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[54] **ELECTRIC POWER DRIVE ASSEMBLY**

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[51] **Int. Cl.**[2] **E21B 19/16**

[58] **Field of Search** 173/57, 164; 175/170, 85; 74/411.5, 467, 468; 184/6.25; 166/77.5

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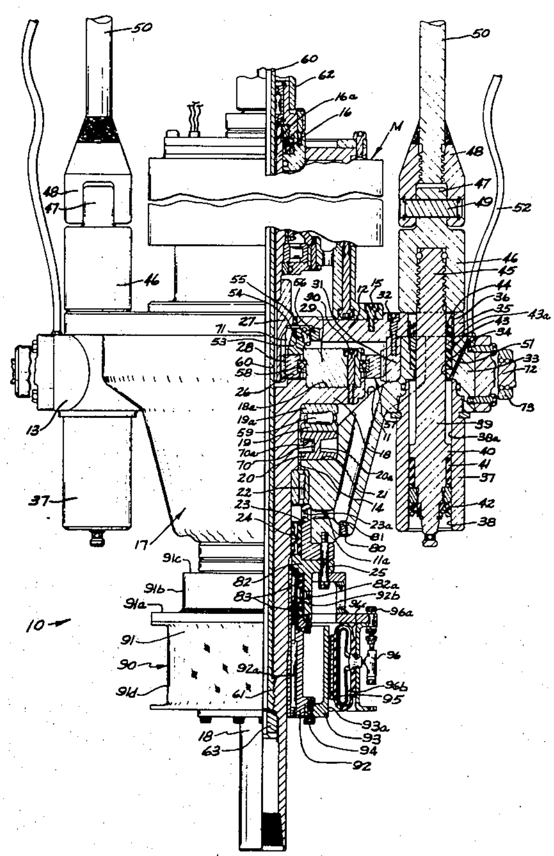
[57] **ABSTRACT**

Disclosed is a reversible, electric motor drive assembly pivotally supported from the traveling block in a derrick employed to rotate, raise, lower or otherwise handle tubular members used in the drilling and production of oil and gas wells. Hydraulic cushioning means support the assembly from the traveling block. A tubular mandrel extending through a bore in the motor shaft provides a conduit for introducing drilling fluid to a drill string connected to the rotating output drive stem of the assembly. The assembly is equipped with a pneumatically operated friction brake to permit precise and rapid alignment of equipment carried by the stem with tubular members to be handled. A locking means is employed to prevent loosening of the mandrel during reverse rotation of the stem. The reduction gearing in the assembly is immersed in oil and functions as a pumping mechanism to provide improved oil cooling and lubrication while magnetic drain plugs in the gear housing remove metal debris from the circulating oil.

