

March 10, 1942.

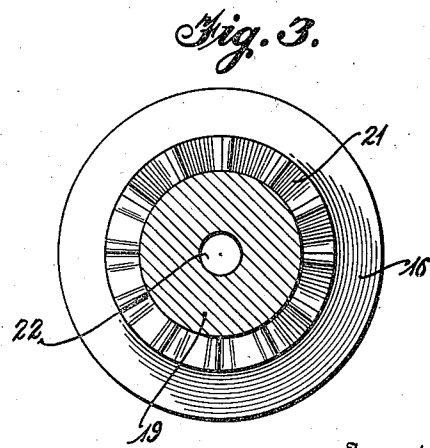
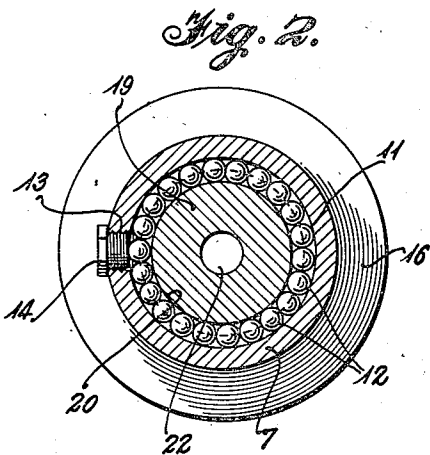
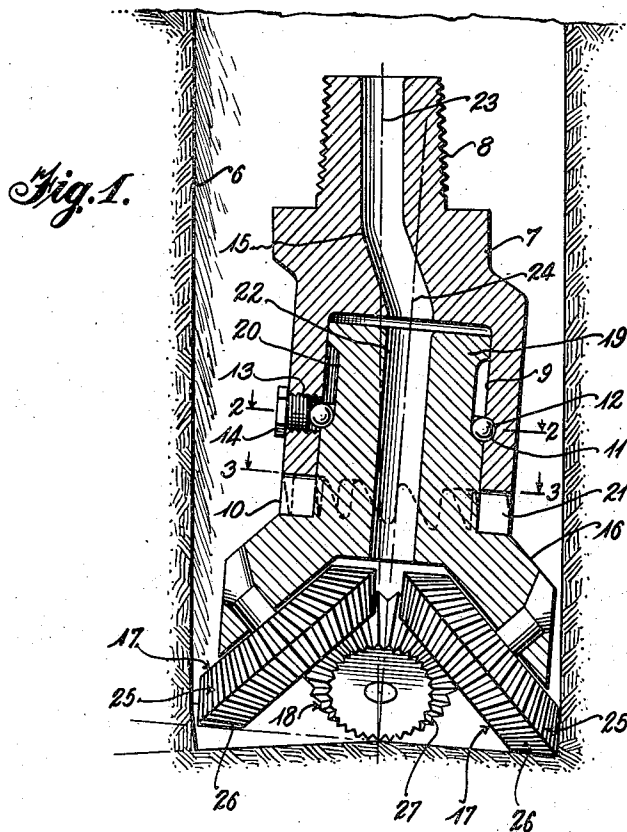
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2,275,832

