** is raised and lowered by a plurality of thrust rams **41.** According to the invention, each thrust ram **41** comprises a hollow piston chamber or "cylinder", designated **42,** and a piston **44.** In the illustrated embodiment the closed ends of the piston housings **42** are directed upwardly and the open ends are directed downwardly. Mounting sockets **46** of split form receive the lower end portions of the housings **42** and firmly secure them to the traveling cross frame **22.** Pistons **44** include upwardly directed head portions (not shown) and lower end mounting portions **48** which are secured to the lower frame **10.** Mounting portions **48** are received between verticlal plate portions of the frame member **14** and are secured to such plate portions by mounting pins **50.**

Thrust rams **41** are essentially identical to the thrust rams shown by the aforementioned U.S. Pat. No. 3,454,114. Accordingly, further details of these thrust rams **41,** including the means for supplying and exhausting a motive fluid to and from them, will not be specifically described herein. Rather, reference is made to U.S. Pat. No. 3,454,114, the contents of which are expressly incorporated herein by this reference.

As shown by FIGS. **1, 2** and **10,** the guide columns **18** and two of the thrust rams **41** are spaced apart in a quadrangular pattern, with the guide columns **18** being relatively close to corner portions of the base frame assembly **10** on one side of such base frame **10** and the two thrust rams **41** being in the corner portions on the other side of base frame assembly **10.** The third thrust ram **41** is located generally between the guide columns **18** and forms a triangular pattern with the other two thrust rams **41.** The drilling axis is located substantially at the center of forces within the triangle. The upper ends of the cylinders **42** are interconnected by a generally triangular shaped traveling head frame **52.**

Reference is now made to FIG. **3** of the drawing. The output member **36** of the collector gearing **32** is shown to be drivingly connected to a rotary drive housing **54** supported for rotation on the traveling cross frame **22** by upper and lower sets of combination bearings **56, 58.** The expression "combination bearing" is used herein to mean a bearing which carries both axial and radial loads. A drive head **60** is received in a lower portion of the rotary housing **54.** A plate **62** having axial splines on its periphery is connected to the upper end of drill head **60.** These mesh with corresponding internal axial splines **64** carried by the inner side wall of housing **54.** The peripheral splines on plate **62** and the splines **64** serve to drivingly connect the housing **54** to the drill head **60** for rotational drive but permits the drive head **60** to travel axially a limited amount relative to the housing **54.**

A support stem **66** is rigidly connected at its lower end to the drill head **60** and extends upwardly therefrom. Stem **66** includes a swivel joint **68.** The swivel joint **68** connects the upper and lower portions of the stem **66** together so that they move together axially. The portion of stem **66** below swivel joint **68** rotates with the drill head **60.** The portion of the support stem **66** above swivel **68** does not rotate. A piston rod **70** rigidly connects the non-rotating portion of support stem **66** with a piston head **72.** Piston head **72** is mounted for linear up and down travel within a piston housing or cylinder **74** of a linear motor **76** which is mounted on top of the traveling head frame **52.** The primary function of linear motor **76** is for counterbalancing the weight of the drill head assembly and the drill stem connected thereto. However, it also plays a part in the drill stem breakout technique of the present invention, as will hereinafter be described in detail.

Drill head **60** includes a drilling fluid passageway **78** extending axially through it. This passageway **78** extends from the drill head **60** upwardly through support stem **68,** the swivel coupler **68,** and an upper branch part **80** of support stem **66.** The branch part **80** extends upwardly through an opening **82** in plate **54.** Opening **82** is sufficiently large that the branch part **80** is free to move axially up and down during axial travel of the support stem **66.**

As best shown by FIG. **8,** a radial support arm **84** extends laterally from the piston **70** below head frame **52.** The outer end of arm **84** is connected to the lower end of a movable core **86** mounted for axial travel within the tubular housing **90** of a variable voltage trans-

former **88.** Housing **90** includes an electrical coil **92** which surrounds the path of rod **86.** Change in the axial position of core **86** changes the voltage output of transformer **88.** Since core **86** is structurally coupled to the drill head **60** through the piston rod **70** and the support stem **66,** the change in resistance of variable voltage transformer **88** gives an indication of the internal position of the drill head **60** and the other internal components connected thereto. Variable voltage transformer **88** may be in an electrical circuit (not shown) which includes a direct read out device. In some installations a variable resistor may be used in place of the variable voltage transformer.

