July 1, 1958 J. C. DUNN 2,841,366

METHOD AND APPARATUS FOR DRILLING WELLS

Filed Oct. 25, 1954

FIG. 1.

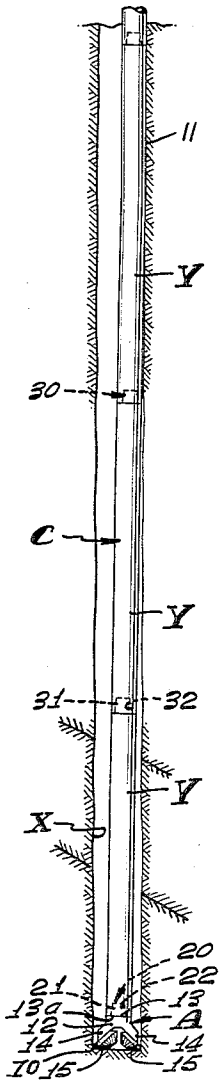


FIG. 2.

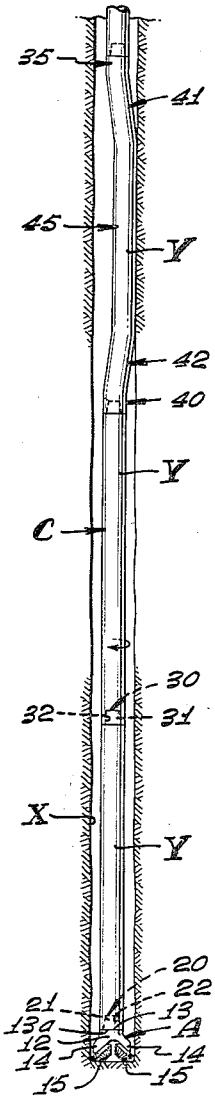


FIG. 3.

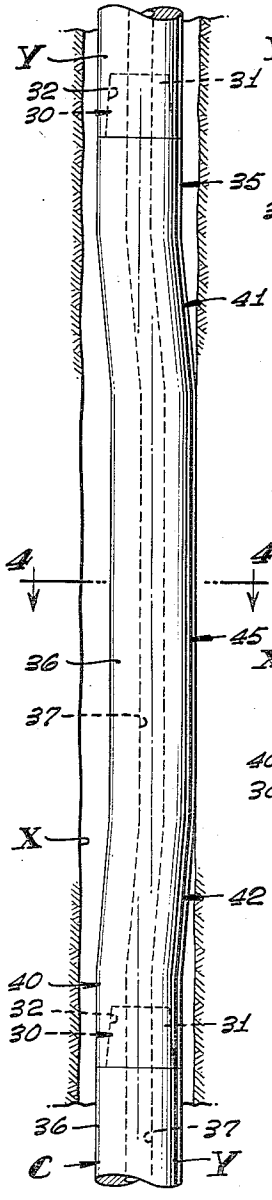


FIG. 5.

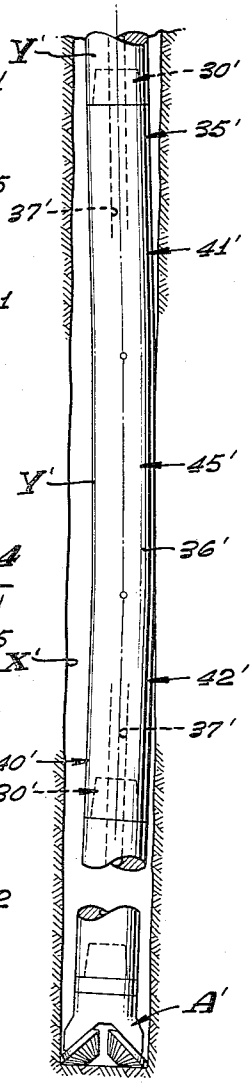
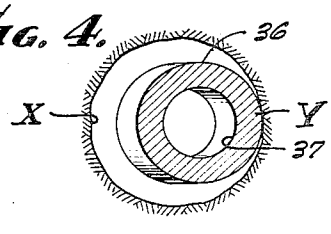


FIG. 4.



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United States Patent Office

2,841,366

Patented July 1, 1958

2,841,366

METHOD AND APPARATUS FOR DRILLING WELLS

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Application October 25, 1954, Serial No. 464,338

11 Claims. (Cl. 255—1.8)

This invention has to do with a method and apparatus for drilling wells and is particularly concerned with controlling and stabilizing the drill collars and bit at the lower end of a drilling string. A general object of the invention is to provide a simple, inexpensive arrangement of elements and a method of using the same that will rapidly penetrate the earth formation and which will effect a straight well bore.