APPARATUS FOR ROTARY DRILLING

Filed Jan. 29, 1941

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

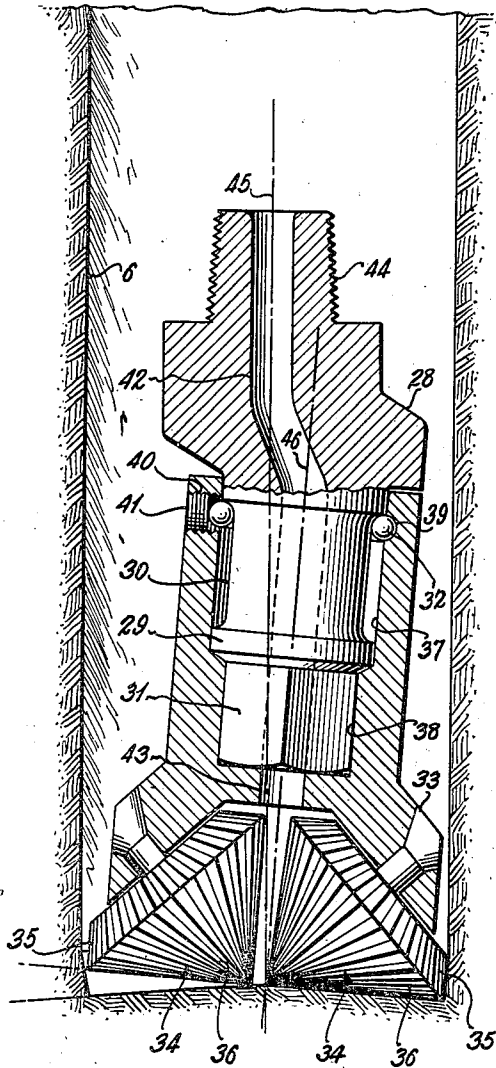
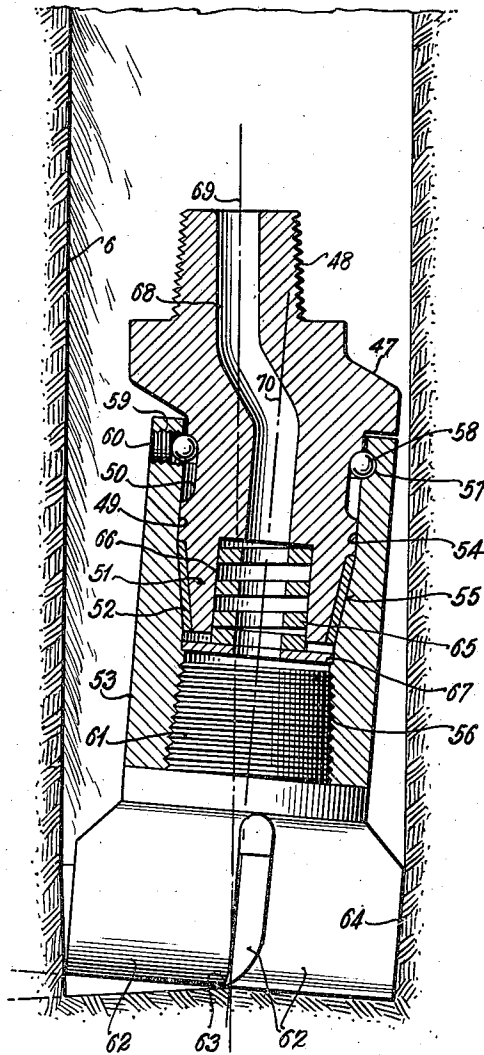


Fig. 5.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR ROTARY DRILLING

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11 Claims. (Cl. 255—61)

This invention relates to new and useful improvements in apparatus for rotary drilling oil wells, or the like.

It is the present practice in rotary drilling to employ bits which have two or more cutters of the roller, cone, or drag type. These cutters collectively provide a working face which is usually flat, or substantially flat, and is symmetrical with, as well as normal to, the axis of the hole. Consequently, the active edges of the cutters, be they the teeth of rollers or cones or the wings of drag bits, all simultaneously engage the bottom of the hole, and the shape of this bottom will correspond with the shape of the aforesaid collective working face of the cutters.

When a hole must be dug through hard formations having great crushing strength, this simultaneous engagement of so many cutting edges with the bottom of the hole makes penetration difficult, and it can only be accomplished by employing heavy drill collars and by applying much drilling weight to the bit.

In drilling holes with a bit that produces a bottom corresponding in shape with the collective working face of the cutters, the various cutting edges all attack the formation at the same angle. This is not a desirable action, particularly with roller or cone cutters, because the teeth of the different cutters have a tendency to track, which will wear out the teeth without making the desired progress.

It is the primary object of this invention to provide apparatus for rotary drilling oil wells, or the like, in which the number of cutting edges simultaneously in contact with the formation at any one time is materially reduced with the result that hard formations may be drilled while using considerably less weight.

A still further important object of the invention is to provide apparatus for rotary drilling which will product greater footage for each bit employed by manipulating the bit in the hole so as to provide an increased reserve of drilling teeth.

Another important object of the invention is to provide methods and apparatus for rotary drilling which will increase the drilling efficiency by preventing tracking of the teeth of the different cutters as a result of repeatedly changing the angle of attack of the cutting teeth against the bottom of the hole.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part

of this specification and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a vertical sectional view of rotary drilling apparatus embodying this invention,

Figure 2 is a transverse sectional view taken on line 2—2 of Figure 1,

Figure 3 is a transverse sectional view taken on line 3—3 of Fig. 1,

Figure 4 is a longitudinal vertical sectional view of a slightly modified form of rotary drilling apparatus embodying this invention, and

Figure 5 is a longitudinal vertical sectional view of a still further modified form of drilling apparatus.

In the drawings, wherein for the purpose of illustration are shown the preferred embodiments of this invention, and particularly referring to Figs. 1 to 3, inclusive, the reference character 6 designates the oil well, or other hole, being produced by the disclosed rotary drilling apparatus. This drilling apparatus includes a shank 7 having the conventional reduced, threaded end 8 to enable the apparatus to be coupled to the conventional drill collar of the drill pipe, both of which are not shown. The lower portion of this shank 7 is hollowed out to form a socket 9 having a circular series of clutch teeth 10 formed on its lower edge. The major portion of the side wall of this socket 9 is of cylindrical formation. An annular groove 11, however, is formed therein to act as the outer race for a circular series of retaining balls 12. These balls may be introduced through the hole 13 that is closed by the threaded plug 14. The shank additionally is provided with a duct 15 for passage of the conventionally employed rotary mud water.

