

[72] Inventor **James Lewis Foster**
P.O. Box 1351, Wichita Falls, Tex. 76307
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Primary Examiner—James A. Leppink
Attorneys—James F. Weiler, Jefferson D. Giller, William A. Stout, Paul L. De Verter II, Dudley R. Dobie, Jr. and Henry W. Hope

[54] **KELLY SPEED BUSHING**
25 Claims, 7 Drawing Figs.

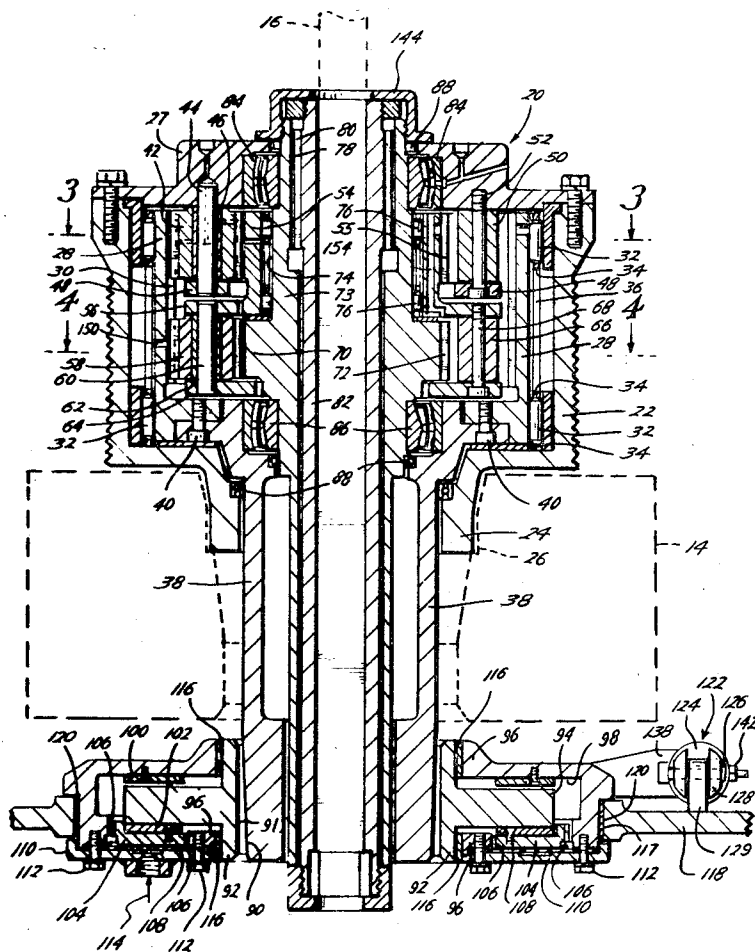
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[51] **Int. Cl.**..... **F21b 3/04**
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74/421, 801; 64/23.5; 175/195, 170, 106

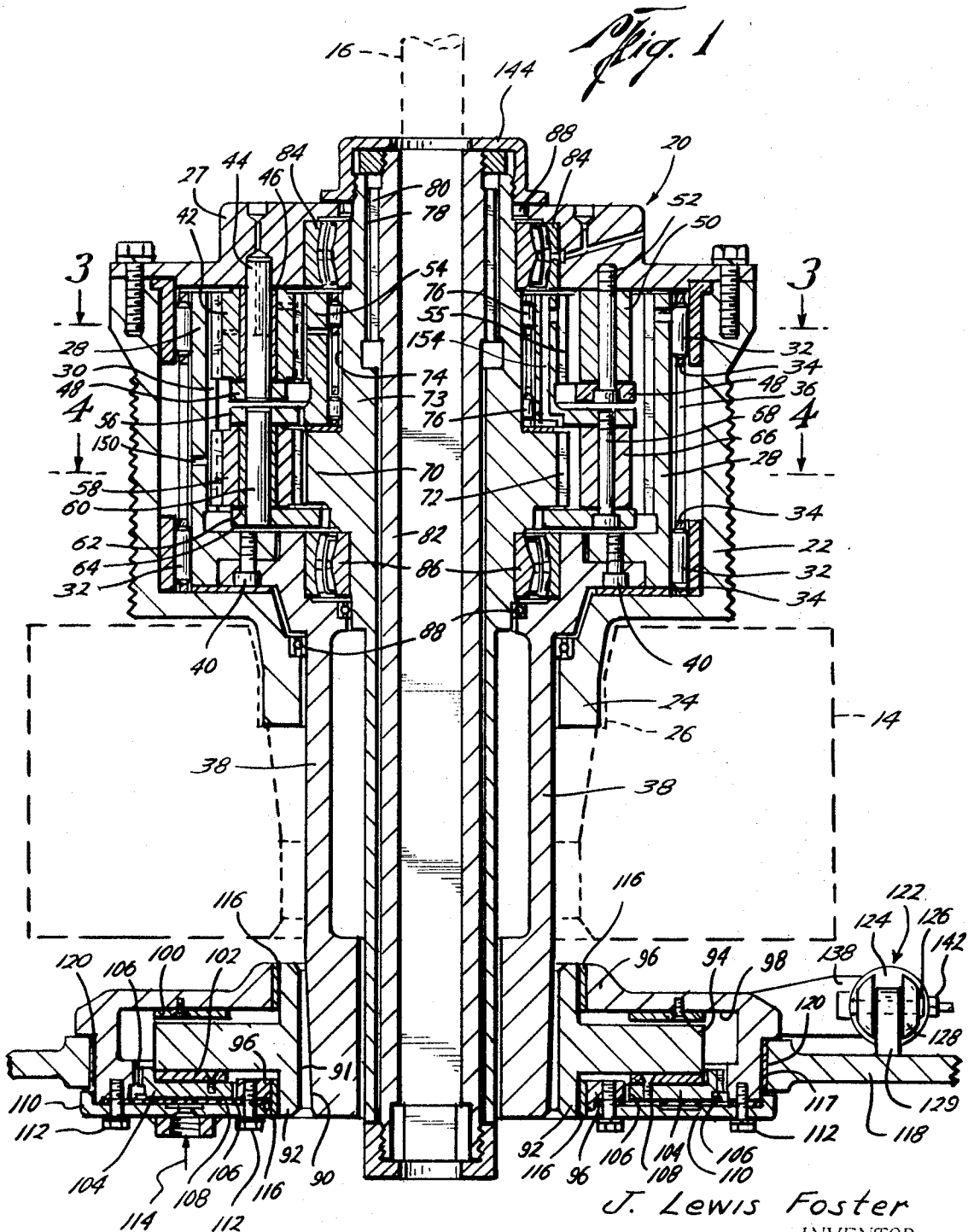
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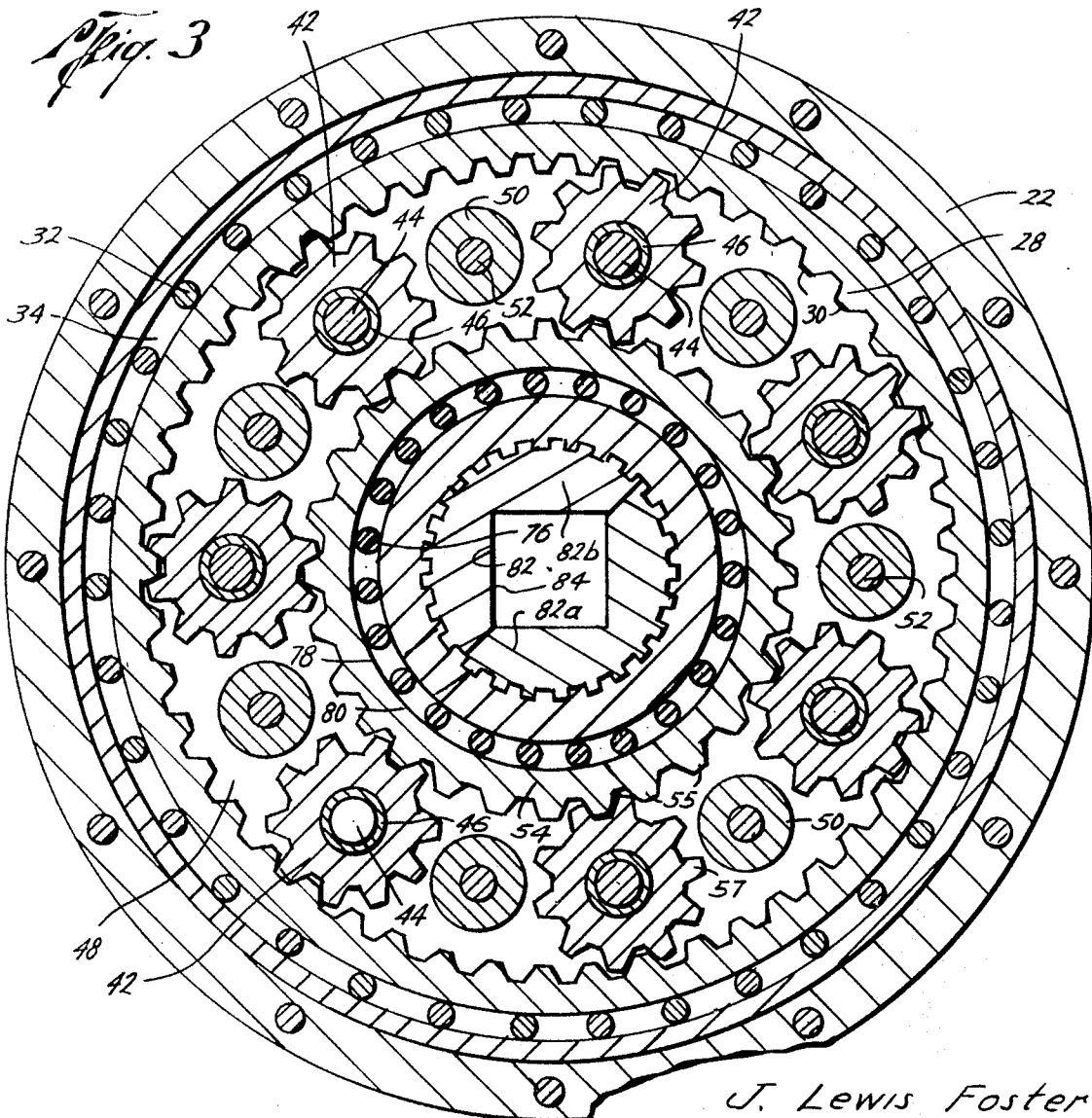
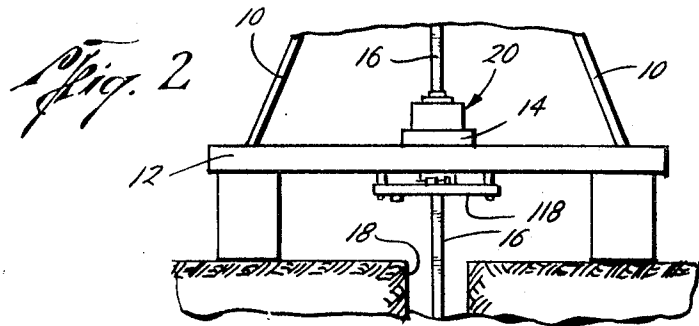
ABSTRACT: An apparatus and method for rotating a kelly and drill string by the rotary of a drilling apparatus at a speed different than the speed of the rotary. The apparatus generally includes a housing or bushing spaced about the kelly which passes through the table, the housing or bushing being adapted to be received and rotated by the rotary. An anchor ring gear is provided concentrically within the housing and extends therefrom for attachment to the drilling apparatus structure. Epicyclic or planetary gear means couple with the bushing or housing and mesh with the anchor ring gear to transmit rotary motion from the housing to the kelly. Additionally, holding means secure the anchor ring gear to the drilling apparatus structure.





