March 21, 1939. P. SUBKOW ET AL 2,151,646

SUBSURFACE SPEED-UP DRILLING MECHANISM

Filed June 28, 1938

Fig. 1.

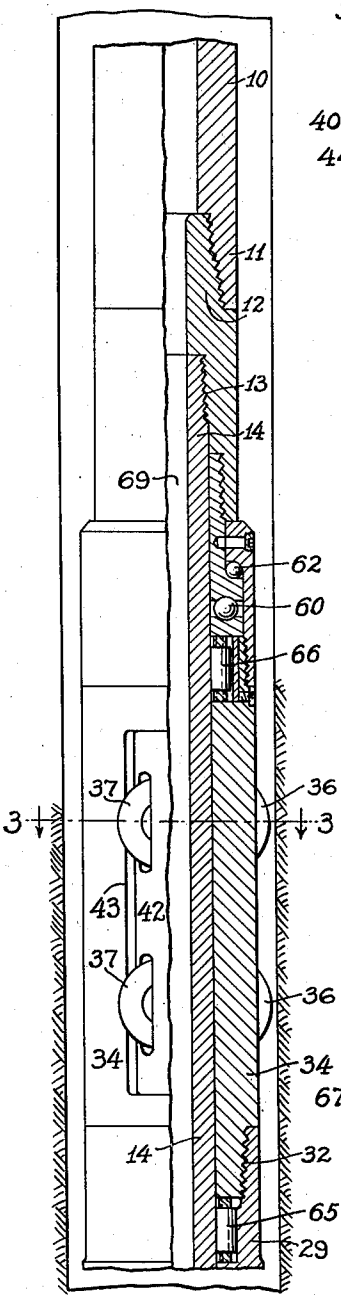


Fig. 3.

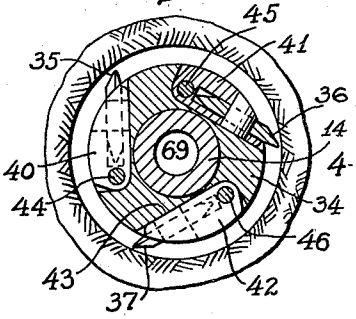


Fig. 4.

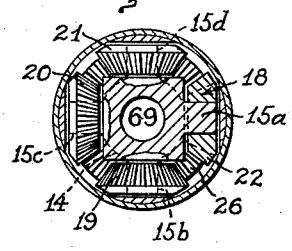


Fig. 5.

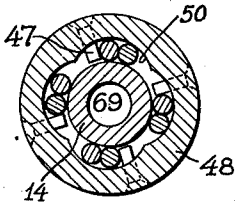


Fig. 6.

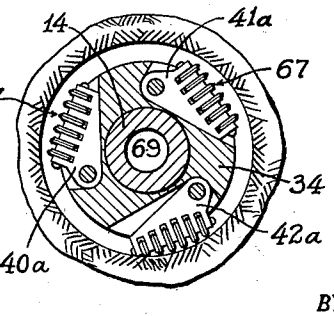
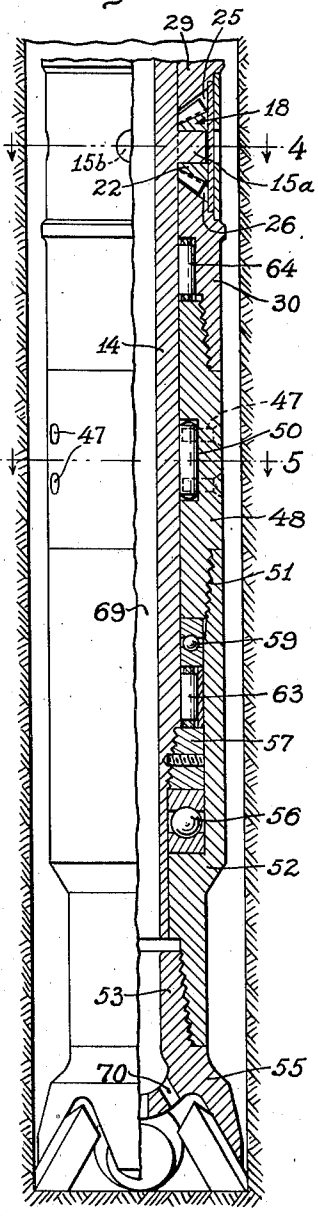


Fig. 2.



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SUBSURFACE SPEED-UP DRILLING MECHANISM

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Application June 28, 1938, Serial No. 216,250

8 Claims. (Cl. 255—1)

This invention relates to apparatus for earth boring and especially for drilling deep wells such as for the production of oil.

In the rotary method of drilling deep wells, such as oil wells, it is desirable that a maximum rotational speed of the drill bit be maintained and a limited weight placed thereupon during drilling operations in order that a reasonably straight borehole can be formed and at the same time rapid drilling progress made.

