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[54] **POWER SWIVEL FOR USE WITH CONCENTRIC PIPE STRINGS**
10 Claims, 7 Drawing Figs.

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173/163, 175/171, 175/173

[51] Int. Cl. **F21b 3/02**

[50] Field of Search **173/57,**
163, 164; 175/173, 258

[56]

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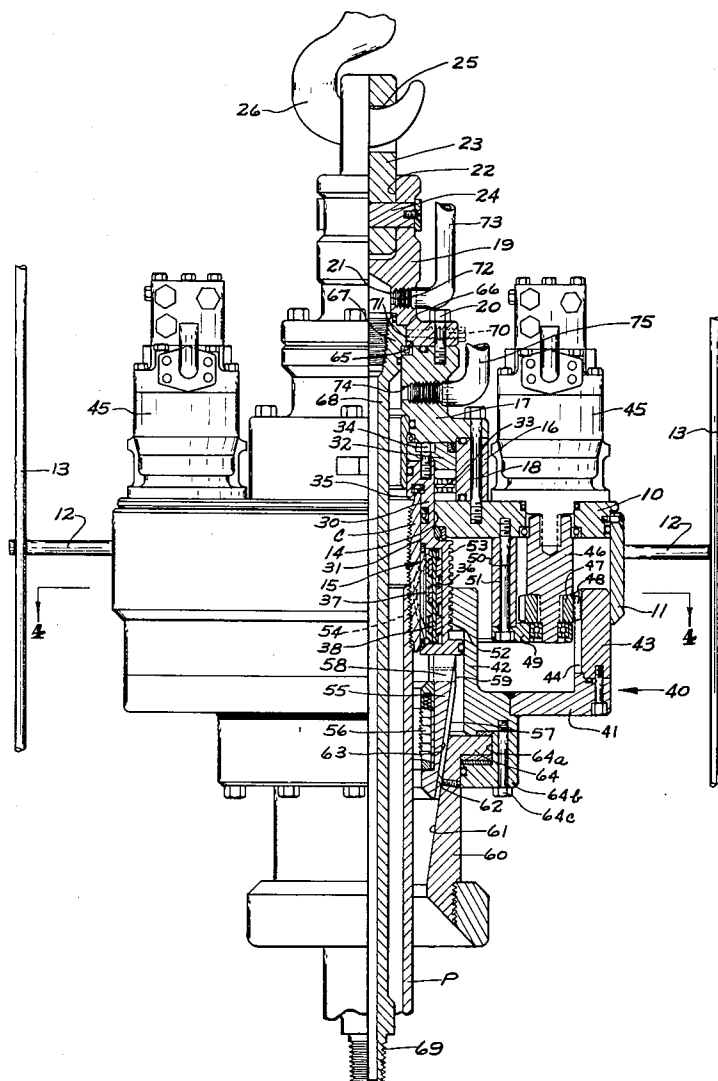
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ABSTRACT: A power swivel for use with concentric drill pipe strings to enable rotation of an outer pipe string while operatively connected to a stationary inner pipe string for supplying power fluid to a turbine drill carried by the inner string.