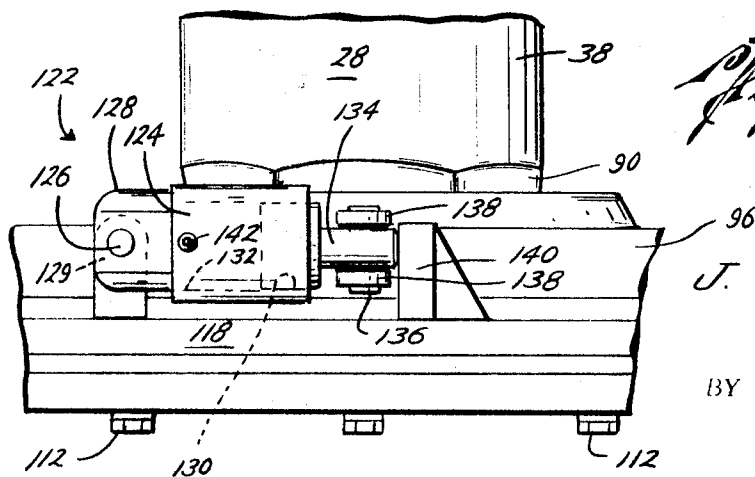
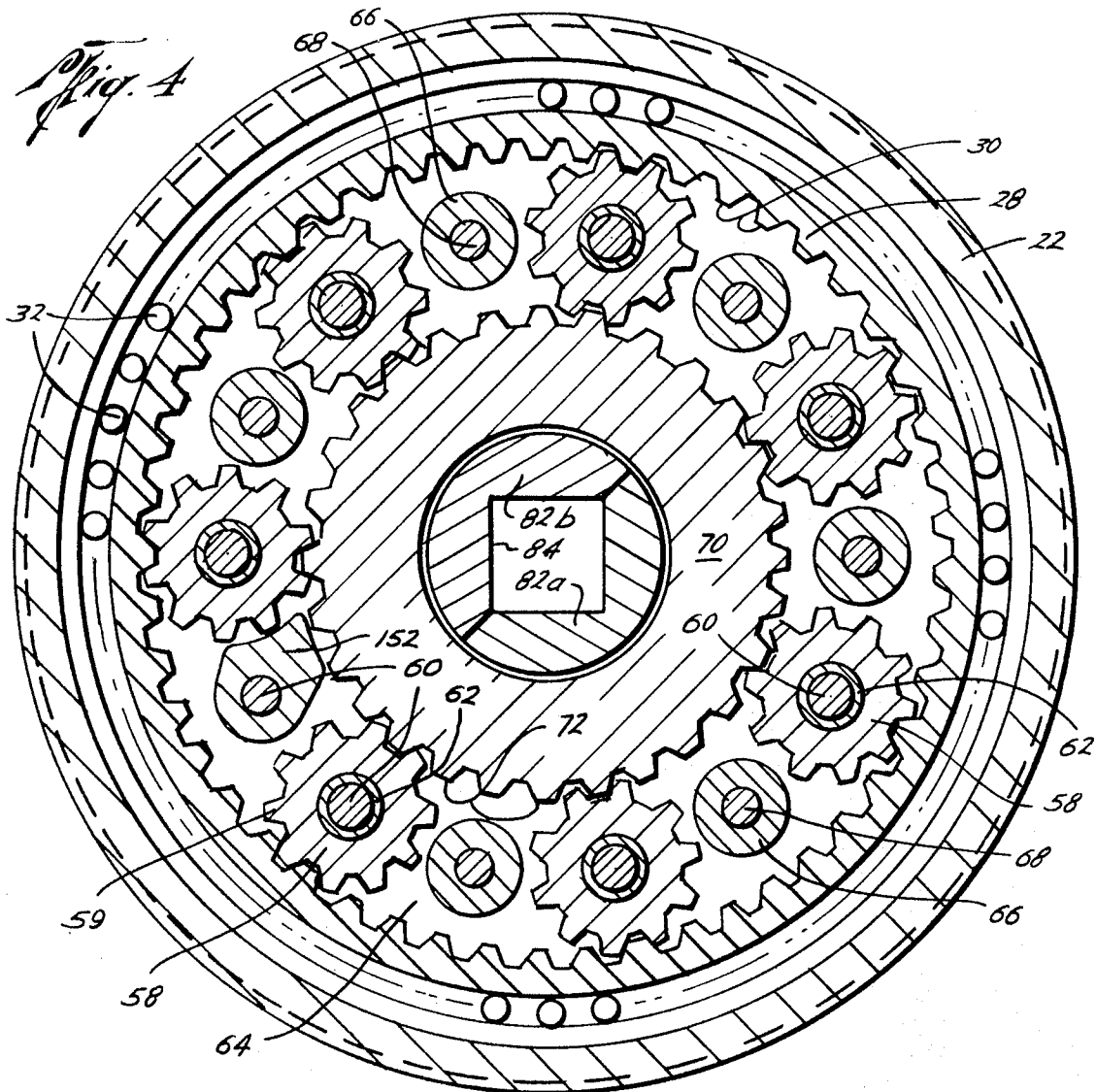
J. Lewis Foster
INVENTOR.

James F. Weller
BY Jefferson D. Miller
William A. Jones
Dudley R. Palmer
ATTORNEYS



