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TORSIONAL DRIVE COUPLING

Filed Dec. 24, 1962

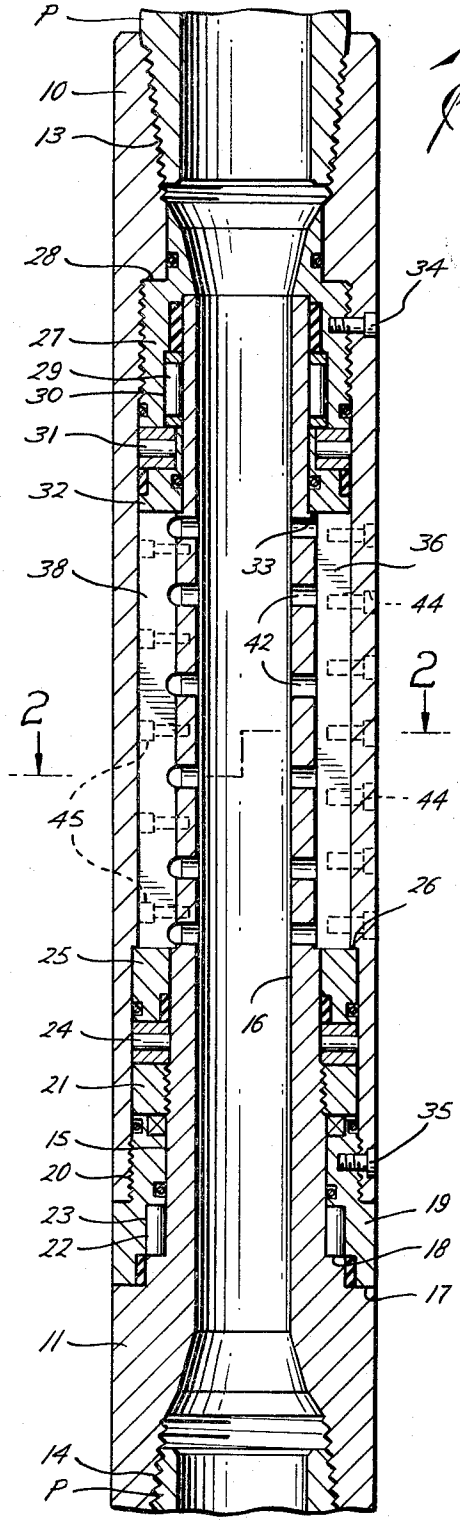


Fig. 1

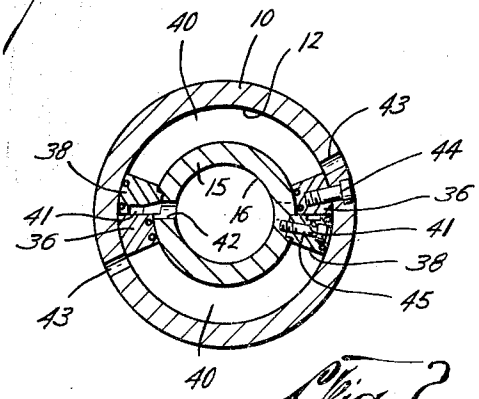


Fig. 2

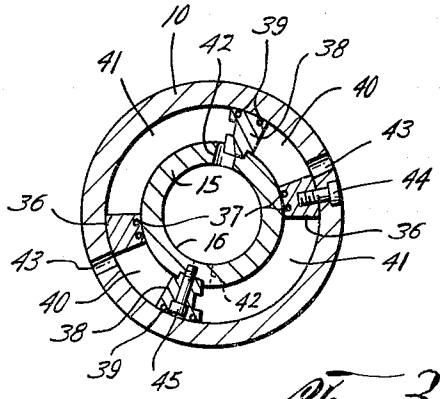


Fig. 3

J C Birdwell
INVENTOR.

BY

ATTORNEY

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TORSIONAL DRIVE COUPLING

J. C. Birdwell, Houston, Tex.
(% McCullough Tool Co., P.O. Box 2575, Houston, Tex.)

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This invention relates to a rotary well drilling system and more particularly to such a system employing a torsional drive coupling member in the drill pipe string for reducing the torque requirements from the surface power means for the system.