10 Claims, 2 Drawing Figures



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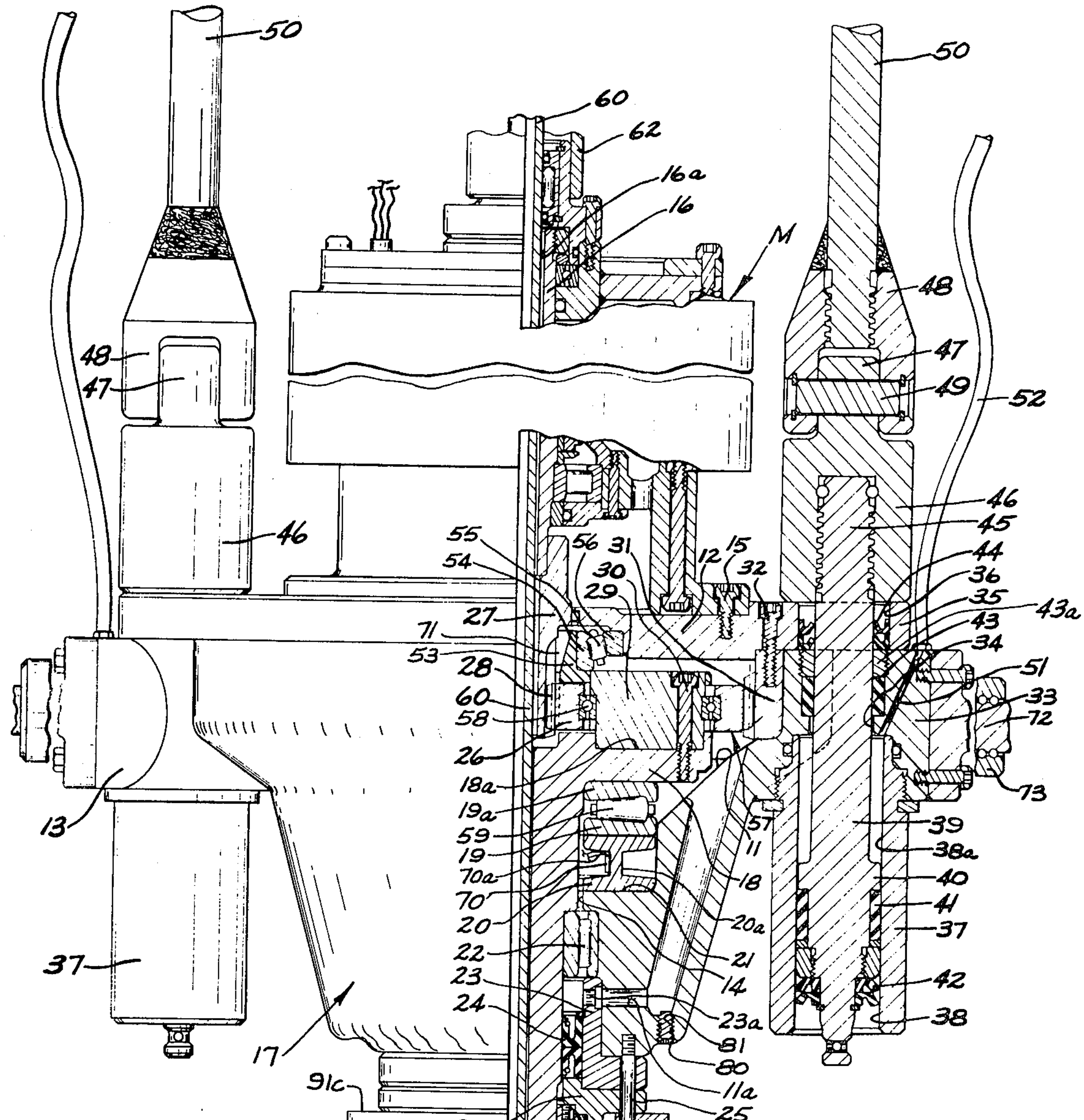