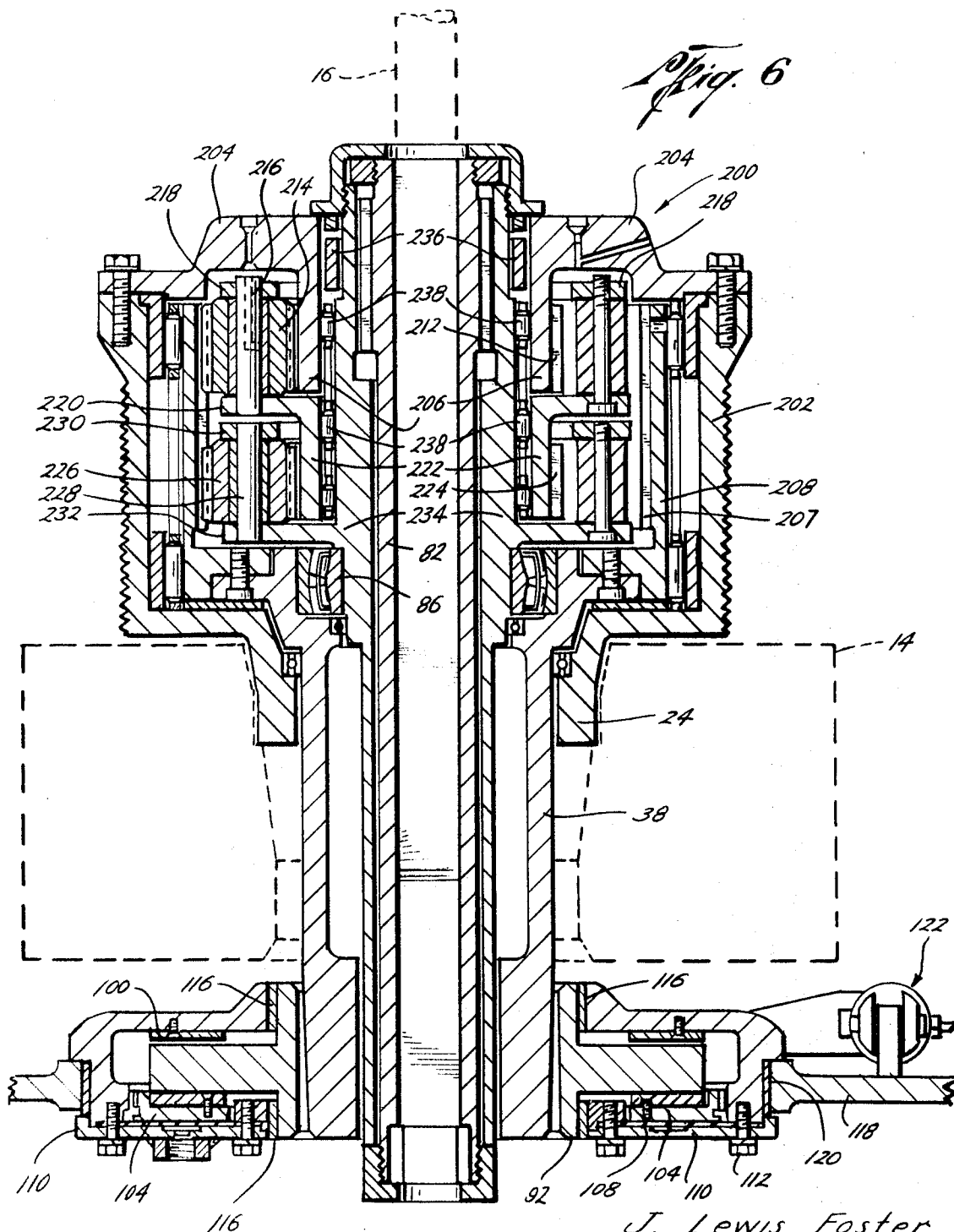
J. Lewis Foster
INVENTOR.

BY James F. Wiles
Jefferson D. Giller
William A. Stout
Dudley R. Coble, Jr.
ATTORNEYS



J. Lewis Foster
INVENTOR.

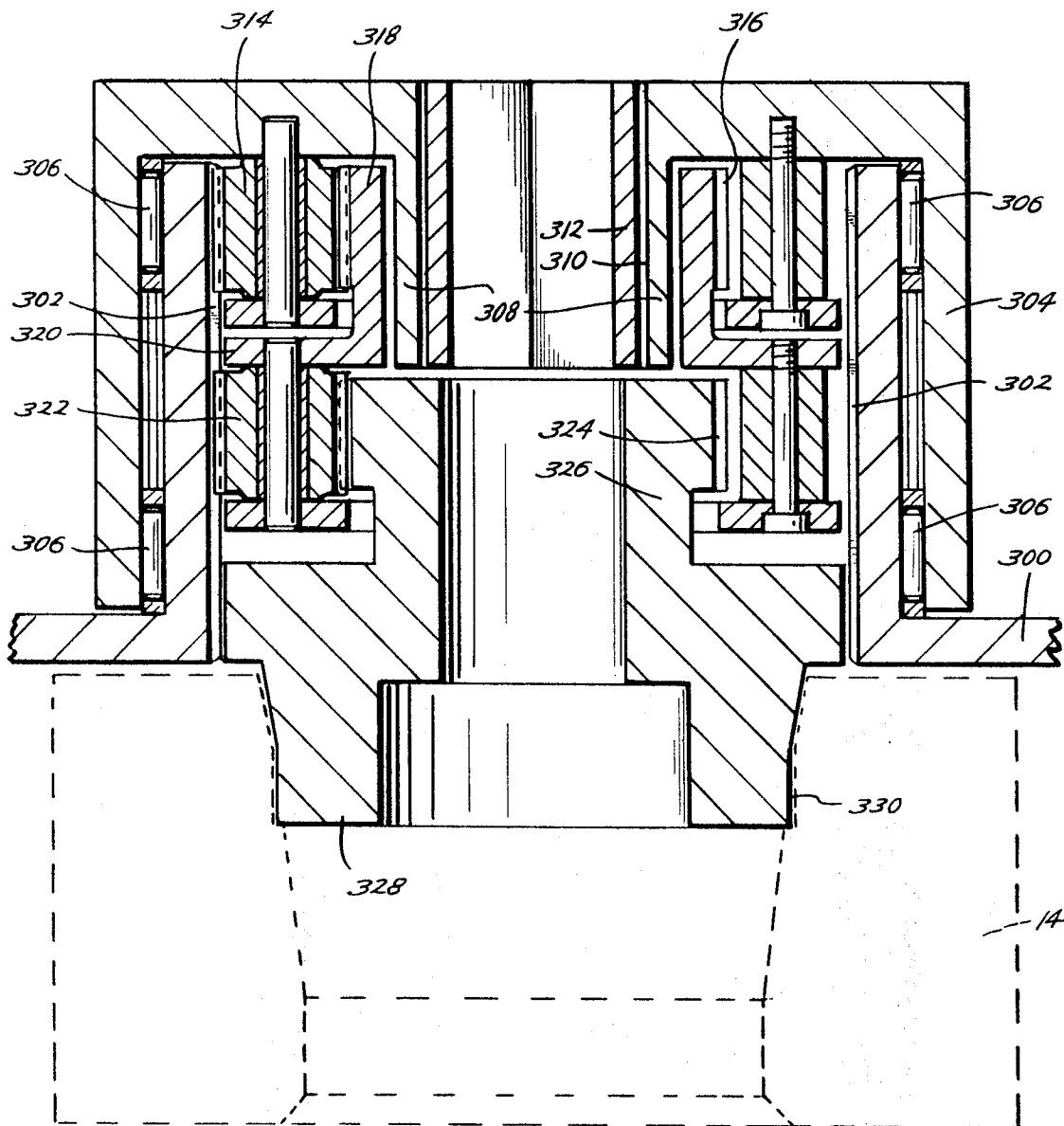
BY *James F. Miller*
Jefferson A. Miller
William R. Stewart
Dudley B. Dossie, Jr.
ATTORNEYS



J. Lewis Foster
INVENTOR.

James F. Widen
BY Jefferson D. Griley
William A. Stout
Dudley R. Dobie, Jr.
ATTORNEYS

Fig. 7



J. Lewis Foster
INVENTOR.

BY *James F. Miller*
Jefferson D. Miller
William H. Stout
Wadley H. L. L. L. L. L.
ATTORNEYS

KELLY SPEED BUSHING

BACKGROUND OF THE INVENTION

The drilling of a borehole such as an oil or gas well into the earth's crust is frequently carried out by drilling apparatus incorporating a rotary table. The rotary table (or rotary as it is often referred to) is rotated to in turn impart rotation through a conventional kelly bushing to a noncircular cross-sectional member known as a "kelly." Typically, the kelly is retained at its upper end by the spindle of a swivel (or a sub attached to the spindle) which in turn depends from a traveling block, and the lower end of the kelly is threaded to engage a drill string as is well known in the art. Drilling proceeds by rotating the rotary table which turns the kelly bushing to impart rotational movement to the kelly and the drill string secured thereto. The kelly passes downwardly through the kelly bushing as drilling proceeds and the bore progressively penetrates the earth.

In rotary drilling as just described, the maximum rotational speed of the well string and drill bit suspended therefrom is limited by, among other things, the power of machinery driving the rotary table. Thus it becomes apparent that if the machinery such as a draw works driving the rotary table can turn the rotary table no faster than, for example, 200 revolutions per minute, then the speed of the drill bit naturally can be no greater than 200 revolutions per minute. Besides the power limitation of the draw works or other machinery driving the rotary table, speed of the rotary is further limited as a practical matter in that prolonged high speeds cause rapid wear of rotary table bearings and frequent replacement thereof naturally is expensive.

The advent of use of drill pipe smaller in diameter than earlier conventional drill pipe has offered the economic advantage of reduced shipping costs and greater ease in transporting the pipe to remote locations. However, a drawback in the use of smaller diameter drill pipe has been that the reduced diameter does not permit transfer of torque from the rotary table to the drill bit as effectively as larger conventional drill pipe because of decreased strength due to the smaller diameter. The increase of rotary table speed has not offered a practical solution to the problem of torque transmission for the reasons previously mentioned, i.e. machinery power limitations and the rapid wearing of the rotary bearings. Thus it would be highly advantageous to provide a means for greatly increasing the speed of a drill string without increasing speed of a rotary table. The present invention provides such an advantage.