In the drilling of wells by the rotary method which employs a tubular pipe string connected to the drill bit which is rotated by drive means at the surface for drilling through the earth formations, a stream of drilling fluid, generally weighted with solids of various types, is circulated through the bore of the drill pipe and out of the discharge orifices at the bit, thence back to the surface through the annulus between the bore wall and the pipe string. To effect rotation of such drill strings, it is, of course, necessary to overcome the resistance to rotation generated by engagement of the bit with the earth formations and the additional friction resulting from engagement of the exterior of the pipe string and its couplings with the bore wall, since the well bore is ordinarily not perfectly straight and the drill string will also not be absolutely perpendicular during rotation.

The resistance to rotation thus arising from the engagement of the bit and the drill string with the bore wall must, of course, be overcome to effect rotation and requires the input of a very substantial amount of power at the surface through the rotary table to overcome the resistance and produce the desired rotation. The resistance to rotation resulting from the engagement of the bit and pipe string with the bore wall will require the generation of internal stress in the pipe walls equal to and opposing the external frictional resistance in order that the drill may then be rotated. The internal stress thus introduced into the walls of the drill string, I have found, may be effectively employed to reduce the torque required at the surface to rotate the drill string, thereby reducing the power requirements for effecting rotary drilling.

In accordance with this invention, there is provided a form of drive coupling to be introduced at one or more points along the drill string, preferably near those points where frictional forces are likely to be greatest, this usually being near the bit. The coupling comprises two concentric tubular elements, the inner element being connected to one part of the drill string and the outer element to the other part of the drill string. In the illustrative embodiment, for example, the inner element will be connected to the lower portion of the drill string adjacent the bit, the outer element being connected to the upper portion of the drill string. Co-operating vanes extend longitudinally of the coupling elements across the annular space between the elements and have slidable sealing engagement with the opposed wall surfaces of the coupling elements to divide the annular space into a series of angularly spaced chambers sealed from communication with each other. Certain of the chambers between the vanes are in communication with the bore of the inner coupling element and thereby with the bore of the drill string through radial ports through the wall of the inner element. Others of the chambers are in communication with the well bore by means of ports through the wall of the outer coupling element. The arrangement of the vanes causes one of the coupling elements to tend to rotate in one direction and the other coupling element to rotate in the opposite direction when subjected to hydraulic pressure differentials. This makes

it possible to make use of the internal stress generated in the pipe walls at the initiation of rotation to transmit additional torque and rotational force to the drill string below the coupling, thereby reducing the power input required at the surface.

The theory of operation of the coupling is as follows:

(1) If a drill pipe string has external frictional resistance to rotation, this external frictional resistance must be overcome by equal internal stress in the drill pipe string. After this stress has been applied, the drill pipe string is free to rotate.

(2) The required internal stress can be supplied from right-hand rotational torque exerted from above, or from left-hand rotation exerted from below. In either case of application, a similar amount of internal stress can be absorbed by the drill pipe string. This absorbed energy will cause a similar stress in the pipe whether applied from the top or bottom.

(3) If this internal stress is applied with a rotary drive means from the upper end of the pipe string by means of right-hand rotation, then the rotary drive means must sustain a corresponding left-hand rotational force equal to the applied internal stress. Correspondingly, if this internal stress is applied from the bottom of the string by means of left-hand rotation of the string, then the bit or other tool which is below must sustain a right-hand rotational force equal to the applied internal stress.

(4) Hence, by using the torsional coupling in accordance with this invention, it is possible to apply the required internal stress in the drill pipe string from the bottom. This gives a reaction torque trying to rotate the bit or lower member of the coupling. In addition, internal stress will be set up in the drill pipe string so that torque applied by the rotary drive means at the upper end of the pipe string will be transmitted directly to the bit or lower member of the coupling.

A primary object of this invention is the provision of a rotary well drilling system employing in the drill pipe string at a point above the bit a torsional drive means forming a fluid coupling between the circulating pressure fluid and the the drill string and actuatable in response to resistance to rotation resulting from frictional engagement of the drill pipe and bit with the well bore walls to reduce the torque requirements from the surface power means for the system.

In accomplishing the foregoing result, the hydraulic pressure of the circulating drilling fluid is employed acting through the hydraulic force generated by the difference in the fluid pressures inside and outside the pipe string which will be applied through the ports in the respective coupling elements, in a direction to, in effect release the energy represented by the stress built up in the pipe string from the frictional resistance to rotation.

The spacing of the vanes permits a limited degree of relative angular movement between the coupling elements, the movements being transmitted from one coupling element to the other through bodies of hydraulic fluid which will have filled the chambers through the respective ports. As a result, the coupling will also function as a shock absorber for the drilling string.