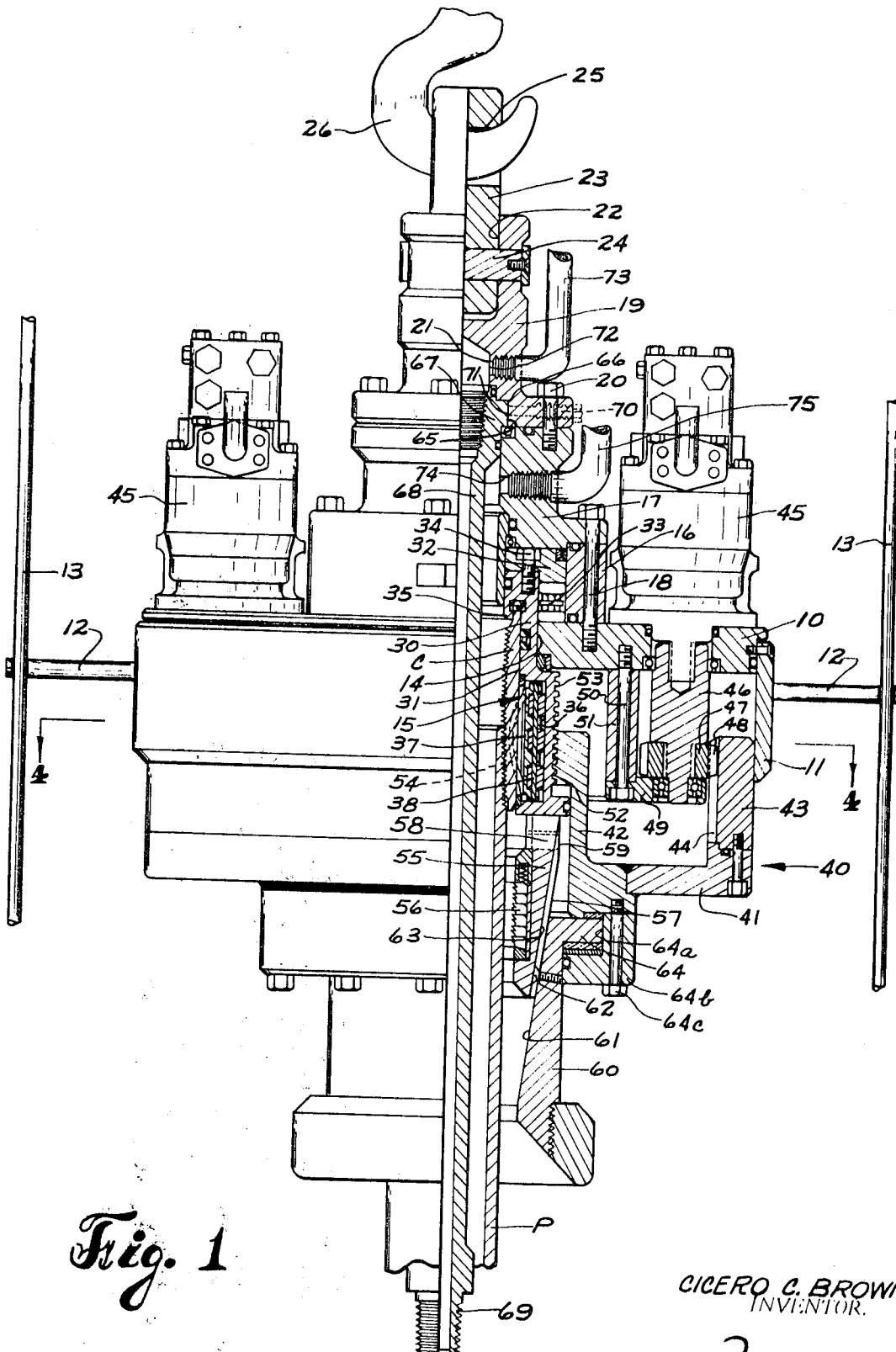


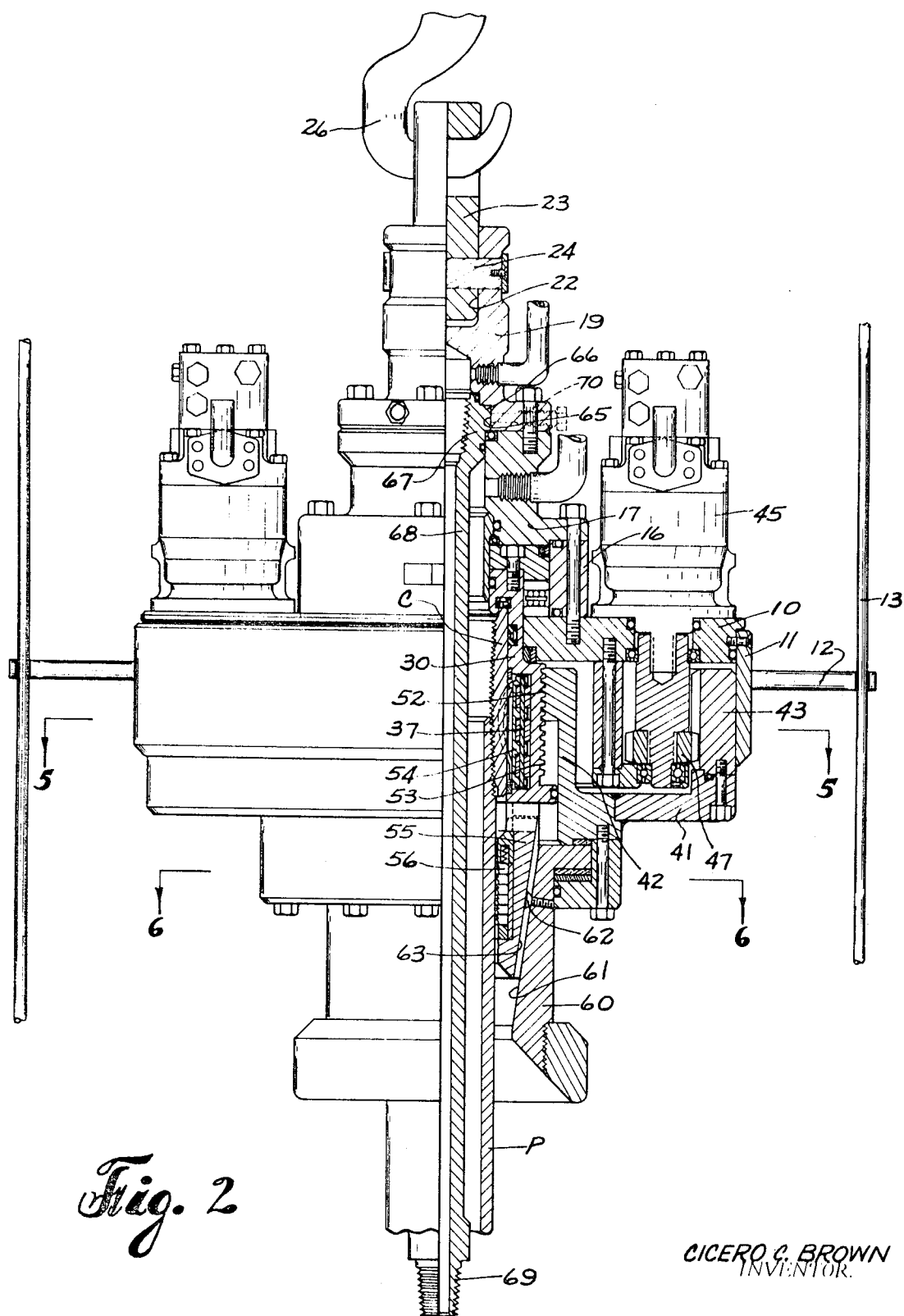
Fig. 1

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