Under circumstances requiring relatively slow or low rotational speed of a drill string, effective transfer of torque from the rotary table to the drill string would be accomplished advantageously by operating the rotary or rotary table at speeds relatively greater than the speed of the drill string. Again, the present invention provides such an advantage.

SUMMARY OF THE INVENTION

The present invention provides a method and means for driving a kelly or drill string at a speed different from the speed of the rotary. In most instances, it is preferable to drive the drill string faster than the rotary and, in order to do so, a housing is adapted so as to be rotated by the rotary. An anchor ring gear is provided within the housing such that the housing rotates about such ring gear and the anchor ring gear extends below the housing and through the rotary table for anchoring to the drilling apparatus structure below the rotary table. Epicyclic or planetary gearing is provided between the anchor ring gear and the kelly, the latter passing axially of the anchor ring gear and housing. The epicyclic gearing includes at least one stage of a plurality of planet gears each journaled to the housing so as to mesh with the anchor ring gear to be rotated upon rotation of the housing. These planet gears also mesh with a sun (ring gear) concentrically spaced therewithin. Preferably, a still further stage of plurality of planet gears is provided wherein each such planet gear is journaled to the

first sun gear to again mesh with the teeth of the anchor ring gear. A second sun gear then meshes with the second stage planet gears and is rotated thereby to in turn impart rotational movement through a kelly drive bushing to the kelly. Additional stages of epicyclic gearing may be employed as may be necessary under the circumstances depending upon the sizing of all elements involved and speed requirements.

The portion of the anchor ring gear extending through the rotary table is annular in configuration and is secured to the drilling apparatus structure. Such secure connection preferably is provided with holding means so as to be releasable upon development of excessive torque between the housing and the kelly in order to avoid damage to the drill string. Torque indicating means are provided to coact with the holding means so as to govern and limit torque imparted to the kelly.

The present invention also provides a method and apparatus for rotating a kelly or drill string slower than the rotary by means similar to that just described but wherein the epicyclic gearing is arranged in a relatively different manner as will be explained.

It is, therefore, an object of the present invention to provide a method and apparatus for rotating the drill string of a drilling apparatus at a speed different than the speed of the rotary table.

Another object is to provide a device between the rotary table and kelly of a drilling apparatus where by one embodiment the kelly may be rotated at a speed greater than the speed of the rotary table and, in another embodiment, the kelly may be rotated at a speed slower than the speed of the rotary table.

Still another object is to provide a device between the rotary table and kelly of a drilling apparatus to rotate the kelly at a speed different than the speed of the rotary table by means of a housing or bushing adapted to be rotated by the rotary table which transfers rotational movement to the kelly through gearing including epicyclic gearing.

Yet a further object is to provide a bushing device for coaction with a rotary table and kelly and including a housing or drive means, and driven means including an anchor ring gear and epicyclic or planetary gearing to transfer rotational motion of the rotary table to the kelly at a speed either faster or slower than the speed of the rotary table itself.

Yet a still further object is to provide such a kelly speed bushing with holding means releasably securing the anchor ring gear to the drilling apparatus structure to release or interrupt the transmission of rotary movement from the housing or bushing to the kelly upon development of excessive or substantial torque therebetween.

Still another object of the present invention is to provide a method for rotating the kelly of a drilling apparatus at a speed different from the speed of a rotary table coacting with the drilling apparatus by the steps including mounting a bushing or housing on the rotary table, rotating the rotary, maintaining an anchor ring gear in secure relationship with the structure of the drilling apparatus, and transferring rotary motion from the bushing or housing through epicyclic gearing to the kelly.

Still other objects, features and advantages will be apparent from the following description of the presently preferred embodiments of the invention, given for the purpose of disclosure and taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

In the drawings forming a part of the disclosure herein, like character references designate like parts throughout the several views, wherein,

FIG. 1 is an elevational view in cross section illustrating an embodiment of the invention for rotating the kelly of a drilling apparatus at a speed greater than the speed of the rotary,

FIG. 2 is a partial elevational schematic view of a drilling apparatus showing the device of the present invention secured thereto,

FIG. 3 is a cross-sectional plan view taken along line 3-3 of FIG. 1 and showing a portion of the epicyclic gearing of the embodiment of the invention shown in FIG. 1,

FIG. 4 is another cross-sectional plan view taken along line 4-4 of FIG. 1 and showing further epicyclic gearing,

FIG. 5 is a partial side view of hydraulically actuated means for sensing development of torque between the kelly and the housing of the present invention,

FIG. 6 is an elevational view in cross section illustrating one form of an embodiment of the present invention for rotating the kelly of a drilling apparatus at a speed slower than the speed of the rotary of the drilling apparatus, and

FIG. 7 is a partial elevational view in cross section showing another form of an embodiment of the present invention for rotating the kelly of a drilling apparatus at a speed slower than the speed of the rotary.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is directed to embodiments of a speed bushing device for coaxial with the rotary or rotary table or a drilling apparatus whereby a noncircular tubular member known as a "kelly" may be rotated at a speed different than the speed of the rotary table. Generally speaking, the speed bushing device of the invention includes a housing for coaxial with and rotation by the rotary or rotary table, an orbit or anchor ring gear within the housing, epicyclic gearing coaxial with the housing and anchor ring gear for purposes of transmitting rotational movement from the housing to the kelly by means of a kelly drive bushing. Rotary motion may be transmitted from the housing to the kelly at a speed greater or slower than the speed of the rotary depending upon the arrangement of the epicyclic gearing relative to the housing as will be explained hereafter with respect to the several embodiments of the invention.

By way of preface to the discussion that follows, reference is first made to FIG. 2 which depicts, in a highly simplified manner, a conventional rotary drilling apparatus with which the present invention coacts for purposes of drilling, for example, an oil or gas well. In the simplified representation of FIG. 2, a derrick 10 is mounted on a platform 12. Also mounted within the platform is a rotary table 14 of the conventional type having a noncircular hole (e.g. a kelly drive square) axially thereof which receives a kelly 16. The kelly 16 likewise is noncircular in cross-sectional configuration and is conventionally rotated by a kelly bushing (not shown) which is rotated by the rotary 14. Thus, in normal drilling operations, a drill string is secured below the kelly 16 and, as the rotary table 14 is rotated by means of a draw works or other prime motive power means, the rotary in turn imparts rotational movement to the conventional kelly bushing (not shown) which imparts rotational movement to the kelly 16. As drilling proceeds, the bit on the drill string bores a hole 18 into the earth's crust. As the bore hole 18 deepens, the kelly 16 passes downwardly through the kelly bushing and rotary 14 until the bore hole 18 has been drilled a depth approximating the length of the kelly member 16. At that point, the kelly 16 is raised and further drill string is added to continue the drilling operation.

As mentioned with respect to background of the present invention, the advent of smaller diameter drill pipe has been accompanied by torque transmission problems arising due to both actual and practical rotary table speed limitations. The present invention is directed to obviating such problems through the provision of a speed bushing device represented generally by the reference numeral 20 in FIG. 2 wherein such speed bushing device occupies the position normally assumed by a conventional kelly bushing. Through epicyclic gearing, the rotational speed of the kelly 16 may be increased substantially which in turn causes the drill string attached thereto to rotate at much higher speed. As will also be explained hereafter, still further embodiments of the present invention provide a kelly speed bushing which will allow the kelly 16 to

be rotated at a speed slower than the rotational speed of the rotary 14.

Referring now to FIG. 1 which illustrates in detail the kelly speed bushing 20 as discussed with respect to FIG. 2 for rotating the kelly at a speed greater than the speed of the rotary table, the speed bushing is shown having a housing 22. The housing 22 has a downwardly extending portion 24 which is noncircular in cross section to seat within a noncircular hole (e.g. a kelly drive square) 26 in the rotary or rotary table 14. Thus, the housing 22 is adapted to be received and rotated by the rotary 14. The housing 22 is also provided with a top or cover portion 27 to complete the housing enclosure.

With reference now to FIG. 3 as well as FIG. 1, the outer peripheral wall of the housing 22 is circular in configuration. Provided concentrically within the housing 22 is an orbit or anchor ring gear 28 having teeth 30 on the interior side thereof as shown in FIG. 3. The housing 22 is rotatable about the outer surface of the ring gear 28 by means of suitable bearings 32 retained by suitable cages 34 and a collar 36. The anchor ring gear 28 has an annular portion 38 extending downwardly for attachment to the structure of the drilling apparatus as will be explained hereafter. Such downwardly extending annular portion 38 may be made integral of the anchor ring gear 28 but preferably is attached thereto in a suitable manner such as bolts 40 as illustrated in FIG. 1.

Continuing with reference to FIG. 1, a first stage plurality of planet gears 42 are each rotatably journaled in the upper portion 27 of the housing by journal pins 44 and suitable pin bushing members 46. These first stage planet gears are illustrated also in FIG. 3 wherein they are shown meshing with and within the teeth 30 of the anchor ring gear 28. It should be noted that the lower end of each journal pin 44 engages a retainer ring 48 so as to retain each planet gear 42 on its respective journal pin. As shown in both FIGS. 1 and 3, retainer blocks 50 are positioned between each of the planet gears 42 and are secured to the retainer ring 48 and upper portion of the housing 27 by any suitable means such as bolts 52. It is to be understood that each of the retainer blocks 50 is slightly longer than the first stage planet gears 42 to create a framework such that each of the planet gears 42 may rotate about its own journal pin 44.