In order to effect rapid rotation of the drill bit without employing excessive drill stem and rotary table rotational speeds, general transmissions have been advantageously employed which are built into the drill collar and adapted to be lowered upon the end of the drill stem with the drill bit into the borehole. Such transmissions usually have ratios such that the drill bit is caused to rotate at a higher speed than the drill stem. When such sub-surface mechanisms utilizing gearing or other suitable types of transmissions adapted to change the speed of rotation of the drill bit with respect to the drill pipe are employed it is necessary that some means be provided within the borehole to resist the reactive torque necessarily associated therewith. Provision for holding the transmission in the borehole and absorbing the reactive torque has in some cases been met by employing a following casing secured against rotation at the top of the borehole and extending down into the borehole and either rigidly attached to the body of the transmission or provided with splined slides or guides whereby the transmission is held against rotation yet the transmission and the drill bit associated therewith may be moved longitudinally in steps of limited distance through the borehole as drilling progresses, sections of said casing being added at the top when necessary. Such a method and apparatus is disclosed in the Hill Patent Nos. 1,894,039 and 1,944,838.

Instead of employing the following casing as disclosed in the Hill patents several well known borehole wall gripping mechanisms have also been employed in connection with this type of geared drill bit transmission to receive and transfer the reactional torque thereof directly to the borehole wall.

However, when such means are employed for transmitting the reactional torque directly to the borehole wall the formation comprising said borehole wall cannot always be depended upon to provide the necessary strength, size or shape to conform with the necessary borehole wall gripping mechanism. When this is the case other means must be provided for preventing the mechanism from being rendered inoperative under such conditions.

It is accordingly a principal object of this invention to provide means to enable drilling operations to be continued in a conventional manner whenever the transmission is rendered inoperative due to such failure of the borehole wall to properly resist the reactional torque of the transmission whereby drilling progress can be continued at all times and until formation is reached suitable to the resumed operation of the transmission wall gripping mechanism.

The principal feature of this invention, therefore resides in means for automatically shifting the drill bit to conventional drilling speeds if at any time the borehole wall gripping means is rendered inoperative for any reason, such as encountering soft formations, cavities, caving or the like, whereby drilling progress can be maintained at all times.

Other objects and features of novelty will be evident hereinafter.

In the accompanying drawing wherein one embodiment of the invention is disclosed by way of illustration, Fig. 1 is a partial sectional elevation of the general assembly of the upper portion of the transmission in place upon the drill stem.

Fig. 2 is a partial sectional elevation of the lower portion of the transmission continued from Fig. 1 and showing the drill bit attached.

Fig. 3 is a cross section taken approximately on line 3—3 of Fig. 1, through a portion of the borehole wall gripping mechanism.

Fig. 4 is a cross section taken approximately on line 4—4 of Fig. 2, through the transmission gearing.

Fig. 5 is a cross section taken approximately on line 5—5 of Fig. 2 through the over-riding clutch transmission.

Fig. 6 is a cross sectional view of an optional arrangement of that portion of Fig. 1 shown on line 3—3.

Apparatus

Referring to the drawing in which like numerals refer to like apparatus throughout the several views, the lower end of the drill pipe 10, terminating in a box 11, is coupled to the upper pin connection 12 carried by the transmission system. Connection 12 at the lower end is connected through threads 13 to the upper end of the hollow central shaft member 14 which extends throughout the length of the transmission apparatus as shown in Figs. 1 and 2. The said hollow shaft 14 serves as the driving member of the transmission

and rotates within the assembly to be described hereinafter. At a mid-section of the central driving member 14 is provided four radially disposed stub shafts 15a—15d as best shown in partial section in Fig. 4, each of which carries a differential bevelled gear pinion journaled thereon, one of which is shown in section at 18 in Figs. 2 and 4. The four differential bevelled gears 19—22 in turn mesh with bevelled gear teeth 25 and 26 carried on and forming a part of the adjacent elements 29 and 30 respectively, each rotatably journaled upon the drive shaft 14 one above and one below the differential bevelled gear assembly respectively.

The upper geared element 29 which is journaled upon the hollow shaft 14, and which carries the bevelled teeth 25 meshing with the differential pinions 19—22, is attached by means of suitable threads at 32 to the formation gripping mechanism body 34. The said formation gripping mechanism 34 carries, by way of illustration, three pairs of rotatable sharp edged discs as shown at 35—37 adapted to swing outward into the formation and prevent clockwise rotation of this section of the apparatus (as viewed from above in Fig. 3) during operation.