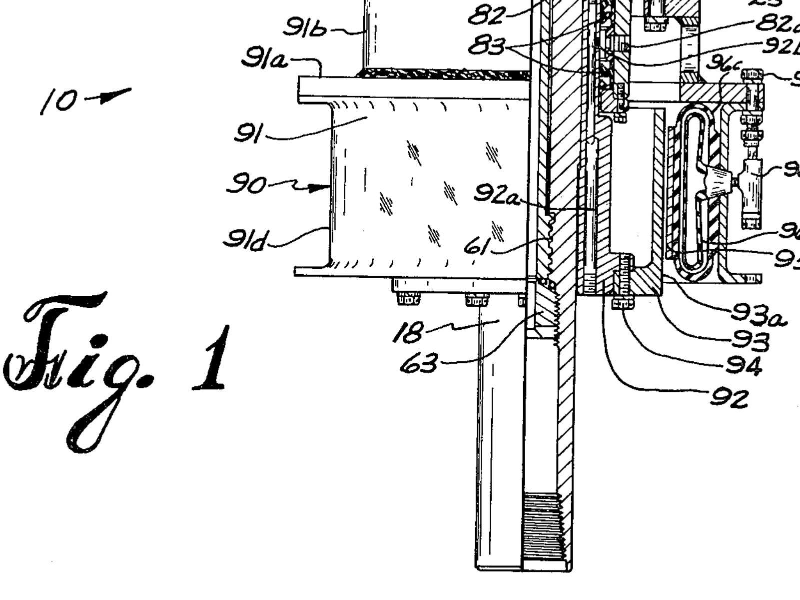

Fig. 1

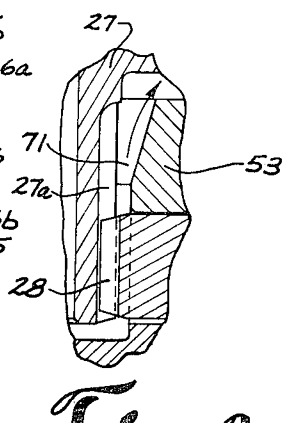

Fig. 2

ELECTRIC POWER DRIVE ASSEMBLY

RELATED APPLICATIONS AND PATENTS

This application is related to the inventions described in U.S. Pat. application Ser. No. 130,597 filed Apr. 2, **1971** and now U.S. Pat. No. 3,766,991 entitled Electric Power Swivel and System for Use in Rotary Well Drilling, and in U.S. Pat. application Ser. No. 206,325 filed Dec. 9, 1971 and now U.S. Pat. No. 3,774,697 entitled Rotary Drive Assembly for Handling Tubular Members, both of said inventions as well as the present invention being assigned to a common assignee.

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.

As described in the prior related patent applications, a power swivel of the type referred to herein may be used to raise, lower, rotate and pivot pipe members, and any other equipment employed in drilling and completing a well. The ease with which such a swivel may be raised, lowered or pivoted, as well as the operator's ability to manipulate the device automatically from a control panel, makes the task of making or breaking strings, or handling other equipment, faster and safer. While the apparatus of the related applications have substantially reduced many of the foregoing problems, there has been a need for improved control over the angular positioning of the power drive stem in the power swivel. Such a need arises for example when elevators are carried by the drive stem and it is desired to align the access opening in the elevators with a length of pipe which is to be moved. Simple reversal of the polarity of the electrical power supplied to the motor functions to brake the stem rotation but does not operate to hold the stem stationary. Moreover, several repeated turns

of the stem may be required before the stem comes to rest at the desired angular position.

During the process of working a well, and in particular when a pipe string is being broken, there are times when the swivel stem must be operated in reverse rotation. The fluid conducting mandrel that passes through the center of the swivel and of the motor, and which is used to conduct drilling mud and other fluid to the well, as described in U.S. Pat. application Ser. No. 130,597 may tend to loosen, due to fluid drag, where conventional right-hand threads are used to secure the mandrel to the stem.

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 reduction gearing is mounted as a vertically and pivotally movable rotary drive or power swivel assembly in a well derrick, and is employed to handle the tubular members used in the drilling and production of a well.

An annular brake drum is rigidly attached, concentrically, to the output drive stem of the assembly to assist in precisely orienting the stem. Pneumatically activated annular brake shoes, rigidly mounted ultimately to the assembly housing, are selectively operable to engage the brake drum to prevent or stop rotation of the swivel stem and whatever equipment is attached thereto. With this latter improvement, the operator need no longer rely on a hit-or-miss approach in orienting the drive stem and the equipment attached thereto in order to make a union with other equipment.

Extensive hollow regions within the gear housing permit increased circulation of lubricating and cooling fluid around the bearings supporting and aligning the swivel stem. In addition, a pumping action is provided by the mating of gear teeth to further enhance the circulation of the lubricant-coolant. One or more magnetic drain plugs in the lower portion of the swivel housing collect metal shavings that result from wear. Draining and replacement of the lubricating oil, as well as removal of the collected metal shavings are effected by merely removing the drain plugs.

The mandrel passing through the motor and drive stem, and used to communicate drilling fluid to the drill string, is threadedly connected to the inside of the stem at a point below the swivel. This connection is secured by a lock nut which is threadedly joined to the interior of the stem by threads having a thread lead which is less than that in the mandrel connection. The lock nut functions to tighten against the base of the mandrel when the assembly is undergoing reverse rotation and prevents the mandrel from loosening from the stem.