Still with reference to FIGS. 1 and 3, a first sun gear 54 is spaced concentrically within the first stage plurality of planet gears 42 and is provided outwardly with teeth 55 (as shown in FIG. 3) which mesh with corresponding teeth 57 of the planet gears 42. As best seen in FIG. 1, the first sun gear 54 has an outwardly extending lowermost projection 56.

Rotatably journaled in the outwardly extending lowermost projection 56 of the first sun gear 54 are a second stage plurality of planet gears 58. As shown in both FIGS. 1 and 4, each of the second stage plurality of planet gears is retained by a journal pin 60 and a suitable pin bushing 62. The lower end of each journal pin 60 is secured to another retainer ring 64. As discussed with reference to FIG. 3, a plurality of retainer blocks 66 are positioned between each of the planet gears 58 in the second stage of planet gears, each such retainer block 66 being secured between the retainer ring 64 and the outwardly extending portion 56 of the first sun gear 54 by suitable means such as a bolt 68.

Again with respect to FIGS. 1 and 4 of the drawings, spaced concentrically within the second stage plurality of planet gears 58 is a second sun gear 70. As seen in FIG. 4, the second sun gear 70 has outwardly positioned teeth 72 which mesh with corresponding teeth 59 of each of the planet gears 58 in the second stage plurality of planet gears. As seen in FIG. 1 the second sun gear has an upwardly extending portion 73, the outer surface 74 of which forms a bearing surface. Positioned between the bearing surface 74 and the inwardly facing side of the first sun gear 54 are a plurality of suitable bearings 76 retained by suitable cage and collar means. Thus the first sun gear 54 is rotatably positioned about the second sun gear 70.

The inwardly facing side of the upper portion 73 of the second sun gear 70 is provided with axial splines 78 which

mesh within similar splines 80 provided on the outer surface of the upper portion of a kelly drive bushing member 82. For purposes of initial installation as will be explained hereafter, the kelly drive bushing 82 comprises two axially divided halves 82a and 82b. Together, the two halves 82a and 82b form the kelly drive bushing 82 which has a noncircular axial bore 84 to receive the noncircular kelly member 16 as explained with respect to FIG. 2. Once again with reference to FIG. 1, the kelly drive bushing 82 is of such a length that it passes substantially downwardly through the rotary table 14 as preferably does the second sun gear 70.

As is shown in FIG. 1, the second sun gear 70 is rotatable with respect to both the anchor ring gear 28 and the upper portion 27 of the housing 22. Thus, a suitable bearing 84 is positioned between the upper portion 27 of the housing 22 and the upper portion 73 of the second sun gear 70. Additionally, a suitable bearing 86 is positioned between the second sun gear 70 and the lower portion 38 of the anchor ring gear 28. Suitable sealing rings 88 likewise are provided between the moving parts just described in order to prevent leakage of oil from within the device as will be described hereafter and in order to prevent entry of dirt or other foreign particles that might interfere with operation of the device.

As stated previously, the lower portion 38 of the anchor ring gear 28 is attachable to the structure of the drilling apparatus shown in FIG. 2. As illustrated in FIG. 5, the lower extremity of the lower portion 38 of the anchor ring gear 28 is machined or otherwise provided with a noncircular configuration 90 such as a hex configuration. As shown in FIG. 1, the hex surface 90 of the anchor ring gear 28 engages a similar noncircular configuration hole or bore 91 in a first ring member 92, such first ring member 92 thus being secured against rotation relative to the anchor ring gear 28. The first ring member 92 has an outward annular projection 94 about which is engaged a second ring member 96 having an inwardly facing annular groove 98 to receive the annular projection 94 of the first ring member. Braking means as will be described are provided between the projection 94 of the first ring member and the groove 98 of the second ring member so that the first ring member is normally engaged against rotation relative to the second ring member but is releasable to permit rotation of the first ring member 92 upon development of substantial torque between the housing 22 and the kelly being rotated.

Referring to FIG. 1 for purposes of describing the brake means between the first and second ring members, suitable brakeshoe material in the form of annular rings 100 and 102 (discs may be substituted if desired) are provided between the projection 94 of the first ring member 92 and the inner walls of the groove 98 of the second ring member 96. While the brakeshoes (or discs) 100 and 102 may be positioned in any manner desirable, it is preferred that the shoe 100 be secured such as by bolting or riveting to the upper wall of the groove 98 in the second ring member while the brakeshoe 102 is secured to a "floating" ring (or disc pad) 104. At this point, it should be understood that if either of the brake members 100 or 102 take the form of annular flat rings, then only one of each may be necessary. However, if either of the brake members 100 or 102 take the form of a disc or the like, then a plurality thereof may be necessary as will become apparent. Similarly, if the brake member(s) takes the form of a disc and a plurality thereof are required, then likewise a plurality of "floating" pad members 104 will be required.

By the term "floating" with respect to the pad member 104 just described is meant that the pad member may move up or down with respect to the second ring member 96. This is accomplished preferably by the use of vertical (as viewed in FIG. 1) splines 106 on both of and between the floating pad 104 and the second ring member 96. An air-actuated diaphragm 108 is positioned against the floating pad 104 and, assuming the brake member 102 and floating pad 104 both to be of annular ring configurations, the diaphragm 108 likewise is of an annular ring configuration. The diaphragm member 108 is held by means of a cover plate 110 sealingly secured to the

second ring member 96 such as by a plurality of bolts 112. An air pressure source indicated by the arrow 114 is connected through the cover plate 110 for communication with the diaphragm member 108 as will be described hereafter with respect to operation of the device.

As further shown in FIG. 1, suitable bushing material 116 is provided between the first and second ring members so as to seal the space therebetween yet provide for rotation when necessary of the first ring member 92 with respect to the second ring member 96.

The outer peripheral portion of the second ring member 96 is adapted such as by means of a groove 117 to receive a support or third ring member 118 which is secured to the structure of the drilling apparatus as shown generally in FIG. 2. Between the support member 118 and the second ring member 96 is suitable bushing material 120 so as to provide for rotation of the second ring member relative to the support member 118 when necessary.

Rotation of the second ring member 96 with respect to the support member 118 is limited by a hydraulically actuated means which senses development of substantial torque between the housing 22 and the kelly being rotated. Such hydraulically actuated means is illustrated generally in both FIGS. 1 and 5 by the reference numeral 122. As best shown in FIG. 5, the hydraulically actuated means 122 comprises a cylinder member 124 pivotally secured to the third ring member 118. Such secure connection is preferably accomplished by means of a pin or bolt 126 passing through holes in ears 128 extending from the cylinder 124 and an upright lug 129 secured to the third ring member 118. A piston member 130 engages within the chamber 132 of the cylinder member. The rod 134 secured to the piston is pivotally secured such as by means of a bolt 136 passing through the rod 134 as well as ears 138 secured to the second ring member 96. Outward axial movement of the piston 130 within the cylinder 124 is limited by means of a stop member 140 secured to the third ring member 118 to prevent complete disengagement of the piston from within the cylinder chamber. Hydraulic fluid communicates with the chamber 132 interiorly of the cylinder 124 such as by means of an appropriate bore and nipple connection 142 in the wall of the cylinder.

The device of the present invention is assembled on the drilling apparatus (as in FIG. 2) preparatory to operation by positioning the device shown in FIG. 1 such that the noncircular portion 24 of the housing 22 engages the noncircular hole or bore 26 of the rotary 14. The kelly drive bushing 82 is removed and the kelly 16 as shown in dotted outline in FIG. 1 is passed axially through and within the second sun gear 70. Then the two halves 82a and 82b of the kelly drive bushing 82 (as shown in FIG. 3) are placed about the kelly and wedged between the kelly and second sun gear 70 to assume the position as shown in FIG. 1. A retainer cap 144 is passed over the kelly 16 and is threadably secured to the upper extremity of the upper portion 73 of the second sun gear 70 to retain the kelly drive bushing 82 within splined engagement with the second sun gear. At this point, the first ring member 92 to which is attached the second and third ring members and associated brake and hydraulically actuated means as illustrated in FIG. 1 is placed about the lower portion of the anchor ring member 38 such that the noncircular configuration 90 of the anchor ring member engages with the noncircular bore 91 within the first ring member 92. The third ring member 118 is then suitably secured such as by bolting to the structure of the drilling apparatus 12 as shown in FIG. 2. The air source 114 (FIG. 1) is then secured to the cover plate 110 associated with the air-actuated diaphragm 108 and a pressurized hydraulic fluid source is connected to the cylinder 124 by means of the piping nipple 142.