Accordingly, a further object of this invention is to employ the torsional coupling as a hydraulic shock absorber to absorb shocks developed during the course of rotation of the drilling string.

Other and more specific 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 one useful embodiment in accordance with this invention.

In the drawing:

FIG. 1 is a longitudinal quarter-sectional view of one of the couplings;

FIG. 2 is a cross-sectional view taken generally along line 2—2 of FIG. 1, showing one position of the vanes of the coupling; and

FIG. 3 is a view similar to FIG. 2 showing a different position of the vanes of the coupling.

The coupling, as best seen in FIGS. 1 to 3, comprises a tubular outer member **10** and a tubular inner member **11** concentrically extending into bore **12** of the outer member. The latter has an internally threaded socket **13** for attachment to the lower end of a section of pipe string P. Inner member **11** is provided at its lower end with an internally threaded socket **14** for threadedly receiving the upper end of the next adjacent section of pipe string P. The external diameter of inner member **11** is substantially reduced from a point a short distance above socket **14** to its upward end, forming the tubular shaft **15** which is coaxial with outer member **10** and provided with an axial bore **16** forming a continuation of the bore of the pipe string. The reduction in diameter of inner member **11** to provide shaft **15** is effected in two steps forming the stepped upwardly facing shoulders **17** and **18**, respectively. A lower bearing assembly is mounted between outer member **10** and shaft **15** and includes a bushing **19** disposed about shaft **15** above shoulder **17**. The upper end portion of bushing **19** is externally threaded at **20** to be threadedly received in the lower end of outer member **10**, whereby to secure the bushing to the latter. A collar **21** is threadedly secured about shaft **15** in abutting engagement with the upper end of bushing **19**. The threaded connection of bushing **19** to outer member **10** and the threaded connection of collar **21** to shaft **15** provide means by which the inner member of the coupling is secured to the outer member to prevent longitudinal separation between these members, while permitting relative rotational movement between the members. Radial bearings **22** are seated in a suitable race **23** in bushing **19** to surround shaft **15** above shoulder **18**. A thrust bearing **24** is mounted between collar **21** and a spacer ring **25** which is seated against an internal shoulder in the bore of outer member **10**. Annular seals are provided at various points in this bearing assembly to prevent fluid leakage between the members. The upper end of shaft **15** is rotatably supported in bore **12** of outer member **10** by means of a bearing assembly which includes an external threaded bushing **27** which is screwed into the upper end of bore **12** of the outer member and seated against a downwardly facing shoulder **28** in the latter bore. A radial bearing **29** is disposed about the upper end of shaft **15** in a race **30** provided in the bore wall of the bushing **27**. A thrust bearing **31** is mounted about the exterior of shaft **15** between the lower end of bushing **27** and a bearing ring **32** is seated on an external shoulder **33** formed on the exterior of shaft **15**. Set screws **34** extend through the wall of outer member **10** into bushing **27** to lock these elements together, and other set screws **35** similarly lock the lower end of outer member **10** to bushing **19**. Seals are provided at various points in the upper bearing assembly to secure against leakage of fluid between the inner and outer members.

Between the upper and lower bearing assemblies, outer member **10** is provided with a pair of diametrically disposed longitudinally extending vanes **36—36** which extend radially across the annular space between the coupling members into rotationally slidable engagement with the exterior surface of shaft **15**. Seal elements **37** are disposed in the inner longitudinal edges of vanes **35** and extend across the ends of the vanes to form fluid-tight seals with the exterior of shaft **15** and the bearing assemblies. Shaft **15** is provided with a pair of diametrically opposed vanes **38—38** which extend radially therefrom across the annular space between the coupling members to rotationally slidably engage with the bore wall of outer member **10**. The outer edges and ends of vanes **38** are provided with longitudinal seal element **39** to form fluid-tight seals with the inner wall of outer member **10** and the bearing assemblies. The vanes **38** are interspersed with outer vanes **36**, thereby dividing the annular space between the coupling elements into two pairs of arcuate chambers, the members of each pair being diametrically opposed. One of these pairs may be termed the "vent" chambers **40—40** and the other two may be termed "pressure" chambers **41—41**, best seen in FIG. 3. Pressure chambers **41—41** communicate with bore **16** of shaft **15** by means of diametrically opposed ports **42—42** which are disposed closely adjacent vanes **38—38**. Vent chambers **40—40** communicate with the exterior of the device through ports **43—43** which open into chambers **40** at points adjacent the vanes **36—36**, as seen particularly in FIGS. 2 and 3. Vanes **36** are secured to outer member **10** by means of the studs **44** and vanes **38** are similarly secured to shaft **15** by means of studs **45**.