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 vertical elevation in partial section illustrating a preferred form of the swivel and brake system of the present invention; and

FIG. 2 is an enlarged scale insert from FIG. 1 showing details in the construction of the lubricant-coolant pumping means of the present invention.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The assembly of the invention is indicated generally at **10** in FIG. **1.** The assembly includes a main housing **17** in the form of a substantially annular, hollow body which encases the upper end of a rotatable output drive or swivel stem **18** and reduction gears connected between a motor shaft and the stem. A flow path **11** extends through the housing **17** to supply lubricant to the various internal components. The upper end of the housing **17,** which is closed over by a circular, centrally apertured plate **12,** includes two radially extending diametrically opposed suspension ears **13** and **33** used to suspend the assembly **10** from the derrick (not shown).

A tubular sleeve **37,** having an axial throughbore **38,** is screwed into the lower end of a vertical bore **34** formed through the suspension ear **33,** which is similar in construction to the ear **13.** A bore **36** through the ear **35** of plate **12** registers with the bore **34.** The bore **38** defines a pressure cylinder **38*a*** adapted to receive a piston **39** formed with a lower head **40** fitted with seal rings **41** and **42** for slidable sealing engagement with the wall of bore **38.** Piston **39** extends upwardly through bores **34** and **36** which are provided with packings **43** and **44** respectively, sealing with the piston to close the upper end of the cylinder. A nut **43*a*** screws into the bore **34** in the suspension ear **33,** keeping the seal **43** under pressure, and providing a smooth base, flush with the top of the ear **33,** upon which the seal **44** may be seated. The upper end portion of piston **39** which projects above plate **12** is provided with an externally threaded pin **45** which is screwed into a hanger cap **46.** The latter has an upwardly extending lug **47** which is received in a clevis **48** and pivotally secured thereto by means of a transversely extending pivot pin **49.** The clevises on both sides are secured to the opposite ends of a bail **50** by means of which the entire device is swung (in a manner not illustrated) from a hook or like connection of a travelling block employed in conventional rotary drilling and suspended from drilling cables in a conventional drilling derrick.

Each of the cylinders **38*a*** is in communication with a port **51** which is connected to a conduit **52** leading to a closed reservoir of an inert pneumatic fluid (not shown) such as nitrogen gas, which is kept continuously pressurized.

The outer ends of ears **33** are fitted with trunions **72** journalled in the ends of guide arms **73** which connect to guide sleeves (not shown) disposed for sliding movement on vertically positioned guide bars (not shown) suitably mounted in the drilling derrick in which the power swivel is suspended. The trunions thus provide a pivoting connection between the power swivel and the guide sleeves so as to permit the power swivel to be tilted at an angle to the vertical when required.

In order to effect tilting of the power swivel when desired, a fluid pressure actuated tilting jack (not shown) is connected between the travelling block supporting the power swivel and housing **17** of the power swivel. Such a tilting jack is disclosed in U.S. Pat. application Ser. No. 130,579, and further information regarding the mounting and use of the assembly **10** may be derived from the said patent application as well as U.S. Pat. application Ser. No. 206,325.

A reversible electric motor encased within a motor housing M is employed to provide power in the form of rotary motion in a hollow drive shaft **16** having an axial bore **16*a*.** Bolts **15** secure the motor housing M to the top plate **12.** The lower end of the drive shaft **16** is locked to a central spur or pinion gear **27** equipped with gear teeth **27*a*** (FIG. 2). An annular bearing mount **53** encircles the gear **27** and supports an inner race member **54** on inclined roller bearings **55.** An outer race **56** for the bearings **55** is mounted concentrically within the circular plate **12.** The roller bearings **55** are employed for preloading the rotatable drive assembly and provide both axial and radial friction reducing support.