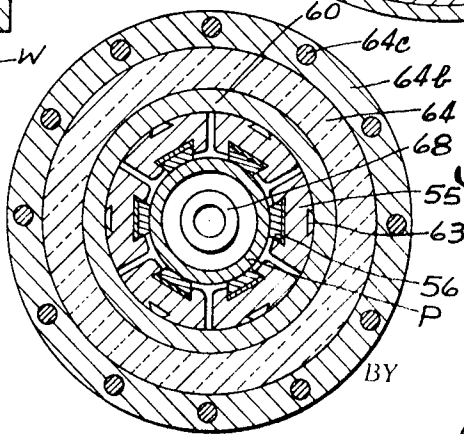
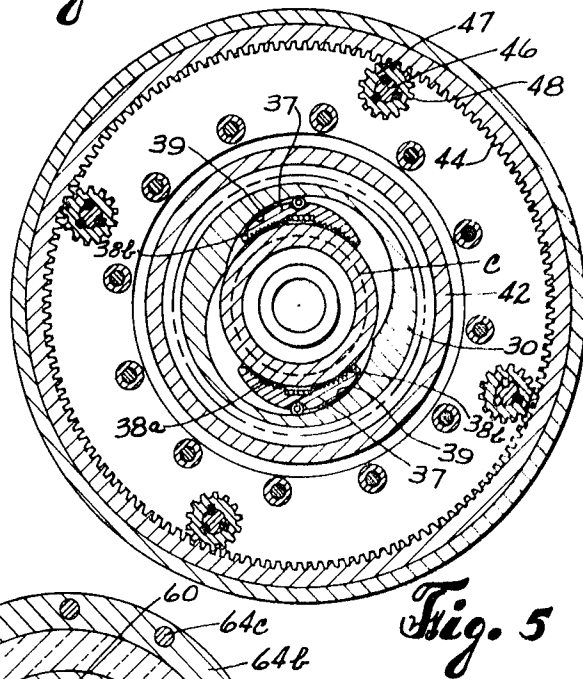
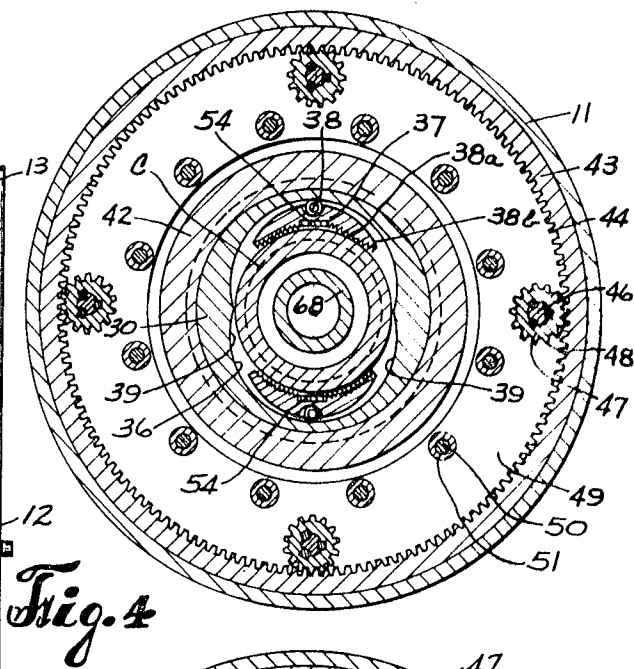