With this arrangement of the vanes it will be seen that limited relative rotation may take place between the inner and outer members, the limitation of rotation or oscillation being approximately one hundred eighty degrees, as will be evident from the position shown in FIG. 2.

In operation, one or more of the couplings will be installed in the drill pipe string adjacent the bit and at other points along the drill string to utilize frictional forces which develop at such points through engagement of the pipe string with the bore wall. Circulation of drilling fluid will be initiated through the bore of the pipe string and the well bore annulus. This fluid will enter chambers **41** and through ports **42** and its pressure will be exerted against the opposed faces of vanes **36** and **38** defining these chambers, tending to rotate members **10** and **11** in opposite directions. Vent ports **43** being open to the well annulus, a substantial pressure differential will be established between chambers **41** and chambers **40**. As inner member **11** will be held against rotation by the frictional engagement of the bit with the earth formations. this pressure differential will become effective to develop reaction torque in the inner coupling member which will be transmitted to the bit section below the coupling with the effective result of transmitting the torque applied a the surface by the rotary drive means directly to the bit, thereby greatly reducing the rotary power requirements for rotating the drill string.

Since the rotational driving force on the drill string will be transmitted through the hydraulic fluid trapped in chambers **41**, this fluid will also serve as a hydraulic shock absorber which will effectively smooth out the rotations of the drill string.

In many instances, it may be desirable to increase the extent of relative rotation between the parts of the drill pipe string connected by the couplings. This may be readily accomplished by connecting two or more couplings together. The number of couplings thus employed will be dependent upon the degree of relative rotation desired.

While the illustrative embodiment employs two pairs of interspersed, diametrically spaced vanes on the coupling members, it will be understood that the coupling structure will be operative with various members of vanes. In some instances, a single vane on each coupling element will be sufficient, while in other cases more than two vanes on each coupling element at suitable angular spacings may be employed. In short, any vane arrangement employing at least one vane on each coupling member may be effectively employed.

It will be evident that numerous other modifications and variations 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 torsional drive coupling for rotary drill pipe strings, comprising concentric telescopically disposed tubular outer and inner coupling elements connectible

respectively to the upper and lower sections of a rotary drill pipe string, means connecting said coupling elements for relative rotation, said means including longitudinally spaced upper and lower collar members disposed between the inner and outer coupling members, said upper collar member being secured to said outer coupling member and rotatable about said inner coupling member, said lower collar member being secured to the inner coupling member and rotatable relative to said outer coupling member, at least one longitudinally extending vane secured to each of the coupling elements, the vanes being angularly interspersed and extending radially in opposed directions across the annular space between the coupling elements into rotationally slidable sealing engagement with the walls of the opposed coupling elements whereby to divide the annular space between the coupling elements into at least two arcuate chambers sealed from each other and expandable and contractable in response to relative rotational movement of the coupling elements, port means through the wall of the inner coupling element communicating the bore thereof with the interior of one of said chambers, and port means through the wall of the outer coupling element communicating the interior of the other of said chambers with the exterior of said outer element.

2. A torsional drive coupling for rotary drill pipe strings, comprising concentric telescopically disposed tubular outer and inner coupling elements connectable respectively to the upper and lower sections of a rotary drill pipe string, means connecting said coupling elements for relative rotation, said means including longitudinally spaced upper and lower collar members disposed between the inner and outer coupling members, said upper collar member being secured to said outer coupling member and

rotatable about said inner coupling member, said lower collar member being secured to the inner coupling member and rotatable relative to said outer coupling member, a plurality of angularly spaced longitudinally extending vanes secured to each of the coupling elements, the vanes on one element being angularly interspersed with those on the other element and extending radially in opposed directions across the annular space between the coupling element into rotationally slidable sealing engagement with the walls of the opposed coupling elements whereby to divide the annular space between the coupling elements into a plurality of arcuate chambers sealed from each other and expandable and contractable in response to relative rotational movement of the coupling elements, ports through the wall of the inner coupling element communicating the bore thereof with the interiors of angularly spaced ones of said chambers, and ports through the wall of the outer coupling element communicating the interiors of the intervening ones of said chambers with the exterior of said outer element.

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ROBERT C. RIORDON, *Primary Examiner.*

FRANK SUSKO, *Examiner.*