Three planetary gears, one shown generally at **57,** are mounted for rotary motion about shafts secured to a circular mounting head formed at the upper end of the stem **18.** The lower end of the stem **18,** which extends downwardly through bore **14** in the housing **17** and below the brake system **90,** is internally threaded to receive other equipment. The centers of the gears **57** are positioned on the same radius and are circumferentially spaced 120° from each other. The three gears **57,** which are the same, will be described with specific reference only to the one gear shown. This gear **57** includes a central shaft **29** which is mounted in a receiving recess **18*a*** formed in the top surface of the mounting head on the stem **18.** Socket head bolts **30** hold the shaft **29** in firm engagement with the stem **18** and ball bearings **58** mount an annular gear ring **26** about the shaft **29.** The ring **26** is equipped with external gear teeth **28** which mesh with the gear teeth **27*a*** on the pinion gear **27** and also mesh with gear teeth **31*a*** formed internally of a large ring gear **31.** The ring gear **31** is rigidly secured to the plate **12** by suitable socket head bolts **32.**

Rotary and axial support for the large weight which is to be suspended from the stem **18** is provided by tapered roller bearings **59** supported between lower and upper races **19** and **19*a*,** respectively. The lower race **19*a*** is supported on an annular H-beam collar **20** which in turn is supported on an internal shoulder **21** formed in the housing **17.** A conventional strain gauge **70** is attached to the upstanding web **20*a*** connecting the upper and lower portions of the collar **20** and suitable electrical leads **70*a*** extend to an external control panel (not shown) to provide an input signal to a transducer which forms a visible indication of the weight being supported by the stem **18.**

At the lower end of the housing **17,** the stem **18** is supported radially by roller bearings **22.** An annular fitting **23** secured to the base of the housing **17** by bolts **25** mounts a resilient seal **24.**

Magnetic drain plugs **80** (one shown) are threadedly inserted in vertical holes **81** (one shown) located in an annular arrangement about the lowest portion of the passage **11** in the housing **17.** Passageways **11*a*** (one shown), forming a portion of the flow passage **11** in the housing **17,** are radially aligned with corresponding holes **23*a*** in the annular fitting **23,** just below each roller bearing **22.** An enlarged spacing **71** (FIG. **2**) in the passage **11** forms a passageway above gear teeth **27*a*** and **28,** between the bearing mount **53** and the pinion gear **27,** and up to the bearings **55.**

The mating of the pinion gear with the planar gear displaces the oil located between the teeth of each gear, causing this oil to flow parallel to the cylindrical axes of the gears. The open space **71** above the region of the meshing of the gear teeth is greater than that below the gears, permitting a greater amount of the moving oil to flow into the upper space **71** as compared with that flowing in the opposite direction. In this way, as the gears turn in either direction, oil is circulated upwardly to flow over and around the bearings **55**, while more oil is drawn into the region of the meshing teeth from below, and a continuous pumping action is established to keep the oil circulating.

A tubular mandrel **60** extends upwardly through the bore of the stem **18**, being threadedly connected to the stem at a point at the bottom of a brake system **90** by a threaded connection **61**. The mandrel extends upwardly through the bore of pinion gear **27** and the bore **16***a* of the motor shaft **16** and thence through a swivel housing **62**. The mandrel **60** continues externally to appropriate fittings (not shown) required for the conduction of drilling mud or other fluid to the drill string through the bore of the mandrel **60**.

Viscous drag between the interior surface of the mandrel **60** and the fluid it contains tends to unthread the mandrel during reverse rotation of the stem **18**. A lock nut **63** is threadedly connected to the interior of the stem **18** just beyond the mandrel-to-stem connection **61**. The thread lead of the lock nut connection is made smaller than that of the mandrel connection. The lock nut **63**, having a smaller surface area exposed to the fluid within than does the mandrel **60**, will experience smaller viscous drag than will the mandrel. Furthermore, with a smaller thread lead, the lock nut's axial movement will be less than that of the mandrel for one turn. Since the mandrel, upon loosening, must move in the direction of the lock nut, any loosening of the mandrel induced by reverse rotation of the swivel stem will be blocked by the slower moving lock nut. This locking force increases as the forces tending to rotate the lock nut and mandrel increase.