The lower end of drill head **60** is a tool joint component **94** connectible to a complementary tool joint component **96** at the upper end of each section **98** of the drill stem **100.** In the illustrated embodiment tool joint component **94** is a threaded "box" and tool joint component **96** is a threaded "pin".

The illustrated form of drill pipe **98** is of composite form. It is shown to comprise a double box major section **102** and a double pin minor section or "sub" **104.** At least the box type tool joint component **106** at the lower end of section **102** has threads which complement and will engage the threads of each pin component **96.**

As best shown by FIGS. **11–13,** each length of drill pipe **98** includes a triangular pattern of axially elongated recesses **108.** As shown by FIG. **12,** shouldered portions **110** are located circumferentially between the recesses **108.**

The recesses **108** are provided for receiving wrench jaw portions of a breakout wrench. A second set of recesses or "flats" are provided on each length **98** axially inwardly of the recesses **108** and are designated **112.** The base surfaces of recesses **112** are preferably flat chord surfaces.

As shown by FIGS. **3–9,** the drill head assembly includes an axial lower extension **114** of drive housing **44** which carries a breakout wrench mechanism **116,** hereinafter sometimes referred to as the "turning wrench".

Referring to FIGS. **5–7** and **9,** the turning wrench **116** comprises a drum like carrier **118** which is rigidly secured to and is rotated by the extension **114.** A plurality of short posts **120** project downwardly from the lower end of carrier **118.** An open centered plate **122** is secured to the posts **120,** such as by bolts **124.** Three circumferentially spaced apart wrench jaws **126** are pivotally mounted on the carrier **118** for swinging movement radially in and out relative to the position of the drill stem **100.** Each jaw **126** includes an outer end portion which is received between a pair of the posts **120.** Pivot pins **128** fit through openings formed in the outer end portions of the wrench jaws **126** and the wrench jaws **126** move relative to the pins **128.** The pivot pins **128** extend between the plate **122** and the carrier **118.** A linear fluid motor **130** is associated with each wrench jaw **126** for moving the same into and out from its wrenching positions. The linear motors **130** are interconnected between connectors **132** on the wrench jaws **126,** near the free ends thereof, and connectors **134** secured to the carrier **118.** Pivotal connections are provided at **136** and **138** so that extension and retraction of the pistons **140** in motors **130** will cause the wrench jaws **126** to swing laterally of the drill pipe axis **140** between the wrenching positions depicted by solid lines in FIG. **9** and the retracted or inactive positions depicted by broken lines in FIG. **9** with respect to the upper wrench jaw **126** only.

The wrench jaws **126** are of the spanner wrench type. Each includes a radially inwardly directed recess **142** which is bounded at each of its circumferential ends by a generally radially extending wrench surface, designated **144, 146** in FIG. **9.**

When the wrench jaws **126** are in their operative positions the shouldered portions **110** of the drill pipe are received in the recesses **142.**

Each wrench jaw **126** has an inner shank portion **148** which is in tight load transferring engagement with an end surface **150** of an enjoining wrench jaw **126.**

In FIG. **9** the turning wrench **116** is shown in the process of being rotated counterclockwise. The wrench surfaces **146** engage radial surfaces on the wrench sections **110.** The loading on the wrench jaws **126** is such that the wrench jaws want to swing further inwardly. This means that compressive loads are transferred from each wrench jaw **126** to the next where contact is made at surfaces **148, 150;** the wrench jaws **126** are mutually self-bracing. Together the wrench jaws **126** cooperate to define a compression ring which surrounds the engaged portion of the drill pipe.

Referring now to FIGS. **1, 3–7** and **10,** the base member **12** carries a holding wrench assembly **152** in axial alignment with the turning wrench **116.** An opening **154** is provided in table **12** in axial alignment with the opening **156** in turning wrench plate **122.** Three wrench jaws **158** are pivotally connected to the table **12** by pivot pins **160.** Wrench surfaces **162** are formed on radial inner portions of the wrench jaws **158.** In the illustrated embodiment the surfaces **162** are essentially flat surfaces and when the wrench **152** is in its operative position the surfaces **162** form a triangular pattern which corresponds to the triangular pattern of the pipe surfaces **112.** In this operative position the wrench jaw surfaces **162** are contiguous the pipe surfaces **112.**

The wrench jaws **158** are surrounded by a control ring **164.** The ring **164** includes three radially inwardly extending enlarged portions **166** in which are formed recesses **168** for receiving the rounded end portions of control links **170.** Similar recesses **172** are formed in radial outer portions of the wrench jaws **158** to receive the opposite rounded ends of the control links **170.** The guide means for the control ring **164** includes three brace blocks **174.** These brace blocks **174** are circumferentially spaced equal distances apart and are located such that when the turning wrench **152** is in its operative position they are radially aligned with the control links **170** and with the mating pairs of wrench surfaces **162, 112.** In such operative position the control links **170** are substantially radially oriented.