Heretofore considerable difficulty has been encountered in the drilling of wells, particularly oil wells, where the earth formation effects the action of the drilling bit causing the bit to be deflected from the vertical axis or line of drilling. It is accepted that roller rock bits, and the like, drill hole in the direction they are pointed and that the rate of penetration of the bit is usually in direct relation to the amount of weight placed on the bit, it being understood that sufficient circulation of drilling fluid is provided. It is also recognized that deep wells cannot be successfully drilled if allowed to become crooked. For example, the drill collars fail due to excessive bending resulting in fatigue.

In order to overcome the tendency for a drilling string to deviate from vertical as illustrated in Fig. 1 of the drawings, long strings of drill collars have been employed which collars are stiff and tend to keep the bit pointed donnwardly on a vertical axis. However, when the formation is inclined, as shown, the tendency is for the bit to be deflected by the formation. Most formations, especially shale, are encountered in rather thin layers that resist penetration and when the bit breaks through the top of the layer the remaining portion of the layer or the "down dip" portion, breaks up very easily. Therefore, more weight is carried on the "up dip" portion of the bit as indicated at 10 in Fig. 1. It will be apparent that this action unbalances the drill string causing it to lean in the hole and to lie against the wall thereof as indicated at 11 in Fig. 1, and with the result that the drill collar is bent slightly with each revolution of the drill string.

Various means have been employed to keep the collars straight in the well bore including guides and reamers, and by carefully controlling the speed of rotation. High rotary speeds have been used of 250 to 300 R. P. M., however, the present practice is to use anywhere from 150 to 200 R. P. M. depending upon the characteristics of the well formation. When employing rather long strings of drill collars and when rotating them at relatively high rotative speeds, and when a substantial amount of weight is supported by the drilling bit, it has been found that the drill collars become distorted and swing in a side motion which results in side motion waves that progress up the drilling string. The higher the rate of speed the more violent this side motion becomes, and it is very likely that this is the cause of many fatigue failures in drill collars and drill pipe. However, it is this side motion or swing which keeps the collars from lying or hugging one wall or side of the well bore, which action would point the bit off the vertical, and is probably the reason

why a reasonably straight hole can be produced using the method.

One of the limitations of the methods and apparatus now employed is that the amount of weight placed on the bit must be reduced in order to drill a straight hole when the bit is effected by inclined formations (see Fig. 1). The result of reducing the weight is to increase the time required to complete a well.

It is an object of my invention to provide a method and apparatus for drilling wells whereby the action of the drill collars and bit is controlled and stabilized by the provision of an eccentric weight. With the method and apparatus that I have provided the drill collar string is prevented from lying at one side of the well bore and is centralized within the well bore so that the bit is faced downwardly on a central vertical axis.

Another object of my invention is to control the bending or deflection of the drill collars at a point spaced above the drilling bit so that the bit remains concentric with and on a vertical axis within the well bore and so that a straight vertical well bore is produced.

The various objects and features of my invention will be fully understood from the following detailed description of typical preferred forms and applications of my invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a vertical sectional view through a well bore and showing a typical drill collar string and bit as it operates in the bore. Fig. 2 is a vertical sectional view through a well bore showing one form of the apparatus that I have provided. Fig. 3 is an enlarged view of a portion of Fig. 2. Fig. 4 is an enlarged sectional view taken as indicated by line 4—4 on Fig. 3, and Fig. 5 is a view similar to Fig. 3 showing another form of the apparatus that I have provided.

The method and apparatus that I have provided is useful in the drilling of wells and is particularly useful in the drilling of oil wells by the rotary method. The apparatus of the present invention involves, generally, a drill bit A, and a string of drill collars C in a drilling string at the lower end thereof and carrying the drill bit A. The bit A, drilling string and string of drill collars C are adapted to be operated in a well bore X to penetrate the earth formation and to deepen the well. The ordinary rig equipment, such as a derrick, a rotary table and mud pump, etc., may be employed in their usual manner in order to operate the apparatus that I have provided.

The drill bit A is preferably of a typical or conventional type, that is, of a type of known, effective, dependable form and construction. The particular bit A illustrated has a body 12 extending longitudinally of the bit and is provided at its top end with a face 13 to fit against or to oppose the lower end 13a of the string of collars C. The drilling head provided on or carried by the body of the bit is shown as involving depending legs 14, which project downwardly from the body to carry suitable cutters. The legs 14 are shown as carrying cutters 15 that act upon or remove the bottom of the bore. In the particular case illustrated there are three legs 14 equally spaced around the body 12, and these legs carry the cutters 15 so that they act upon the bottom of the well bore and also act upon the wall of the bore to maintain the desired gauge or size.

The bit A is provided with a coupling means 20 that serves to rigidly connect the body of the bit and the lower end portion of the lowermost drill collar. The upper end face 13 of the bit body 12 is in a plane normal to the vertical or longitudinal axis of the bit, and the coupling means 20 involves conventional connecting means concentric with the axis of the bit, for instance, a pin and

socket connection between the lowermost collar and bit body. In the case illustrated a tapered pin **21** is shown located centrally on the face of the body **12** and a socket **22** is provided in the lower end of the lowermost collar to receive the pin **21**.