The brake system **90** is enclosed by a hollow, annular housing **91**, the upper portion of which is composed of a flange **91***a* welded to a ring **91***b* which is welded to a second, smaller flange **91***c*. The housing **91** is thus suspended by flange **91***c* which is connected, through an annular fitting **82**, to the annular fitting **23** by bolts **25**. The lower portion of the housing **91** is formed by a flanged ring **91***d* which is welded to the flange **91***a*.

An annular sleeve **92** is locked to and thereby rotates with swivel stem **18**. An annular brake drum **93** is bolted to the sleeve **92** by bolts **94**. The outer annular surface **93***a* of the brake drum **93** provides the braking means when contacted by brake shoes **95** (only one shown).

A pneumatic connector **96**, suspended from the housing **91** by a bolt **96***a*, leads from a pneumatic supply line (not shown) to a flexible member **96***b*, which is designed to inflate with pressurized air supplied from the pneumatic line. Inflation of the member causes the member to press against an enclosing flexible member **96***c*. This in turn causes the brake shoes **95** carried on the member **96***c* to be forced inwardly against the brake drum **93***a*. The brake shoes comprise a plurality of plates of any suitable material suspended annularly about the inner surface of the flexible member **96***c*. The flexible member **96***c* is resilient and causes retraction of the brake shoes **95** and collapse of the flexible member **96***b* when the pressure within the flexible member **96***b* is relieved through the pneumatic supply line.

The sleeve **92** is equipped with a vertical, cylindrical bore **92***a* plugged at the top end to form a flow passage rotating with the swivel stem **18**. The bottom of the passage **92***a* is threaded to receive a hose fitting (not shown). A circumferential recess **92***b* in the sleeve **92** communicates between the passage **92***a* and a passageway **82***a* in the vertical wall of the annular fitting **82**. The passageway **82***a* is aligned with an opening in the ring **91***b* of the housing **91** to permit access, via a conduit (not shown), to the passageway **82***a*, which is threaded to receive a hose fitting (not shown). Double resilient seals **83** above and below the region of the passageway **82***a* preserve the integrity of the communication from the passage **92***a* to the passageway **82***a* to the conduit.

OPERATION OF THE ASSEMBLY

In operations such as making or breaking a pipe string, attaching orienting equipment for directional drilling, etc., the operator is periodically required to stop and hold the swivel stem **18** steady in some particular angular orientation. When this need arises, the operator actuates the brake system **90** by increasing the pneumatic pressure via the conduit (not shown) connected to the pneumatic connector **96**. The flexible member **96***b* is thereby inflated, pressing against the flexible member **96***c*, causing the brake shoe **95** to be forced against the brake drum **93**. Friction between the brake shoe **95** and the outer surface **93***a* of the brake drum **93** supplies the braking action, which prevents the brake drum **93** from rotating with respect to the brake shoe **95**. Since the brake shoe is held fixed to the brake system housing **91**, which is rigidly connected to the swivel housing **17**, and since the brake drum **93** is rigidly connected to the stem **18**, activation of the brake system in this manner prevents rotation of the stem **18** with respect to the housing **17**. The operator may thus align the stem, including whatever equipment may be attached thereto, and selectively lock the stem against rotation about its axis.

Once the activity necessitating the locking of the stem in position is completed, the operator need only reduce the pneumatic pressure via the conduit to the connector **96**. The resilient member **96***c* will collapse, causing the retraction of the brake shoe **95** from the brake drum surface **93***a*. The stem is then released, and the operator may continue with rotational motion, if desired.

Once the mandrel **60** is installed and screwed into place within the stem **18**, the lock nut **63** is fastened below the mandrel, tightly against the bottom face of the mandrel. Any viscous drag or other retarding force exerted on the mandrel during forward rotation of the stem **18** only serves to tighten both the mandrel **60** and the lock nut **63** in their respective threaded connections to the stem **18**. In reverse rotation, however, the retarding forces tend to unthread the mandrel **60** and the lock nut **63**. The mandrel attempts to overrun the slower moving lock nut, which in turn jams the two members together to prevent further movement. Thus, if the mandrel tends to loosen, it will be blocked by the lock nut, with the result that the mandrel is effectively locked in place in its attachment to the swivel stem **18**.