In operation, drilling by means of a rotary apparatus proceeds in the conventional manner. However, by use of the kelly speed bushing 20 as shown in FIGS. 1 and 2, the kelly 16 is rotated substantially faster than the speed of the rotary table 14 by virtue of epicyclic gearing within the kelly speed bush-

ing. The housing 22 which is seated within and rotated by the rotary 14 carries the first stage plurality of planet gears 42 in a circular orbit as these gears are journaled in the housing. Since the anchor ring gear 28 is normally maintained in a stationary position and the teeth 30 of the anchor ring gear mesh with the teeth of the planet gears, the first stage plurality of planet gears are each thus rotated about their respective journal pins 44. The first stage plurality of planet gears 42 each are also in meshing engagement with the teeth 55 of the first sun gear 54 causing the first sun gear 54 to rotate about the bearings 76.

With reference to both FIGS. 1 and 4, the second stage plurality of planet gears 58 are each rotatably journaled in the outwardly extending lowermost projection 56 of the first sun gear 54 and are thus carried in a circular orbit as are the first stage planet gears. Since the teeth of each of the planet gears of the second stage plurality of planet gears are in meshing engagement with the teeth 30 of the anchor ring gear 28, each of the planet gears 58 of the second stage plurality of planet gears also rotate about their respective journal pins 60. As the teeth of each of the second stage plurality of planet gears mesh with the teeth 72 of the second sun gear 70, the second sun gear is thus rotated about its own axis to in turn impart rotational movement to the kelly drive bushing 82 in splined engagement therewith. At the same time, the kelly drive bushing 82 imparts rotational movement to the kelly 16 since the kelly is noncircular in cross-sectional configuration and the bore 84 in the kelly drive bushing 82 is noncircular in configuration.

To illustrate the utility of the device as shown in FIG. 1 for rotating the kelly faster than the rotary 14, and continuing with respect to operation of the device as shown in FIGS. 1—4, assume that there are a total of 70 teeth 30 on the anchor ring gear 28 and each of such teeth extend the length of the outer portion of the anchor ring gear 28, i.e. engage the planet gears of both the first and second stages of planet gears. Assume also that each of the planet gears in both the first and second stages 42 and 58 respectively of the planet gears have 14 teeth and that the first and second sun gears 54 and 70 respectively each have 42 teeth. The speedup ratio in the first stage is determined by dividing the number of teeth on the orbit or anchor ring gear by the number of teeth on the first sun gear and adding one which equals a 2.66 speedup ratio in the first stage. Since the number of teeth involved in the second stage is identical, there is also a 2.66 speedup ratio in the second stage and the total speedup ratio for both stages is 2.66 times 2.66 which equals about 7.08 total speedup ratio. With respect to the example just discussed, this means that the kelly 16 driven by the kelly drive bushing 82 will rotate about seven times faster than the rotary 14 so that if the rotary 14 revolves at 200 revolutions per minute, the kelly will revolve at about 1400 revolutions per minute.

Further stages may be added to the epicyclic gear train by adding further pairs of planetary gear stages and sun gears. As will be recognized however, there may be a practical limitation on the number of stages in the epicyclic gearing depending on the space available in the epicyclic gear train and the relative strength and balance of the overall assemblage.

It is important that the epicyclic gear train within the kelly speed bushing 20 as shown in FIG. 1 be lubricated properly to ensure smooth operation and reduce friction losses among the moving parts. For these reasons, a suitable lubricant should be added to the housing preferably to a level approximating a height as indicated by location of the weep hole 150 in the wall of the anchor ring gear 28. Thus the lubricant may pass through the hole 150 and lubricate the bearings 32 between the anchor ring gear 28 and the housing 22. At the same time, the lubricant coats each of the planet gears 58 in the second stage plurality of planet gears and thus coats the teeth 30 of the anchor ring gear 28 as well as the teeth 72 of the second sun gear 70 as shown in FIG. 4. In order that the lubricant may also contact the planet gears of the first stage, one or more of the retainer blocks between two planet gears 58 in the second stage plurality of planet gears is eccentrically shaped and mounted as represented by the reference numeral 152 in FIG.

4. The effect of such eccentric block is to create a pump action as the eccentric retainer block 152 acts to confine oil in the space between the gear teeth until this space is filled by a meshing tooth and the oil is forced upward through the passage 154 (FIG. 1) for distribution to the working parts. Suitable lubricant passages are provided in each of the parts as shown in FIG. 1 but not specifically identified by reference numerals.

As mentioned previously, during operation of the kelly speed bushing 20 of the present invention, the anchor ring gear 28 as best viewed in FIG. 1 is normally maintained in a stationary position, being held against rotation by the support ring 118 which is fastened to the structure of the drilling apparatus as discussed with reference to FIG. 2. In order to maintain the anchor ring gear 28 in such a stationary manner, air pressure is exerted against the diaphragm 108 as shown in FIG. 1 and the diaphragm 108 in turn is forced against the ring pad 104. In turn, the brakeshoe member 102 is forced against the outward projection 94 of the first ring member 92 which contacts the brakeshoe member 100. In this connection, it will be noted that the first ring member 92 is slidable axially to at least a limited extent in order that the braking action as just described may occur. As long as sufficient air pressure is exerted against the diaphragm 108 to maintain the outer projection 94 of the first ring member 92 securely engaged between the brakeshoe members 100 and 102, then the anchor ring gear member 28 will be held stationary due to the noncircular configuration 90 of the lower extremity 38 of the anchor ring gear 28. While the second ring member 96 is rotatable with respect to the third ring member 118, such rotational movement is limited to a matter of a few degrees only by virtue of limited movement of the piston-cylinder means 122 as will be described hereafter.

Thus, during drilling operations, if the drill bit depending from the well string or if the well string itself should seize or bind for any reason and cause excessive torque to build up between the rotary 14 and the kelly 16, the possibility exists that continued exertion of torque on the well string by the rotary 14 will cause the drill string to twist, break or otherwise become damaged. In order to avoid any such possible damage, the air pressure that is exerted against the diaphragm 108 is regulated such that upon development of excessive torque as described, the brake means will slip and/or the air pressure will be reduced or shut off completely thereby releasing the outer projection 94 of the first ring member 92 from engagement by the brakeshoe members 100 and 102. The first ring member is thus allowed to rotate freely likewise permitting the anchor ring gear member 28 to rotate freely. Under these circumstances, the housing will continue to rotate each of the planet gears of the first stage plurality of planet gears in their orbit but the planet gears will not rotate the first sun gear due to inertia presented by the kelly 16, kelly drive bushing 82, second sun gear 70 and the second stage plurality of planet gears 58. In other words, clutch or torque release effect is thus accomplished. Then, once the difficulty encountered by the drill bit or drill string is overcome and drilling is to be continued, air pressure may once again be exerted on the disc 108 to force the brake shoes 100 and 102 against the outward projection 94 of the first ring member 92 again causing the anchor ring member 28 to be placed in the stationary position such that the gear train may resume rotation of the kelly drive bushing 82 and the kelly therein. The hydraulic braking and torque sensing apparatus as herein described are one means to accomplish the braking and slipping functions of the first ring member 92. It will become apparent that this same function may be accomplished with a suitable magnetic brake and surface electrical indicating means.

As shown in FIGS. 1 and 5, the development of torque between the rotary table and the kelly or drill string is sensed by means of the hydraulically actuated torque sensing means 122. Hydraulic fluid of a suitable type is placed in the cylinder chamber 132 as shown in dotted outline in FIG. 5 and communicates with a hydraulic fluid source by means of the nipple

142 and appropriate piping and hydraulic fluid apparatus not shown. The hydraulic fluid is pressurized thus forcing the piston 130 outward and, if it strikes the piston stop 140, the fluid pressure is reduced to allow the piston 130 to reach an equilibrium point such that it may travel in either direction in the chamber of the cylinder 124. The equilibrium position and pressure of the hydraulic fluid required to maintain such equilibrium piston position are established while the kelly speed bushing 20 is rotating the kelly under normal torque conditions experienced in drilling operations. When excessive torque is encountered between the rotary 14 and the kelly 16, the kelly drive bushing 82 will tend to become inert as will each of the planet gear stages and the sun gears. Under these conditions, continued rotational force applied by the rotary 14 to the housing 22 causes the inert epicyclic gearing to impart torque to the anchor ring gear 28 such that the tendency of the torque is to rotate the anchor ring gear which is maintained in the stationary position by the brake means associated with the first and second ring members 92 and 96 respectively as shown in FIG. 1. Thus the inertia and torque working against that inertia is passed from the anchor ring gear 28 to the first ring member 92, and then to the second ring member 96 by means of the brakeshoes 100 and 102 acting against the projection 94 of the first ring member. Since the second ring member 96 is held against rotation by virtue of the cylinder-piston connection 122 with the third ring member 118, torque between the second ring member 96 and third ring member 118 (the third ring member being securely connected to the structure of the drilling apparatus) passes from the second ring member to the third ring member via the hydraulic fluid between the piston 130 and the cylinder 124. As long as drilling proceeds in a normal manner, the pressure of the hydraulic fluid in the cylinder 124 will vary according to the torque being delivered to the kelly. However, when excess torque between the kelly and the rotary 14 builds up as just discussed, the piston 130 will tend to compress fluid within the chamber 124 thereby causing pressure of the hydraulic fluid to increase. This pressure may be noted by a pressure gauge or may be continually sensed and used to regulate air loading against the diaphragm 108. In like manner the pressure thus indicated may be used to activate weight regulating means to lessen the load on the drill and reduce torque requirement. In other words, the hydraulic fluid system of the cylinder-piston means 122 may be interconnected as will be appreciated by those skilled in the art with the controls of the pressurized air system coacting with the diaphragm 108 such that upon buildup to a given level of hydraulic pressure communicating with the cylinder 124 air pressure against the diaphragm 108 will be dumped. This releases the first ring member permitting the anchor ring gear 28 to rotate freely with the housing 22 and the rotary table 14. Such "given point" of buildup of hydraulic fluid pressure can be determined as will become apparent to those skilled in the art as a point such that torque imparted by the rotary table to the kelly does not become so excessive as to twist, break or otherwise damage the drill string attached to the kelly.