The drilling string is the driving element of the apparatus that I have provided, and may be driven by means of a kelly supported by a derrick and turned by a rotary table. The drilling string is made up of a series of stands of drill pipe which are screw threaded together or coupled in the usual manner.

The string of drill collars C is carried by the lower end of the drilling string and may be sectional, that is, the string of drill collars may be made up of a plurality of individual drill collars Y coupled together in the usual manner by coupling means **30**. The coupling means **30** serves to rigidly connect the drill collars Y and involves conventional connecting means concentric with the central axis of the drill collars, for instance, a pin and socket connection between each drill collar Y. In the case illustrated a tapered pin **31** is shown centrally located at the end of one drill collar and a socket **32** is provided at the opposing end of the other drill collar to receive the pin **31**.

In accordance with the present invention it has been recognized that a string of drill collars C does not necessarily remain absolutely vertical in a substantially vertical well bore X but, on the contrary, will lie against one side thereof or whip around the well bore in a side motion. This motion of the string of drill collars C results in a buckling or bending of the string C at points above the bit A, and it may be determined from experience where the string of drill collars C will take the natural buckles or bends. Therefore, I have incorporated the features of my invention in the drill collars Y at either one or more of these points. For the purpose of illustration, I have shown the invention as applied to the lowermost point of bend which, in practice, in this case is the third collar above the bit.

In the form of the invention illustrated in Figs. 2 to 4 of the drawings, the drill collar Y which is modified is made so that it has, generally, aligned upper and lower coupling portions **35** and **40**, and an eccentric intermediate portion **45**. The drill collar Y is a typical drill collar and is an elongate cylindrical element with an outer wall **36** and a central longitudinal bore **37**. The aligned upper and lower coupling portions **35** and **40** are on a common vertical axis extending centrally of the well bore and are of sufficient length to accommodate the pin and socket elements of the coupling means **30**. When the drill collar Y is about thirty feet in length the intermediate portion **45** may be approximately fifteen feet in length. As shown, upper and lower offset portions **41** and **42** are provided that extend laterally and inwardly toward the intermediate portion **45** from the coupling portions **35** and **40**, so that the portion **45** is carried on an axis offset laterally from and parallel to the axis of the aligned portions **35** and **40**. The portions of the drill collar above described are formed integrally with each other.

With the drill collar of the present invention, as above described, a maximum amount of weight can be applied to the bit A, whereupon the collar Y with the eccentric intermediate portion **45** will swing by action of centrifugal force in a circular path around the well bore X and have wiping engagement with the side wall of the bore. This wiping action has a beneficial effect since it tends to smooth the wall of the well bore. It will be apparent that as the eccentric portion **45** of the collar Y revolves, the aligned portions **35** and **40** are held concentric with the central axis of the well bore and hold the drill bit A vertically disposed. Thus, the bit A will penetrate the earth formation in a manner to produce a straight vertical bore.

In the form of the invention illustrated in Fig. 5 of the drawings, the drill collar Y' which is modified is made so that it has generally upper and lower coupling portions **35'** and **40'**, and an eccentric intermediate portion **45'**. The drill collar Y' is also a typical drill collar and is an elongate cylindrical element with an outer wall **36'** and a central longitudinal bore **37'**. The upper and lower coupling portions **35'** and **40'** are on substantially vertically disposed angularly related axes and accommodate the pin and socket elements of the coupling means **30'**. In this form of the invention the upper and lower offset portions **41'** and **42'** are, in effect, continuations of the coupling portions **35'** and **40'** and extend laterally and inwardly toward the intermediate portion **45'** from the coupling portions **35'** and **40'**, so that the portion **45'** is carried on an axis offset laterally from and parallel to the axis of the well bore X'.

The angular deviation of the offset portions from the intermediate portion is, in practice, small in number of degrees and the angular relationship acute. In accordance with my invention the angular relationship of the intermediate portion **45'** to the offset portions **41'** and **42'** is such that the bit A' is concentric with the bottom of the well bore X' when the intermediate portion is in contact with the side of the well bore as shown. It will be apparent that when the drill string is rotated the eccentric intermediate portion **45'** will swing by action of centrifugal force in a circular path around the well bore X' and have wiping engagement with the side wall thereof. With this form of the invention the offset portions **41'** and **42'** form a part of the eccentric weight that acts to swing the string to the side of the well bore, and, in addition thereto, the collars above and below the collar Y' rotate eccentrically in the well bore. The bit A' will be held concentric with the vertical axis of the well bore at the bottom thereof by virtue of the angular relationship of the portions of the drill collar Y' as above set forth.