This rotary drilling apparatus is completed by the bit unit which includes the body 16 on which the desired number of roller cutters 17 and 18 are mounted. The remainder of the bit body includes a pin 19 which is fitted for axial sliding movement in the socket 9 of the shank 7. The periphery of this pin 19 is generally cylindrical in shape but is provided with an annular ball race 20 that is of considerably greater width than the ball race 12 formed in the inner wall of the socket 9. It will be appreciated that the greater width of the inner ball race 20 will permit the pin 19 of the bit body 16 to partake of axial movement relative to the socket 9 of the shank, and this relative movement will be limited by the annular series of balls 12 engaging the opposite sides of the extended race 20.

At the base of the pin 19, the bit body 16 is

provided with a circular series of clutch teeth 21 which are intended to cooperate with the clutch teeth 10 of the shank 7 when the shank and bit body are arranged as is shown in Fig. 1, that is, when the series of balls 12 are cooperating with the lower side portion of the extended inner race 20. These cooperating clutch teeth 10 and 21, when properly engaged, will cause the bit body 16 to be driven by the shank 7 when it in turn is rotated by the drill collar and drill pipe. The bit body 16 is provided with a duct 22 which cooperates with the duct 15 of the shank 7 for delivering the rotary mud to the aforementioned roller cutters.

It will be noted by inspecting Fig. 1 that the axis of the hole 6 and the axis of the threaded upper end 8 of the shank 7 are represented by the dash line 23, while the axis of the socket 9 of the shank and the axis of the pin 19 of the bit body are represented by the dash line 24. It is apparent, therefore, that the bit axis is tilted or angularly arranged with respect to the axis of the hole being produced by the bit. This angle may be varied as desired, but it has been determined that an angle of approximately 4° will be preferred.

The roller cutters 17 and 18, disclosed in Fig. 1, are of more or less conventional form. Each one of the two illustrated cutters 17 is provided with a cutting face, or a series of cutting teeth 25 which will determine the shape of the sides of the hole 6. A second cutting face, or series of cutting teeth, 26 is provided on the periphery of each one of the roller cutters 17 and these teeth will help to make the bottom of the hole.

Only one roller cutter 18 is illustrated in Fig. 1, but several similar cutters will be provided to fill the open space between cutters 17 so as to remove the center portion of the hole. The cutters of this type are provided with a series of teeth 27 which will cooperate with the teeth 26 of the cutters 17 for making the bottom of the hole.

With the axis of the bit tilted relative to the axis of the drill hole and with the bit body clutched to the shank in the position illustrated in Fig. 1, the right-hand roller cutter 17 will be the only one of these two side wall producing cutters which will be arranged in a cutting position. In other words, the left-hand roller cutter 17 will be held out of engagement with both the side wall and the bottom of the hole and will be idle. The two inner cutters 18 will be arranged so as to penetrate the formation being worked upon to an equal extent or degree. This equal penetration of the inner cutters 18 results from the particular arrangement of the bit body 16 with respect to the shank 7.

If we now assume that the operator is watching the progress made by the bit and decides that the cutting efficiency of the right-hand roller, when operating in the illustrated position, has been reduced to a predetermined extent, he may then decide that it is time to bring about an adjustment between the shank 7 and the bit body 16. This adjustment is accomplished by raising the drill pipe to a sufficient extent to clear the two sets of clutch teeth 10 and 21. Sufficient relative movement to accomplish this desired result is permitted by the inner ball race 20. Due to the weight of the bit body 16 and its several cutters 17 and 18, the bit will remain stationary while the shank 7, and the drill pipe, are elevated. After the clutch teeth 10 and 21 have been disconnected, the operator may cause

the shank 7 to be rotated to any desired degree relative to the bit. After this angular adjustment has been accomplished, the drill pipe with its shank 7 may be lowered and the two sets of clutch teeth 10 and 21 will re-engage each other.

It will be appreciated, however, that the relative positions of the bit and the shank have now been changed. Any desired number of different relative positions may be provided by employing the proper number of teeth 10 and 21 for the two clutch portions. If we assume that the drill pipe and its shank 7 have been rotated a few degrees in a counter-clockwise direction when viewed from above, the bottom dead center of the illustrated inner cutter 18 will be lowered with respect to the bottom dead center of the right-hand outer cutter 17 and the bottom dead center of the left-hand outer cutter 17 will approach more nearly the plane occupied by the bottom dead center of the right-hand outer cutter 17. Also, the inner cutter 18 which is not shown will have its bottom dead center elevated above the bottom dead center of the illustrated inner cutter 18.