Turning to the discussion now to FIGS. 6 and 7, there are circumstances wherein it may be desirable to rotate a drill string at a speed slower than the rotary. This may be true of operations in the course of drilling oil and gas wells as well as in situations wherein much larger bores are drilled to penetrate the earth. Thus the discussion that follows is directed to any situation wherein a bore is drilled into the earth by rotary means of any type. Therefore, it will be understood that the rotary 14 as discussed with respect to FIGS. 1-5 will again be referred to as a rotary 14 in FIGS. 6 and 7 although the rotary may be of any configuration whether or not similar to that shown in the drawings.

With respect first to the embodiment of the present invention illustrated in FIG. 6, the general arrangement of parts and elements is similar to those discussed with reference to FIGS. 1 through 5 except for the arrangement of the epicyclic gearing. Thus, the kelly drive bushing illustrated in FIG. 6 will be

referred to generally by the reference numeral 200 and further reference numerals will be used to describe only those elements differing in function or arrangement as compared with the embodiment illustrated in FIGS. 1 through 5.

Proceeding with reference to FIG. 6, the housing 202 is received for rotation by the rotary 14. The housing is provided with an upper or cover portion 204 which has a downwardly extending portion 206 forming an outwardly toothed sun gear between the anchor ring gear 208 and the kelly 16 within the kelly drive bushing 82. Teeth on the first sun gear 206 are indicated by the reference numeral 212 and mesh with teeth of the planet gears of the first stage planet gears 214. Each of the planet gears 214 is journaled by a journal pin 216 at its upper end with a retainer ring 218 and at its lower end in an outwardly extending portion 220 of the second sun gear 222.

The teeth 224 of the second sun gear are in meshing engagement with the teeth of each of the planet gears 226 of the second stage plurality of planet gears likewise journaled by journal pins 228 to a retainer ring 230 at the upper end and to an outwardly extending portion 232 of a sleeve member 234 at the other end. Suitable bearings 236 are provided between the upper extremity of the sleeve member and the upper portion 204 of the housing. Likewise, suitable bearings 238 are provided between the outwardly toothed first sun gear 206 and the sleeve member 234 and between the second sun gear 222 and the sleeve member 234.

Generally speaking, other than the epicyclic gearing arrangement just discussed, functioning of the embodiment of the invention illustrated in FIG. 6 is similar to that of the embodiment illustrated in FIGS. 1-5. Thus, in operation, the rotary 14 rotates the housing 202. The first sun gear 206 of the housing imparts rotational movement to each of the planet gears 214 of the first stage plurality of planet gears which thus rotate about their respective journal pins 216 and at the same time mesh with teeth 207 of the anchor ring gear 208. Consequently, the planet gears 214 travel in a circular orbit thereby causing the second sun gear 222 to rotate. The teeth 224 of the second sun gear are in meshing engagement with the teeth of the planet gears 226 of the second stage plurality of planet gears thus causing each of the planet gears 226 to rotate about their respective journal pins 228. Again, the teeth of the planet gears 226 mesh with teeth of the ring gear 208 thus causing the second stage plurality of planet gears 226 to revolve in a circular orbit thereby imparting rotational movement to the sleeve member 234.

In contrast with the first embodiment of the present invention illustrated in FIGS. 1 through 5, operation of the embodiment of the invention illustrated in FIG. 6 causes the sleeve member 234 to rotate at a speed slower than the speed of the rotary 14. As in the first embodiment, if it is assumed that the anchor ring gear 208 has 70 teeth, each of the planet gears in the first and second stages has 14 teeth and each of the first and second sun gears has 42 teeth, then the sleeve member 234 will rotate at a speed approximately one seventh the speed of the rotary 14. In other words, if the rotary revolves at 200 revolutions per minute, the sleeve member 234, kelly drive bushing 82 and the kelly 16 will each revolve at approximately 28.6 revolutions per minute.

FIG. 7 schematically illustrates a still further embodiment of the present invention wherein the anchor ring gear that is normally held in a stationary position is secured to the structure of the drilling apparatus above the upper plane of the rotary table rather than passing through the rotary table for attachment to the drilling structure therebelow. While it will be appreciated that the epicyclic gearing may be arranged so that the kelly or drill string may be rotated either faster or slower than the rotary, FIG. 7 illustrates the embodiment of the present invention wherein the epicyclic gearing is arranged so that the drill string may be rotated slower than the rotary.

Referring now to FIG. 7, again the rotary or rotary table is designated by the reference numeral 14. Secured to the drilling structure above the rotary table is the anchor ring gear member 300 having teeth 302. The housing 304 is rotatably

spaced about the ring gear 300 by means of suitable bearings 306, the housing having an inner downwardly extending portion 308 with axial splines 310 engaging similar splines of a kelly drive bushing 312. Journaled within the housing 304 are a second stage plurality of planet gears 314, the teeth of which mesh with the teeth 302 of the anchor ring gear 300 as well as the teeth 316 of the second sun gear 318. The second sun gear 318 has an outwardly extending portion 320 to which are journaled a first stage plurality of planet gears 322, the teeth of which also engage the teeth 302 of the anchor ring gear 300 as well as the teeth 324 of the first sun gear 326.

The first sun gear 326 has a downwardly extending portion 328, the outer periphery 330 of which is noncircular in configuration so as to seat within and be engaged by a corresponding noncircular kelly drive hole within the rotary 14.

With respect to operation of the embodiment illustrated in FIG. 7, the anchor ring gear 300 is secured to the drilling apparatus structure and the lower portion 328 of the first sun gear 326 is seated within the rotary table. The rotary 14 is rotated to in turn impart rotation to each of the planet gears of the first stage plurality of planet gears. The planet gears 322 thus rotate about their own axis and also revolve in a circular orbit by virtue of the engagement of the teeth thereof with the teeth 302 of the anchor ring gear member 300. Thus the second sun gear 318 is rotated and the teeth 316 thereof engaging with the teeth of the planet gears 314 of the second stage plurality of planet gears cause each of the planet gears 314 to rotate about their own axis. Again, by virtue of engagement of the teeth of the planet gears 314 with the teeth 302 of the anchor ring gear 300, the second stage plurality of planet gears 314 revolve in a circular orbit thus causing the housing 304 to rotate about the anchor ring gear 300. This rotational movement is imparted to the kelly drive bushing 312 to in turn rotate the kelly at a speed slower than the speed of the rotary 14.

Thus provided by the present invention are embodiments of a kelly speed bushing uniquely useful for transmitting rotary motion from a rotary member to a drill string whereby the drill string is rotated at a speed different than the speed of the rotary. Through the provision of one or more stages of epicyclic gearing within the kelly speed bushing, the drill string may be rotated either substantially faster than or substantially slower than the rotary depending upon arrangement of the epicyclic gearing. It will be appreciated by those skilled in the art that the size and precise arrangement of the various parts and elements of the embodiments may be varied depending upon various factors such as speed and torque requirements, strength of structural parts, size of rotary, size of the kelly and drill string and the like.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein. While a presently preferred embodiment of the invention has been given for the purpose of disclosure, numerous changes in the detail of construction and the combination, shape, size and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What I claim is:

1. A bushing device for coaction with the rotary of a drilling apparatus having a kelly, said bushing device comprising,
 - a. a housing spaced about the kelly and adapted to be received and rotated by the rotary,
 - b. an anchor ring gear within the housing and having an extended portion for attachment to the drilling apparatus, and
 - c. means within the housing coacting with the anchor ring gear and housing for transmitting rotary motion from the housing to the kelly at a speed different than the speed of the rotary.
2. The bushing device of claim 1 wherein, more particularly, the means (c) comprises,
 - a first stage plurality of planet gears each rotatably journaled in the housing and meshing with and within the anchor ring gear, and
 - a first sun gear within and meshing with the planet gears.