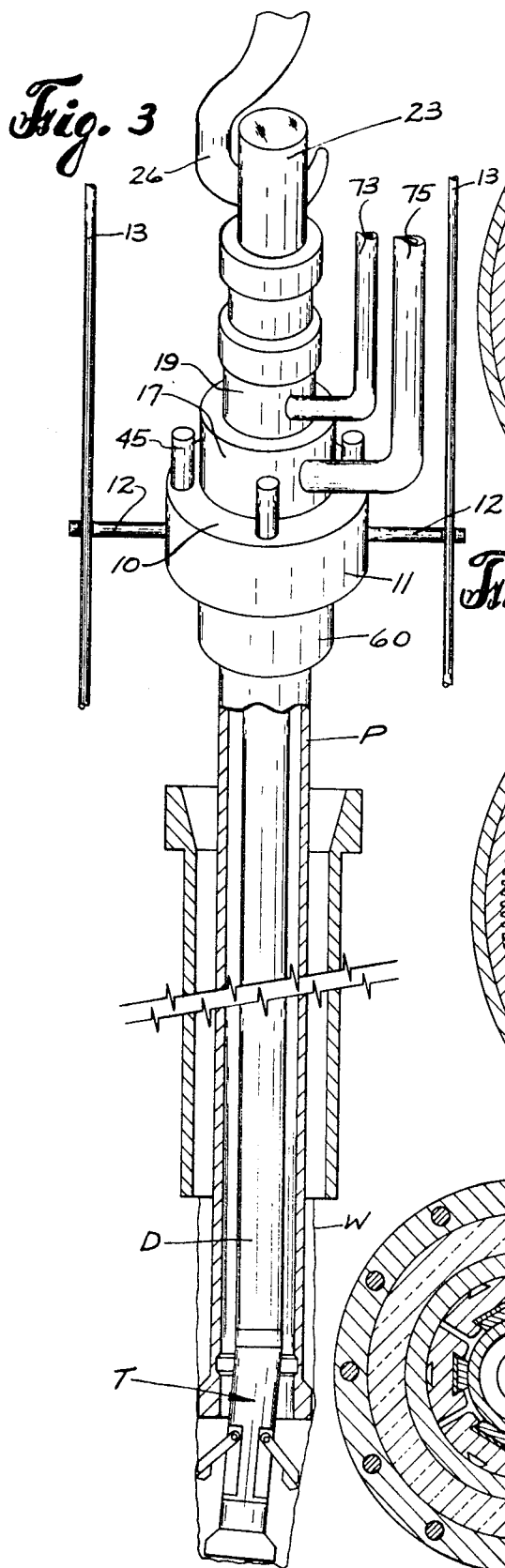
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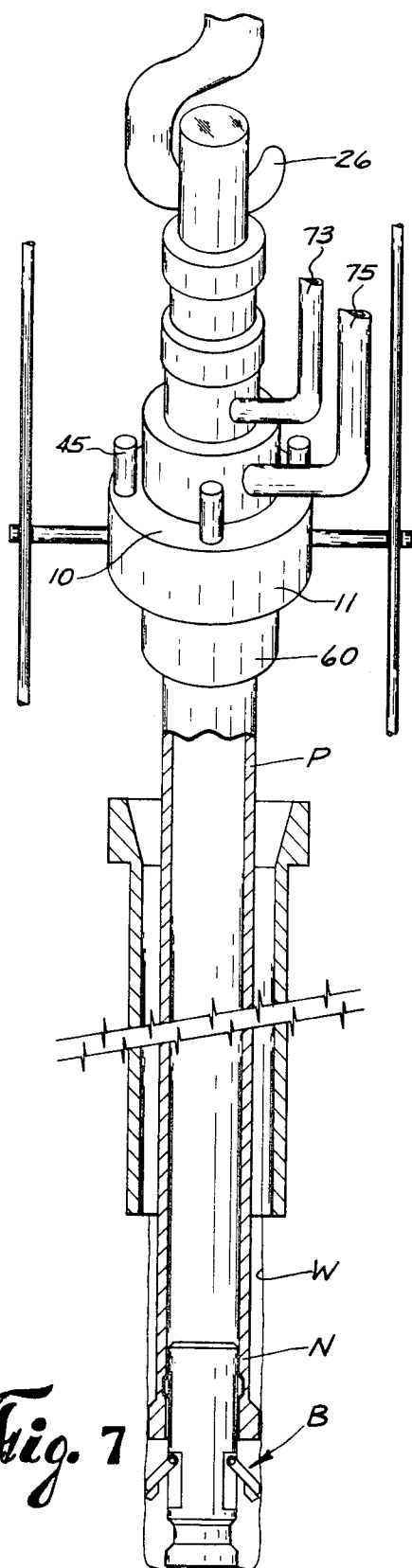