The housing **17** is filled with an appropriate lubricating and cooling fluid such as a light weight motor oil. As the assembly is driven rotationally by the motor M, the meshing of the pinion gear **27** with the planatary gears **57**, combined with the increased volume above the region of the mating of the teeth of these gears, produces a circulating pumping action. Oil is thus forced over the roller bearings **55**, and then through the rest of the expanded cavity **11** within the housing **17**.

The passageway formed at **11***a* and **23***a* through the housing **17** and the annular fitting **23** respectively allows circulation of the oil to the roller bearings **22**. The roller bearings **59** giving vertical support to swivel stem **18** are also open to the oil circulation due to the shape of the passageway **11** within the housing **17**. The described oil circulation serves to keep all exposed parts within the housing **17** lubricated, to cool parts that tend to heat up during operation of the swivel, and to flush all metal fillings and chips and other metallic debris produced during operation. In the process of circulating around the flow path **11**, the oil moves this debris past the magnetic drain plugs **80**. These plugs magnetically attract and hold the metallic debris, removing it from the circulating oil. The debris can then be periodically removed by removing and cleaning the magnetic drain plugs **80**.

The flow passage **92***a* in the sleeve **92** which rotates with the swivel stem **18** permits a pneumatic, hydraulic, or other type connection between any equipment attached to and rotating with the swivel stem **18** and an external source (not shown). A hose connection is made from said rotating equipment via the threaded bottom of the passage **92***a*. Communication of the fluid to or from the external source is then made via the groove **92***b*, the passageway **82***a*, threaded for an external hose fitting, and thence to the source via said hose (not shown).

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.

We claim:

1. A rotary drive assembly for rotating tubular members comprising:

a. motor means for developing rotary power in said assembly;

b. an axially extending rotatable stem means rotatably powered by said motor means; and

c. friction braking means included in said assembly for selectively stopping and/or retaining said stem means at a fixed angular position about its axis.

2. A rotary drive assembly for rotating tubular members as defined in claim **1** further including fluid powering means for selective activation of said friction braking means.

3. A rotary drive assembly for rotating tubular members as defined in claim **1** further including:

a. a tubular mandrel means extending axially through said stem means; and

b. locking means, movable relative to said mandrel means, for retaining said mandrel means within said stem means, said locking means including means for providing increasing locking forces in response to increasing rotational forces tending to displace said mandrel means within said stem means.

4. A rotary drive assembly for rotating tubular members as defined in claim **3** further including fluid powering means for selective activation of said friction braking means.

5. A rotary drive assembly for rotating tubular members comprising:

a. motor means for developing rotary power in said assembly;

b. an axially extending rotatable stem means rotatably powered by said motor means;

c. gear reduction means disposed between said motor means and said stem means;

d. housing means enclosing said gear reduction means;

e. fluid means contained within said housing means;

f. pumping means for preferential circulation of said fluid means through flow passage means provided within said housing means, said pumping means including differential volume regions provided adjacent the axial ends of meshing gear means in said reduction means to induce a circulatory flow of fluid; and

g. magnetic means for removing metallic debris from said circulating fluid means.

6. A rotary drive assembly for rotating tubular members as defined in claim **5** further including friction braking means for selectively stopping and/or retaining said stem means at a fixed angular position about its axis.

7. A rotary drive assembly for rotating tubular members as defined in claim **6** further including fluid powering means for selective activation of said friction braking means.

8. A rotary drive assembly for rotating tubular members as defined in claim **5** further including:

a. tubular mandrel means extending axially through said stem means; and

b. locking means, movable relative to said mandrel means, for retaining said mandrel means within said stem means, said locking means including means for providing increasing locking forces in response to increasing rotational forces tending to displace said mandrel means within said stem means.

9. A rotary drive assembly for rotating tubular members as defined in claim **8** further including friction braking means for selectively stopping and/or retaining said stem means at a fixed angular position about its axis.

10. A rotary drive assembly for rotating tubular members as defined in claim **9** further including fluid powering means for selective activation of said friction braking means.

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