3. The bushing device of claim 2 including additionally,
 - a second stage plurality of planet gears each rotatably journaled to the first sun gear and meshing with the anchor ring gear,
 - a second sun gear within and meshing with the second stage plurality of planet gears, and
 - a kelly drive bushing member within and in engagement with the second sun gear.
4. The bushing device of claim 3 including at least a further stage of a plurality of planet gears and a sun gear between the second sun gear and the kelly drive bushing member wherein said kelly drive bushing member is within and in engagement with the last stage sun gear.
5. The bushing device of claim 1 including, additionally, means engaged with the extended portion of the anchor ring gear for securably attaching said anchor ring gear to the drilling apparatus but releasable upon development of substantial torque between the housing and the kelly.
6. The bushing device of claim 5 wherein more particularly the means engaged with the extended portion of the anchor ring gear comprises,
 - a. an outwardly projecting ring member connected about the extension of the anchor ring gear, and
 - b. pressure-responsive, releasable brake means engageable with the ring member for normally holding the ring member against rotation.
7. The bushing device of claim 1 wherein the housing,
 - a. includes a downwardly extending portion forming an outwardly toothed sun gear between the anchor ring gear,
 - b. and the kelly and wherein, more particularly, the means,
 - c. comprises, a first stage plurality of planet gears each in meshing engagement between and with the sun gear and the anchor ring gear.
8. The bushing device of claim 7 including, additionally,
 - a second sun gear to which is rotatably journaled each of the planet gears of the first stage plurality of planet gears,
 - a second stage plurality of planet gears each in meshing engagement between and with the anchor ring gear and the second sun gear,
 - a sleeve member to which is rotatably journaled each of the planet gears of the second stage plurality of planet gears, and
 - a kelly drive bushing member within and in engagement with the sleeve member.
9. The bushing device of claim 8 including at least a further stage of a plurality of planet gears and a sun gear between the second sun gear and the sleeve member wherein said sleeve member is within and in rotatable engagement with the last stage plurality of planet gears and engages the kelly drive bushing member.
10. A bushing device for coaction with the rotary table of a drilling apparatus having a kelly, said bushing device comprising,
 - a. a housing spaced about the kelly and adapted to be received and rotated by the rotary table,
 - b. an anchor ring gear within and adjacent the housing such that the housing is rotatable about the anchor ring gear, the anchor ring gear having an annular portion extending downwardly through the rotary table for attachment to the structure of the drilling apparatus, and
 - c. means between the anchor ring gear and the kelly for transmitting rotary motion from the housing to the kelly at a speed greater than the speed of the rotary table.
11. The device of claim 10 wherein more particularly the means (c) comprises,
 - a. a first stage plurality of planet gears each rotatably journaled to the upper portion of the housing within the anchor ring gear and meshing with the anchor ring gear,
 - b. a first sun gear spaced concentrically within the first stage plurality of planet gears and meshing with the planet gears, said first sun gear having an outwardly extending lowermost projection,
 - c. a second stage plurality of planet gears each rotatably journaled in the outwardly extending lowermost projection

- tion of the first sun gear and meshing with the anchor ring gear,
- d. a second sun gear spaced concentrically within and meshing with the second stage plurality of planet gears and having an upwardly extending outer bearing surface portion rotatably supporting the first sun gear, the inwardly facing side of which portion is splined axially, and
- e. a kelly drive bushing member axially splined outwardly and concentrically engaged within the splines of the second sun gear.
12. The device of claim 10, including, additionally, means engaged with the downwardly extending portion of the anchor ring gear for securably attaching said anchor ring gear to the drilling apparatus structure but releasable upon development of substantial torque between the housing and the kelly.
13. The device of claim 12, wherein, more particularly, the means engaged with the downwardly extending portion of the anchor ring gear comprises,
- a first ring member engaging about the lower periphery of the downwardly extending portion of the anchor ring gear, said first ring member being secured against rotation relative to the anchor ring gear,
- a second ring member engaging about the first ring member, said second ring member being securely attachable to the drilling apparatus structure, and
- brake means between the first ring member and the second ring member for normally engaging the first ring member against rotation relative to the second ring member but releasable to permit rotation of the first ring member upon development of substantial torque between the housing and the kelly.
14. The device of claim 12 wherein, more particularly, the means engaged with the downwardly extending portion of the anchor ring gear comprises,
- a first ring member engaging about the lower periphery of the downwardly extending portion of the anchor ring gear and having an outward annular projection, said first ring member being secured against rotation relative to the anchor ring gear,
- a second ring member engaging about the first ring member and having an inwardly facing annular groove to receive the annular projection of the first ring member,
- brake means between the projection of the first ring member and the groove of the second ring member for normally engaging the first ring member against rotation relative to the second ring member but releasable to permit rotation of the first ring member upon development of substantial torque between the housing and the kelly, and
- hydraulically actuated means securing the second ring member to the drilling apparatus structure for sensing development of substantial torque between the housing and the kelly.
15. The device of claim 14 wherein, more particularly, the hydraulically actuated means comprises,
- a third ring member rotatably mounted about the second ring member and secured to the drilling apparatus structure,
- a cylinder member pivotally secured to the third ring member,
- a piston member pivotally secured to the second ring member for slidable engagement within the cylinder member,
- means secured to the third ring member for preventing disengagement of the piston member from the cylinder member, and
- pressurized hydraulic fluid communicating with the interior of the cylinder member and piston member.
16. A bushing device for coaction with the rotary table of a drilling apparatus having a kelly passing axially through the rotary table, said bushing device comprising,
- a. a housing spaced about the kelly and adapted to be received and rotated by the rotary table,

- b. an anchor ring gear within and adjacent the housing such that the housing is rotatable about the anchor ring gear, the anchor ring gear having an annular portion extending downwardly through the rotary table between the rotary table and the kelly for attachment to the structure of the drilling apparatus,
- c. means between the anchor ring gear and the kelly for transmitting rotary motion from the housing to the kelly at a speed greater than the speed of the rotary table, said means including,
- i. a first stage plurality of planet gears each rotatably journaled to the upper portion of the housing, within the anchor ring gear and meshing with the anchor ring gear,
- ii. a first sun gear spaced concentrically within the first stage plurality of planet gears and meshing with the planet gears, said first sun gear having an outwardly extending lowermost projection,
- iii. a second stage plurality of planet gears each rotatably journaled in the outwardly extending lowermost projection of the first sun gear and meshing with the anchor ring gear,
- iv. a second sun gear spaced concentrically within and meshing with the second stage plurality of planet gears and having an upwardly extending outer bearing surface portion rotatably supporting the first sun gear, the inwardly facing side of which portion is splined axially, and
- v. a kelly drive bushing member axially splined outwardly and concentrically engaged within the splines of the second sun gear, and
- d. means engaged with the downwardly extending portion of the anchor ring gear for securably attaching said anchor ring gear to the drilling apparatus structure but being releasable upon development of substantial torque between the housing and the kelly, said means including
- i. a first ring gear engaging about the lower periphery of the downwardly extending portion of the anchor ring gear, said first ring member being secured against rotation relative to the anchor ring gear,
- ii. a second ring member engaging about the first ring member, said second ring member being securely attachable to the drilling apparatus structure, and
- iii. holddown means between the first ring member and the second ring member for normally engaging the first ring member against rotation relative to the second ring member but releasable to permit rotation of the first ring member upon development of substantial torque between the housing and the kelly.
17. A bushing device for coaction with the rotary of a drilling apparatus having a kelly, said bushing device comprising,
- a. a housing engageable about the kelly,
- b. an anchor ring gear concentrically positioned within the housing and about which the housing may be rotated, said anchor ring gear having an extension from the housing for attachment to the drilling apparatus, and
- c. means within the housing coacting with the anchor ring gear and housing for transmitting rotary motion from the rotary to the housing at a speed slower than the speed of the rotary.
18. The bushing device of claim 17 wherein more particularly, the means (c) comprises,
- a plurality of planet gears each rotatably journaled in the housing and meshing with and within the anchor ring gear, and
- a sun gear within and meshing with the planet gears, said sun gear having a downwardly extending portion engageable with the rotary table to be rotated thereby.
19. The bushing device of claim 17 wherein, more particularly, the means (c) comprises,
- a second stage plurality of planet gears each rotatably journaled in the housing and meshing with and within the anchor ring gear,

a second sun gear within and meshing with the second stage plurality of planet gears,

a first stage plurality of planet gears each rotatably journaled to the second sun gear and meshing with the anchor ring gear, and

a first sun gear within and meshing with the first stage plurality of planet gears, said first sun gear having a downwardly extending portion engageable with the rotary table to be rotated thereby.

20. The method of rotating a drill string at a speed different than the speed of the rotary table turning a kelly to which the well string is connected, comprising the steps of,

a. supporting a bushing on the rotary table,

b. rotating the rotary table to in turn rotate the bushing,

c. maintaining an anchor ring gear member stationary within the rotating bushing, and

d. transmitting rotary motion from the bushing to the kelly through gearing between the anchor ring gear member and the kelly.

21. The method of claim 20 wherein, more particularly, the drill string is rotated at a speed greater than the speed of the

rotary table.

22. The method of claim 20 wherein, more particularly, the drill string is rotated at a speed slower than the speed of the rotary table.

23. The method of rotating a drill string at a speed different than the speed of the rotary table turning a kelly to which the well string is connected, comprising the steps of,

a. supporting a bushing on the rotary table,

b. rotating the rotary table to in turn rotate the bushing,

c. maintaining an anchor ring gear member stationary within the rotating bushing, and

d. transmitting rotary motion from the bushing to the kelly through epicyclic gearing between the anchor ring gear member and the kelly.

24. The method of claim 23 wherein, more particularly, the drill string is rotated at a speed greater than the speed of the rotary table.

25. The method of claim 25 wherein, more particularly, the drill string is rotated at a speed slower than the speed of the rotary table.

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