Fig. 7

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POWER SWIVEL FOR USE WITH CONCENTRIC PIPE STRINGS

BACKGROUND OF THE INVENTION

In my U.S. Pat. No. 3,467,202, a hydraulically driven power head or swivel is disclosed for rotating a conventional rotary drill string. In my copending U.S. Pat. application Ser. No. 778,509, filed Nov. 25, 1968, there is disclosed a rotary drilling system employing casing as the drill pipe string and driven by a power swivel such as that disclosed in the aforementioned patent, the casing being equipped to receive a bit section which is bodily insertable and removable through the bore of the casing.

While the casing-drilling system described in the aforementioned application is entirely successful, it is sometimes necessary to deviate the borehole from the vertical in order to accomplish slant drilling, as when drilling a plurality of wells from a single location such as an offshore platform. It is difficult to accomplish the desired deviation when using casing as the drill pipe and the present invention is directed to a novel form of power swivel designed to meet this problem.

THE INVENTION

In accordance with this invention there is provided a power swivel which is capable of rotating the casing drill string while also being operatively connected to a stationary drill string, of smaller diameter than the casing string, which extends through the bore of the casing string and is fitted with a turbine drill at its lower end to which operating fluid may be supplied through the power swivel.

With such a turbine drill string, it becomes possible to use the latter either to drill straight ahead or to deviate the bore hole, while at same time rotating the casing string to prevent sticking while drilling ahead with the turbine drill.

In accordance with the illustrative embodiment of this invention, the power swivel comprises a stationary headplate provided with a central opening to receive a hollow spindle to be secured over the upper end of the outer casing string. Surrounding the spindle below the headplate is a drive ring mounted for axial and rotational movement relative to the spindle. Motor means, which may be hydraulic or electric-powered, are mounted on the headplate for reversibly driving the drive ring. The latter is connected to the spindle by means of a threaded connection which permits limited axial movement relative to the spindle while transmitting rotational force to the spindle. The latter has pivoted elements mounted in the bore thereof for transmitting torsional force to the casing string in response to angular movement of the spindle.

Pipe gripping elements are mounted to the spindle below the torsion-transmitting elements and are actuated by the axial movement of a slip bowl mounted to the drive ring to grip and release the casing string.

The headplate of the power swivel carries hanger means mounted above the spindle for nonrotatably securing thereto a second smaller diameter pipe string which extends through the bore of the spindle and the casing string. The second pipe string may be connected to a turbine drill for deviating the bore hole or for drilling ahead of the casing string.

The power swivel is provided with appropriate conduits for transmitting power fluid to the turbine drill and for circulating drilling and wash fluid through the pipe strings as may be required.

The foregoing and other objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIG. 1 is a view partly in elevation and partly in vertical section of the improved power swivel, the drive connections to the casing string being shown in retracted or disengaged positions;

FIG. 2 is a view similar to FIG. 1 showing the drive connection in engaged positions;

FIG. 3 is a perspective view, partly in section showing a turbine drill string in borehole deviating position;

FIG. 4 is a cross-sectional view taken on line 4—4 of FIG. 1;

FIGS. 5 and 6 are cross-sectional views taken respectively on lines 5—5 and 6—6 of FIG. 2; and

FIG. 7 is a view generally similar to FIG. 3 showing the casing string in operation as the drill string in the absence of the inner turbine drill string. Referring to the drawing:

The power swivel comprises an annular headplate 10 to the periphery of which is secured a skirt 11. Spider arms 12 attached to skirt 11 secure the headplate to appropriate vertical guide bars 13 mounted in the derrick or like structure to hold headplate 10 stationary against rotational forces. Headplate 10 has a central opening 14 to rotatably receive a tubular spindle designated generally by the numeral 15. A spacer ring 16 is mounted on the top of headplate 10 concentric with opening 14 and radially spaced therefrom. A tabular hanger body 17 is mounted on spacer ring 16 and secured to headplate 19 by means of bolts 18 which pass through the flange of body 17 and spacer ring 16 into the headplate. A cap 19 is secured to the upper end of hanger body 18 by means of bolts 20 and has an axial bore 21 closed at its upper end above which the cap is provided with a socket 22 to receive an eyebolt 23 which is secured in socket 22 by a crosspin 24. Eyebolt 23 has an eye 25 to receive the hook 26 carried by the usual traveling block (not shown) of a conventional drilling rig, by means of which the power swivel and its attached pipe strings may be raised, lowered and otherwise manipulated as may be required.