A pair of linear fluid motors **176** are interconnected between the table **12** and the control ring **160.** Pivotal connections **178, 180** are provided at the opposite ends of the motors **176** so that there is freedom of movement of the motors **176** as the control ring **164** turns.

In operation, the motors **176** are operated in unison to rotate the ring **164.** In FIG. **10** the left side motor **176** is extended, the right side motor **176** is retracted, and the wrench jaws **158** are swung inwardly into holding engagement with the drill pipe. The control links **170** are radially disposed so that the radially outwardly directed forces imposed on them by the drill pipe **100** through the wrench jaws **158** is transmitted by the control links **170** to the brace blocks **174** which are rigidly

secured to the table **12**. Thus, the control ring **164** does not have to by itself carry the loads imposed on the wrench jaws **158** during the breakout or joint loosening operation.

The breakout technique will now be described:

Let it be assumed in the drilling operation depicted by FIGS. **4–7** that the traveling frame **22** and the drilling head **60** carried thereby are in the process of being moved upwardly along the guide columns **18**, and the drill stem **100** is being withdrawn from the drill hole. When the upper or first section **98** is wholly above the wrench table **12** and the holding wrench receiving depressions **112** of the second section **98** are in position at the wrench table **12** to receive the holding wrench jaws **158**, axial movement of the traveling frame **22** is stopped (FIG. **4**). The control ring **164** is then rotated to place it in the position shown by FIG. **10**, with the wrench jaws **158** engaging the recesses **112**. The portion of the drill stem **100** below the first section **98** is then restrained or anchored against both rotational and downward axial or gravitational movement.

The drill head **60** is then reversed, i.e. rotated in a tool joint loosening direction, for the purpose of randomly loosening one of the tool joints at the opposite ends of the upper section **98**. The threaded connection between the major and minor parts **102, 104** of the composite section **98** are secured against separation by an epoxy bonding agent or by a different thread design. FIG. **5** relates to the situation when the upper tool joint loosens first. For the sake of clearer illustration, in FIG. **5** the upper section **98** is shown to be physically separated from the drill head **60**. However, in the breakout operation the tool joint components **94, 96** are not completed separated, but rather the joint is merely loosened.

Assuming that the randomly loosening operation caused the upper joint to loosen first, and the threaded joint between components **94, 96** is not totally separated but is merely maintained loosely joined, the fluid motors **130** are operated to move the turning wrench jaws **126** into engagement with the shouldered portions **110** between the recesses **108** (FIG. **9**). After this has been done the drill head **60** is again rotated in the thread loosening direction. The portion of the drill stem **100** below the upper section **98** is still retained by the holding wrench **152**. During such rotation the wrench jaws **126** transmit torque from the drill head **60** to the upper section **98**, resulting in a loosening of the threads at the lower tool joint **106, 96**. With the tool joints at both ends of the upper section **98** now loosened, the upper section **98** can be easily unscrewed and removed from the drill stem **100**. After this is done the drill head **60** is lowered and coupled to the next pipe section by loosely screwing together its box component **94** and the upstanding pin **96** of the next section **98**. The drill head **60** is then raised, with the weight of the drill stem **100** being carried by the loosely engaged threads of the loosely made-up tool joint, until such next section is in a position for removal wholly above the holding wrench table **12**, and the holding wrench receiving depressions **112** of the following section **98** are at the holding wrench station of the table **12**. The breakout wrench **116** is again operated to engage the new upper section **98**, and the drill head **60** is rotated in reverse as before to loosen the threaded tool joint at the wrench table **12**. This sequence of steps is repeated with the subsequent sections until all sections of the drill stem **100** have been removed from the drill hole.

During loosening of a threaded tool joint allowance must be made for thread travel. Otherwise, thread damage will occur. According to the invention, sufficient fluid pressure is maintained in the counterbalancing linear motor **76** below the piston head **72** to bias the drill head **60** upwardly. Thus, the drill head **60** and the drill pipe **98** connected thereto progressively moves upwardly as decoupling at joint **106, 96** proceeds.