The said formation gripping discs 35—37 are mounted upon hinged members as shown at 40—42, each of which is longitudinally hinged as shown as 44—46 within suitable recesses in the body 34 in such a manner that upon tendency of clockwise rotation of the formation gripping mechanism body under the influence of the above mentioned transmission rotation forces the discs and their supporting members 40—42 are caused to swing outward about the said hinged points 44—46 and to be driven into the surrounding formation comprising the borehole wall. Initially or upon counter-clockwise rotation of the formation gripping mechanism body 34, the discs 35—37 and hinged members 40—42 upon which they are carried, are withdrawn into the recesses provided therefor as shown at 43 in Fig. 3, with only the points of the discs 35—37 exposed and extending outwardly therefrom a sufficient distance to enable an intial contact with the formation to be made.

The lower geared element 30 carrying the bevelled gear teeth 26 is threaded into the over-riding clutch body 48, which carries a plurality of rollers retained in four tapered slots as shown at 50, formed between the inner circular shaped milled recesses of the clutch body member and the outside cylindrical surface of the central drive shaft member 14. Pins 47 serve to restrict the position of the rollers to the forward portions of the tapered slots so that only clockwise relative rotation between shaft 14 and body member 48 is prevented. The lower end of the over-riding clutch body member 48 is threaded at 51 into an elongated box coupling member 52 into which in turn the pin connection 53 of the drill bit, as illustrated at 55, is secured.

In operation the longitudinal thrust of the drill bit is transmitted through the box and pin connection 52—53 through the ball thrust bearing 56 and thence through the tapered thrust collar 57 to the central hollow drive shaft 14, which in turn makes direct connection with the drill pipe 10 through the beforementioned pin connection 12 and box 11.

The ball thrust bearings 59 and 60 serve to resist the thrust of the longitudinal components of the torsional forces of transmission which are communicated to the bevelled gear elements 30 and 29 respectively. Ball thrust bearing 62 serves to support the entire weight of that portion of the formation gripping mechanism which surrounds and is journaled upon the shaft 14. The roller bearings 63—66 serve to rotatably support and accurately center the whole assembly about the hollow central drive shaft 14.

In Fig. 6 an optional arrangement of the formation gripping mechanism of Fig. 3 is illustrated wherein instead of employing sharp attached discs 35—37 the hinged members 40a—42a are adapted to carry a plurality of rotatably supported sharp attached discs as shown at 67. These sharp attached discs are graduated in size as shown to approximately conform with the inside cylindrical surface of the borehole.

Operation

In operation the drill stem 10 is rotated in a clockwise direction, as viewed from the top, by means of a rotary table (not shown) in the conventional manner. Said rotation of the drill stem 10 is transmitted through the box and pin connection 11—12 and through the threaded connection 13 to the hollow cylinder drive shaft 14 of the step-up transmission assembly. This rotation of the drive shaft 14 is also imparted through the radial stub shafts 15a—15d to the differential pinions 19—22. The adjacent upper and lower bevelled gear elements 29 and 30 respectively, which carry the bevelled gear teeth 25 and 26 and which mesh with the said differential bevelled gears 19—22, tend also to be carried in clockwise rotation with the drive shaft 14. When the drill bit 55 makes initial contact with the formation at the bottom of the borehole there will be sufficient friction to momentarily resist such clockwise rotation of the lower geared element 30 which is coupled through 48 and 52 to the said drill bit 55 and this resistance will cause the differential pinions 19—22 to rotate momentarily upon the bevelled gear teeth 26 of the lower element 30 in a clockwise direction with respect thereto. This rotation of the differential pinions 19—22 acting through the bevelled gear teeth 25 will in turn momentarily rotate the adjacent upper geared element 29 and the formation gripping mechanism body 34 attached thereto in a clockwise direction at twice the speed of said rotation of the differential pinions 19—22. This said momentary clockwise rotation of the formation gripping mechanism body 34 results in causing the discs 35—37 and their associate hinged supporting members 40—42 to swing outwardly and be forced into the borehole wall. The formation gripping mechanism is thus secured against further rotation and the drill bit 55 is then forced to rotate at a speed twice that of the drive shaft 14 through the action of the differential gears. Whatever force is necessary to maintain rotation of the drill bit 55 upon the bottom of the borehole during drilling is applied through the differential gearing and there is necessarily an equal reactive force or torque transmitted through the geared element 29 to the formation gripping mechanism. In case the gripping formation mechanism is unable to resist this reactional torque for any reason such as encountering formations too soft to withstand the pressure of the discs 35—37 or if cavities are formed having diameters too large to be reached by the formation gripping mechanism, the said formation gripping mechanism will then be free to rotate and under this condition further rotation cannot be imparted to the drill bit and drilling progress will necessarily cease. When the formation grip-