Spindle 15 comprises a tubular body 30 having an axial bore 31. An annular flange 32 is secured by means of bolts 34 to the upper end of body 30 and its outer periphery projects into the annular space between the upper end of body 30 and spacer ring 16. Roller bearings 33 are positioned between the outer extension of flange 32 and the upper surface of plate 10 between the opposed surfaces of body 30 and spacer ring 16. Bore 31 is adapted to receive the upper end of a string of casing P which carries a conventional threaded collar C in abutting engagement with a shoulder 35 provided in bore 31.

An annular drive ring, designated generally by the numeral 40, is disposed in spaced relation below headplate 10 and comprises an annular horizontally disposed bottom plate 41 having an upstanding annular hub 42 about its inner periphery surrounding spindle 15 and an upstanding ring gear 43 having internal teeth 44 mounted on its outer rim to extend slidably inside skirt 11. A plurality of reversible hydraulic motors 45, of conventional design, are mounted on headplate 10. Motors 45 which also may be pneumatic or electric-powered, are connected to downwardly extending drive shafts 46 carrying pinions 47 whose teeth 48 are in mesh with teeth 44 of the ring gear and arranged to permit relative axial movement of the ring gear while in mesh with the pinions. The pinions are supported on the ends of shafts 46 by a bearing plate 49 which is secured to headplate 10 by means of hanger bolts 50 extending through spacer sleeves 51.

A section of external threads 52 is formed on the upper end portion of hub 42 and are in continuous mesh with a section of complementary threads 53 formed on the exterior of spindle body 30 and substantially greater in length than the section of threads 52. This threaded connection provides the primary rotary drive connection between drive ring 40 and spindle 15. As a result of the difference in length between thread sections 52 and 53, rotation of the drive ring will initially produce limited axial movement of the drive ring relative to the spindle from its lowermost position (FIG. 1) to its uppermost position (FIG. 2), for purposes to be described hereinafter. When the latter position has been attained, continued rotation of the drive ring will transmit rotational force to the spindle.

For transmitting torsional force to casing string P, swivel body 30 is provided with an annular recess 36 in its bore wall located at a point which will be opposite collar C when the latter has been received in the bore of the spindle in abutting relation to shoulder 35. As best seen in FIGS. 4 and 5, a pair of arcuate pipe-gripping dogs 37, oppositely disposed in recess 36, are rockably mounted about vertically extending shafts 38

and are provided on their inner faces with pipe-gripping teeth 38a and on their outer faces with smooth arcuate surfaces 38b which taper inwardly toward their opposite ends. The inner wall of recess 36 is formed on opposite sides thereof with cam surfaces 39 which cooperate with tapered arcuate surfaces 38a of the dogs 37 to rock them into and out of gripping engagement with collar C in accordance with the direction of angular movement of the spindle produced by rotation of drive ring 40. An outwardly bowed leaf spring 54 is mounted to extend longitudinally of the center of the inner face of each dog 37 to bear against collar C and bias the dog toward the cam-engaging position (FIG. 5) and thereby assure gripping of the collar in response to the angular movement of the spindle.

Mounted to the lower end of spindle body 30 for radial movement relative thereto is a plurality of circumferential spaced wedge-shaped pipe-gripping slips 55 carrying toothed dies 56 on their inner faces and formed with downwardly and inwardly tapering backfaces 57. The upper ends of the slips are formed with T-shaped heads 58 slidably receivable in correspondingly shaped hangers 59 depending from the lower end of the body 30, this arrangement permitting the aforesaid radial movement of the slips relative to spindle body 30.

A slip bowl 60 having a downwardly and inwardly tapering slip-engaging bore 61 complementing the taper of backfaces 57 of the slips is mounted to bottom plate 41 of the drive ring in surrounding relation to slips 55. Dovetail screwheads 62 project from bore 61 into dovetail slots 63 extending longitudinally of backfaces 57 of the slips and form longitudinally slidable connections between the slips and slip bowl which will constrain radial movement of the slips in response to relative longitudinal movement of the slip bowl. The upper end of the slip bowl carries an outwardly extending annular flange 64 which is rotatably received in a correspondingly shaped annular recess 64a formed in the inner periphery of a hanger ring 64b which is secured by means of bolts 64c to the lower face of bottom plate 41 of the drive ring.