The recesses **108** are axially elongated and the turning wrench jaws **126** are positioned therein such that there is always axial clearance above and below the wrench jaws **126**. This is important because the weight of the drill stem **100** must be carried by the linear motor **76** and none of it by the wrench jaws **126**.

If during the initial reversal of the drill head **60**, to cause a random loosening of the tool joints, the lower joint loosened first, then an added stage must be added to the technique in order to effect loosening of the tool joint between the upper section **98** and the drill head **60**. This stage (not shown) involves maintaining the loosened lower tool joint components coupled, so that their threads may carry the weight of the drill stem **100**, then retracting the holding wrench jaws **158**, and then lowering the drill head **60**, with the drill stem **100** attached, downwardly until the holding wrench receiving depressions **112** of the upper section **98** are at the holding wrench station of table **12**. The holding wrench jaws **158** are then moved inwardly and used to support the drill stem **100** and prevent its rotation. The drill head **60** is then rotated in the joint loosening direction until the threaded tool joint **94, 96** is loosened. When this happens the joint components are maintained loosely coupled so that the threads can carry the weight of the drill stem **100**. The drive head **60** is then raised to locate the upper pipe section **98** in a proper position for removal. The holding wrench **152** is reinserted on the second pipe section **98** and the first section **98**, now having both of its tool joints loosened, is easily unscrewed from the second section **98** and from the drill head **60**, and is then removed from the drill stem **100**.

What is claimed is:

1. In a drilling mechanism comprising a rigid lower frame, upstanding column means rigidly connected to said lower frame, rigid cross frame means mounted for up and down travel along said column means, and drilling equipment carried by said cross frame means comprising a rotary drill head connectible to drill pipe, motor means and transmission means drivingly connecting said motor means to said drill head, the improvement of:

said column means comprising a single pair of spaced apart, parallel, guide columns;

said cross frame means including guide means engaging the two guide columns and guiding said cross frame means for precision movement along said guide columns;

said cross frame means extending laterally from the general plane of said guide columns and overhanging said lower frame;

said motor means comprising a pair of drill motors located above the overhanging portion of said lower frame;

said transmission means comprising collector gearing means carried by the overhanging portion of said cross frame and comprising an output portion connected to the drill heat and two input portions, and

gearing means drivingly connecting the drill motors to the input portions of said collector gearing means;

at least one thrust ram comprising an upwardly directed, downwardly opening, hollow piston chamber having a normally closed upper end, a lower end mounting portion, and a downwardly directed piston slidably receivable in said chamber, said piston having a lower end mounting portion and an upper head portion, means rigidly affixing the lower end mounting portion of said chamber to said traveling cross frame means, with the remainder of said chamber extending upwardly above said traveling frame means, means affixing the lower end of the piston to said lower frame means;

selectively usable means for simultaneously delivering a motive fluid between the closed upper end of the chamber and the head portion of the piston and venting the zone below the piston head;

to move the traveling cross frame means and the rotary drilling equipment and chamber mounted thereon upwardly as an assembly;

selectively usable means for simultaneously delivering motive fluid to the zone below the piston and venting the space above the piston head, so as to cause a downward movement of such assembly comprising the traveling cross frame means and the piston chamber and drilling equipment carried thereby;

said rotary drill head including a tool joint component mounted for limited axial movement;

a linear fluid motor supported above said drill head tool joint component, said motor including a piston and a fluid chamber below said piston, a connector rod interconnected between said piston and said drill head tool joint component; and

means for delivering a fluid into said fluid chamber for exerting a lifting force on said piston for counterbalancing the weight of the drill head tool joint and any drill pipe members attached thereto.

2. Drilling mechanism according to claim **1,** said mechanism including three thrust rams of the character described, two of which are spaced from each other and from the guide columns and are secured to the lower frame in a quadrangular pattern with said guide columns, and the third is located generally between said guide columns in a triangular pattern with the other two thrust rams.

3. Drilling mechanism according to claim **1,** wherein said connector rod is hollow and means are provided for delivering a drilling fluid into it for delivery to the tool joint component and any drill pipe connected thereto.

4. Drilling mechanism according to claim **1,** wherein the collector gearing means includes a vertical passageway axially aligned with said drill head tool joint component, said connector rod extends through said passageway to said fluid motor, and the drill motors are radially offset from said connector rod.

5. Drilling mechanism according to claim **4,** including a plurality of thrust rams of the character described, and cross frame means interconnecting the tops of said thrust rams, with the counterbalancing thrust ram being mounted on said cross frame means.

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