From the foregoing it will be observed that I have provided an extremely simple and inexpensive apparatus effective in the drilling of a well bore and, in accordance with the method of the present invention, it will be apparent that a maximum amount of weight can be applied to the drilling bit. It will be understood that the tool of the present invention can be formed or shaped in a manner to compensate for deflection of the parts thereof caused by weight applied thereto. By providing an eccentric weight at about the point where the first buckle naturally occurs in a string of drill collars and by rotating the entire apparatus at relatively high rotative speeds, the bit A and lower end portion of the string of drill collars is held concentric with the central axis of the well bore so that a maximum amount of weight can be applied, with the result that the earth formation is penetrated as rapidly as possible.

Having described only typical preferred forms and applications of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims:

Having described my invention, I claim:

1. An apparatus for drilling a well bore, including, a drilling string with a rigid drill collar at the lower end thereof, and a drill bit carried by the collar, said collar being initially formed to include, upper and lower coupling portions concentric with the string and the bit, and a straight intermediate eccentric portion extending between the coupling portions and offset from the vertical axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore.

2. An apparatus for drilling a well bore, including, a drilling string with a rigid drill collar at the lower end thereof, and a drill bit carried by the collar, said collar being initially formed to include, aligned upper and lower coupling portions concentric with the string and bit, a straight eccentric portion intermediate the coupling portions and on an axis offset from and parallel to the verti-

cal axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore, offset portions extending laterally and inwardly from the eccentric portion and joining the coupling portions with said eccentric portion, and coupling means at said coupling portions.

3. An apparatus for drilling a well bore, including, a drilling string with a string of rigid drill collars at the lower end thereof, and a drill bit carried by the lower collar, one of said collars being initially formed to include, upper and lower coupling portions concentric with the string and bit, and an eccentric portion intermediate the coupling portions and offset from the vertical axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore.

4. An apparatus for drilling a well bore, including, a drilling string with a string of rigid drill collars at the lower end thereof, and a drill bit carried by the lower collar, one of said collars being initially formed to include, aligned upper and lower coupling portions concentric with the string and bit, a straight eccentric portion intermediate the coupling portions and on an axis offset from and parallel to the vertical axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore, offset portions extending laterally and inwardly from the eccentric portion and joining the coupling portions with said eccentric portions, and coupling means at said coupling portions.

5. An apparatus for drilling a well bore, including, a drilling string with a string of rigid drill collars at the lower end thereof, and a drill bit carried by the lower collar, the collar at the lowermost point of bend in the string of collars being initially formed to include upper and lower coupling portions concentric with the string and bit, and an eccentric portion intermediate the coupling portions and offset from the vertical axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore.

6. An apparatus for drilling a well bore, including, a drilling string with a rigid drill collar at the lower end thereof, and a drill bit carried by the collar, said collar being initially formed to include, angularly related upper and lower end portions with coupling portions concentric with the string and bit, and a straight eccentric portion intermediate the coupling portions and offset from the vertical axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore.

7. An apparatus for drilling a well bore, including, a drilling string with a string of rigid drill collars at the lower end thereof, and a drill bit carried by the lower collar, one of said collars being initially formed to include, angularly related upper and lower end portions with coupling portions concentric with the string and bit, and a straight eccentric portion intermediate the coupling portions and offset from the vertical axis of the string and bit and operable by centrifugal force into engagement with the wall of the bore.

8. The method of drilling a well bore with a drilling string having a rigid drill collar and a bit at the lower end thereof including, placing a single eccentric weight at one side of said rigid collar and engaging the side of the well bore when the bit is concentric with the bore, and then rotating the string so that the said weight is thrown centrifugally against the side of the bore whereby the bit is held vertically disposed and concentric with the bore.

9. The method of drilling a well bore with a drilling string having a string of rigid drill collars and a bit at the lower end thereof including, placing a single eccentric weight at one side of one of said rigid collars and engaging the side of the well bore when the bit is concentric with the bore, and then rotating the string so that the said weight is thrown centrifugally against the side of the bore whereby the bit is held vertically disposed and concentric with the bore.

10. The method of drilling a well bore with a drilling string having a string of rigid drill collars and a bit at the lower end thereof including, placing a single eccentric weight at one side of one of said rigid collars at the lowermost point of bend in the stand of collars and engaging the side of the well bore when the bit is concentric with the bore, and then rotating the string so that the said weight is thrown centrifugally against the side of the bore whereby the bit is held vertically disposed and concentric with the bore.

11. The method of drilling a well bore with a drilling string having a string of rigid drill collars and a bit at the lower end thereof including, placing a single eccentric weight at one side of one of the rigid collars at the lowermost point of bend in the stand of collars and engaging the side of the well bore when the bit is concentric with the bore, and then rotating the string so that the said weight is thrown centrifugally against the side of the bore whereby the bit is held concentric with the bore.

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