An annular recess 65 is provided in the bore of cap 19 immediately above the upper end of hanger body 17 to receive a correspondingly shaped annular lug 66 formed about the exterior of an internally threaded box 67 carried by the upper end of a connector nipple 68, which extends coaxially through the bore of spindle 15 and is smaller in diameter than casing string P. The lower end of nipple 68 carries an externally threaded pin member 69 for attachment to the upper end of a second string of pipe D which extends through casing string C and may be connected to a conventional turbine drill T (FIG. 3) for purposes to be described hereinafter.

A plurality of hanger pins 70 are threaded radially through the lower end of cap 19 and are adapted to be retractably received in a locking groove 71 formed in the wall of recess 65 to releasably lock box 67 in the hanger.

A port 72 through the wall of cap 19 provides fluid communication with bore 21 and thence with the bore of connector nipple 68 and is connected to a conduit 73. Another port 74 through the wall of hanger body 17 below box 67 provides fluid communication with the annular space between connector nipple 68 and casing string P and is connected to a second conduit 75. By means of ports 72 and 74 and their respective conduits 73 and 75, fluid may be circulated to and from each of the pipe strings as may be found necessary or desirable in connection with the various operations performed by the power swivel.

OPERATION

As indicated previously, the power swivel is capable of multiple operations. It may be employed in a casing drilling system to rotate casing string P as a rotary drill string to drive a bit section B (FIG. 7) which is insertable bodily through the bore of the casing string and landed in a suitable landing nipple N therein, the bit section comprising a pilot bit and expansible underreamers. Such a system is fully described in my copending U.S. application, Ser. No. 778,509, filed Nov. 25, 1968.

When so employed connector nipple 68 may be kept in place as seen in FIGS. 1 and 2 or removed from the power swivel assembly. Removal of the connector nipple is easily effected by unbolting cap 19, retracting hanger screws 70 and lifting the connector nipple out of hanger body 17, after which cap 19 is reattached to the hanger body.

When used to drive casing string P, the swivel will be lowered over collar C to insert the latter into spindle 15 until the upper end of the collar abuts shoulder 35. At this stage of operations drive ring 40 will be in its lower or retracted position, as seen in FIG. 1. In this position slip bowl 60 will be in its lowered position and slips 55 retracted. Rotation of the drive ring by operation of motors 45 will not be started. The first results of this rotation will be to cause drive ring 40 and its appurtenances to move upwardly by reason of the threaded connection between hub 42 and spindle 15 which temporarily, will be held relatively stationary by reason of frictional forces between the spindle and the stationary elements of the power swivel. As the drive ring moves upwardly to the limit of the threaded connection to the spindle, slip bowl 60 will be drawn upwardly and will translate this upward movement to radial movement of slips 55 until the latter are driven into tight-gripping engagement with casing string P. At the same time the rotation of the drive ring will actuate dogs 37 to their pipe-gripping position (FIGS. 2 and 5) so that continued rotation of drive ring 40 will transmit torsional force to collar C and casing string P to produce the desired rotation of the casing string and its connected bit section for drilling a borehole W (FIG. 7).

When it is desired to operate a turbine drill from the power swivel, as when necessary to effect a deviation of the borehole from the vertical to permit slant drilling, connector nipple 68 will be installed in the power swivel, if not already in place, and will be connected to the smaller diameter string of pipe D carrying the turbine drill T which will have been extended through the bore of casing string P (FIG. 3) from which bit section B will have been removed. Pressure fluid may then be circulated through conduit 73 to drive the turbine drill, the return fluid flowing through the annulus between casing string P and pipe string D to the surface and discharging through conduit 75.

At the same time, it is desirable to rotate casing string P in order to prevent its sticking while the turbine drill is drilling ahead and to advance the casing string along the borehole with the advance of the turbine drill. This dual operation can be readily accomplished by operating the power swivel as previously described to rotate casing string P while the inner pipe string D remains stationary rotationally while both pipe strings advance axially behind the turbine drill.

Addition or removal of sections of the dual pipe strings when running into and out of the well bore may be effected by generally conventional and well-known procedures.

Reverse rotation of the drive ring will produce downward movement thereof relative to the spindle, lowering slip bowl 60 and retracting slips 55 and reversing dogs 37 to thereby release the attachment of the swivel to casing string P when necessary or desired to enable addition or removal of sections of the pipe strings.