ping mechanism is operated properly the over-riding clutch body 48 together with the lower bevelled gear element 30 and the drill bit connection 52 attached thereto rotates at a speed twice that of the drive shaft 14 and in a direction clockwise thereto. If, however, as above mentioned the formation gripping mechanism is rendered inoperative the over-riding clutch body 48 and drill bit assembly associated therewith will momentarily cease to rotate and drive shaft 14 will continue to rotate within the over-riding clutch body and in a direction clockwise with respect thereto. Such momentary clockwise rotation of the hollow drive shaft 14 with respect to the over-riding clutch body 48 will cause the rolls 49 to move toward the tapered end of the circular recesses 50 and thus resist any further relative rotation between the said drive shaft 14 and the over-riding clutch body member 48. Drill bit 55 will then be forced to continue in rotation at drill stem speed until sufficient additional drilling headway is made to a point where the formation comprising the borehole wall is again suitable for the proper functioning of the borehole wall gripping mechanism at which time the step-up transmission system will again automatically become operative and the drill bit again rotate at twice the drill stem speed.

The optional bore-hole gripping mechanism illustrated in cross section in Fig. 6 employs a plurality of sharp attached discs as shown at 67 instead of the single sharp edged discs 35—37 as shown in Fig. 3. The advantages of so employing a plurality of sharp edged discs is realized when soft formations are encountered and it is therefore desirable to distribute the reactive force over a larger borehole wall area. Another advantage of the borehole wall gripping mechanism of Fig. 6 resides in the greater freedom for longitudinal movement of the apparatus through the borehole as drilling progresses which the roller action of the plurality of discs affords.

Other suitable forms of formation gripping surfaces may obviously be employed.

The central drive shaft 14 is provided with a central duct 69 through which circulating drilling mud from the drill pipe 10 may reach the drill bit 55 and be forced out through the openings 70 to contact the cutting surfaces of the drilling bit.

Other forms of over-riding clutch mechanisms obviously may be employed with equal effect. For example, a rachet mechanism may possibly be substituted for the roller mechanism of the over-riding clutch.

Some of the advantages of the process and apparatus of this invention are that rotational speeds of the drill pipe may be reduced for a given desired drill bit speed, resulting in a substantial reduction in the power applied to the drill pipe, or the bit speed may be increased while maintaining conventional drill pipe speeds, resulting in faster drilling and more nearly straight boreholes. Moreover drill bit mechanism does not become inoperative upon encountering formations and cavities in which the formation gripping mechanism cannot maintain hold and drilling headway can, therefore, be maintained at all times. The necessity for providing means such as a following casing to absorb the reactive torque of the step-up transmission is therefore eliminated.

While for purposes of illustration the process and apparatus of this invention has been described in connection with a transmission adapted to increase the drill bit speed with respect to the drill stem it is obviously equally applicable to apparatus employing a transmission adapted to reduce the drill bit speed with respect to the drill stem with only minor variations in the mechanical structure.

It is to be understood that the specific disclosures herein are to be considered only as illustrative and not as limiting, since various modifications of the invention can be made within the scope of the appended claims by those skilled in the art.

We claim:

1. Drilling mechanism comprising in combination a drill stem adapted to be rotatably suspended in a borehole, a drill bit at the lower end of said drill stem, a change-speed transmission on said drill stem above said drill bit whereby the said drill bit may be rotated at a speed different from that of the drill stem, an automatic clutch means in said transmission to couple said drill stem directly to said drill bit whereby conventional drilling bit speed is automatically resumed when said change-speed transmission is inoperative.

2. Drilling mechanism comprising in combination a drill stem adapted to be rotatably suspended in a borehole, a drill bit at the lower end of said drill stem, a change-speed transmission on said drill stem whereby the said drill bit may be rotated at a speed different from that of the drill stem means associated with said transmission to resist the reactive torque of said transmission, an automatic clutch means in said transmission to render said transmission inactive and to couple said drill stem directly to said drill bit whereby conventional drill bit speed is automatically resumed when said reactive torque resisting means is inoperative.

3. Apparatus according to claim 2 in which the borehole wall gripping mechanism comprises clamping elements adapted to be forced into contact with the borehole wall.

4. Apparatus according to claim 2 in which the borehole wall gripping mechanism comprises blades adapted to swing into contact with and be forced against the borehole walls by the said reactive torque of the said transmission.

5. Apparatus according to claim 2 in which the borehole wall gripping mechanism comprises rotatable disc shaped blades adapted to swing into contact with and be forced against the borehole wall by said reactive torque of the said transmission.

6. Apparatus according to claim 2 in which the borehole wall gripping mechanism comprises a plurality of rotatable friction rollers.

7. Drilling mechanism according to claim 1 in which the automatic clutch comprises a roller type over-riding clutch.

8. Drilling mechanism according to claim 1 in which the change-speed transmission is adapted to step-up the drill bit speed with respect to the drill stem speed.

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