From the foregoing, it will be evident that the above-described power swivel may be employed for multiple drilling uses. It will be understood that various changes and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A power swivel for dual concentric pipe strings comprising:

- a stationary annular headplate having a central opening;
- a hollow spindle rotatably mounted in said opening and adapted to receive the upper end of a first pipe string;
- hanger means on the headplate for securing thereto a second pipe string extending through the bore of said first pipe string in nonrotative relation thereto;

- d. a drive ring disposed about said spindle below said headplate for axial and rotational movement relative thereto;
- e. reversible motor means mounted on the headplate and drivingly connected to said drive ring;
- f. a drive connection between said drive ring and said spindle including a threaded section affording limited axial movement of the drive ring relative to the spindle in response to relative rotation therebetween; and
- g. means mounted on said spindle for transmitting torsional force therefrom to said first pipe string.
- 2. A power swivel according to claim 1 including: pipe-gripping elements mounted to said spindle below said means for transmitting torsional force and arranged for radial movement into and out of gripping engagement with said first pipe string in response to said limited axial movement of said drive ring.
- 3. A power swivel according to claim 2 wherein said pipe-gripping elements include:
 - a. a plurality of angularly spaced pipe-gripping wedges having radially slidable connection to the lower end of said spindle; and
 - b. a tapered slip bowl mounted to said drive ring in surrounding relation to said wedges.
- 4. A power swivel according to claim 1 wherein said drive ring includes:
 - a. an internally toothed ring gear disposed about its outer periphery and meshing with pinions driven by said motor means; and
 - b. a tubular hub surrounding said spindle and a carrying thread section in mesh with a longer thread section on said spindle.
- 5. A power swivel according to claim 1 wherein said hanger means includes:
 - a. a tubular hanger body having an annular recess in the bore thereof;
 - b. a connector nipple disposed coaxially through said bore and having an annular lug seatable in said recess; and
 - c. retractable hanger pins threaded radially through said hanger body for movement into and out of locking engagement with said connector nipple.
- 6. A power swivel according to claim 1 wherein said last-mentioned means includes:
 - a. arcuate dogs having toothed inner faces and smoothly tapered outer faces rockably mounted in angularly spaced relation in the bore of said spindle; and
 - b. cam surfaces in the bore of said spindle cooperating with said tapered outer faces of said dogs to rock said dogs into and out of gripping engagement with said first pipe string in response to angular movement of said spindle.
- 7. A power swivel according to claim 1 including means carried by said headplate for separately providing fluid communication with the respective pipe strings.
- 8. A power swivel for dual concentric pipe strings comprising:

ing:

- a. a stationary annular headplate having a central opening;
- b. a hollow spindle vertically disposed for rotation in said opening and adapted to receive the upper end of a first pipe string;
- c. a drive ring disposed about said spindle below said headplate for axial and rotational movement relative thereto;
- d. motor means mounted on the headplate and drivingly connected to said drive ring;
- e. means mounted in the bore of said spindle for transmitting torsion therefrom to said first pipe string;
- f. a drive connection between said drive ring and said spindle including a threaded section affording limited axial movement of the drive ring relative to the spindle;
- g. pipe-gripping elements mounted to said spindle below said torsion-transmitting means for radial movement into and out of gripping engagement with said first pipe string in response to said limited axial movement of said drive ring; and
- h. hanger means on the headplate for securing thereto a second pipe string extending through the bore of said first pipe string.
- 9. A power swivel according to claim 8 including means carried by said headplate for separately providing fluid communication with the respective pipe strings.
- 10. A power swivel for dual concentric pipe strings comprising:
 - a. a stationary annular headplate having a central opening;
 - b. a tubular spindle vertically disposed for rotation in said opening and adapted to receive the upper end of a first pipe string;
 - c. means mounted in the bore of said spindle for transmitting torsion therefrom to said first pipe string;
 - d. a drive ring disposed below said headplate surrounding the spindle for axial and rotational movement relative to said headplate;
 - e. complementary thread means connecting said drive ring to said spindle for limited vertical movement relative thereto in response to rotational movement of the drive ring;
 - f. motor means mounted on the headplate and drivingly connected to said drive rings;
 - g. a downwardly tapering slip bowl depending from said drive ring;
 - h. a plurality of pipe-gripping wedges mounted to said spindle and extending into said slip bowl for radial movement into and out of gripping engagement with said first pipe string in response to axial movements of said slip bowl;
 - i. hanger means on the headplate for securing thereto a second pipe string extending through the bore of the first pipe string; and
 - j. means carried by said head plate for separately providing fluid communication with each of said pipe strings.

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