With the various cutters assuming these new relative positions, the shape of the bottom of the hole will be different from that illustrated in Fig. 1 and the two inner cutters 18 will penetrate the formation to a different extent or degree. If the change in relative positions between the bit body 16 and the shank 7 have been sufficient, both of the outer cutters 17 will penetrate the formation at the bottom of the hole but the right-hand outer cutter 17 will still penetrate to a greater extent than the left-hand outer cutter. If the relative adjustment has not been as much as was just assumed, the right-hand outer cutter 17 still will be the only one which is operating to chafe the side wall of the hole and to penetrate the outer or marginal portion of the bottom of the hole and the left-hand outer cutter 17 still will be idle.

It is believed from this explanation of a single adjustment of the bit relative to the shank that persons skilled in the art will appreciate the extent to which the bit may be caused to assume different cutting positions and to attack the formation at different angles. These adjustments will operate to prevent tracking of the teeth of similar cutters, as well as the teeth of all of the cutters and a considerable amount of tooth surface will be maintained in reserve at all times. Of course, the operator will continue to repeat his adjustment of the shank 7 relative to the bit body 16 until he has exhausted the effectiveness of the bit. It then will be necessary to pull out the drill pipe and substitute a new unit of the type illustrated in Fig. 1.

In Fig. 4 there is disclosed rotary drilling apparatus of the same general type as that illustrated in Fig. 1 but a different form of clutch connection is provided between the shank and the bit body while cone cutters instead of roller cutters are employed. The shank, in Fig. 4, is designated by the reference character 28. This shank is provided with a pin 29 that includes a ball race portion 30 and a clutch portion 31. The ball race portion 30 cooperates with the circular series of retaining balls 32 in the same manner as the ball race 20 of the bit body shown in Fig. 1. The clutch portion 31 of the shank is formed exteriorly so as to provide any desired number of flats. Four of such flats are represented by the disclosure of Fig. 4 but it will be

understood that three, five, six, or more flats may be provided, as desired.

The bit body 33 has a suitable number of cone cutters 34 mounted thereon. Each one of these cutters includes a side wall forming set of teeth 35 and a bottom forming set of teeth 36.

The upper portion of the bit body is socketed in a manner to provide a cylindrical socket portion 37 and a clutch portion 38. The cylindrical portion is provided with a ball race 39 that cooperates in an obvious manner to receive the circular series of balls 32. These balls are inserted through the hole 40 which is normally closed by the threaded plug 41. The clutch portion 38 of the socket, of course, is formed with the same number of flats as is provided on the clutch portion 31 of the shank pin.

A suitable duct 42 is provided in the shank 28, including its pin portion, to deliver the rotary mud water to the relatively short duct 43 formed in the bit body 33. The rotary mud water will reach the cutters through these two cooperating ducts. The shank 28 is provided with the conventional, threaded upper end 44 for connection with the drill collar which is carried by the drill pipe.

The axis of the hole 6 and the reduced upper end portion 44 of the shank 28 is represented by the dash line 45. The axis of the bit body 33 and the shank pin portion are represented by the dash line 46. It will be seen, therefore, that the axis of the bit is tilted relative to the axis of the hole.

This rotary drilling unit may be employed in the same manner as the unit illustrated in Fig. 1; i. e., the angle of attack of the active cone cutter or cutters with respect to the formation being drilled may be varied by angularly adjusting the bit body 33 with respect to the shank 28. This relative adjustment may be accomplished by elevating the drill pipe and its connected shank with respect to the bit body 33 a sufficient distance to cause the two clutch portions 31 and 38 to be disconnected. The shank, through the medium of the drill pipe, then may be rotated to a desired degree and lowered into its new position with respect to the bit body 33. As a result of such adjustments, the angle of attack of the cutters may be varied as desired and the number of different relatively adjusted positions will be controlled by the number of flats provided on the clutch portions 31 and 38.

Fig. 5 discloses another modified form of rotary drilling unit. This unit also differs from the preceding units by including a different type of clutch and a different type of cutters. This unit includes a shank 47 which is provided with the conventional, reduced, threaded upper end 48 by means of which the unit may be connected to the drill collar carried by the lower end of a drill pipe, both of which are not shown. The shank is provided with a pin portion that includes a cylindrical part 49, having formed in its periphery an annular ball race 50. A clutch portion 51 also is provided as a part of the shank pin. This clutch portion constitutes the male part of a cone clutch which is provided with the usual clutch leather face 52.

The bit body 53 takes the form of a sleeve, the bore of which is shaped to provide a cylindrical portion 54, a male cone clutch portion 55, and a threaded portion 56. The cylindrical portion 54 is formed with a retainer ball race 57 for receiving the circular series of balls 58 that are positioned through the hole 59 normally closed by

the plug 60. As was the case with the previously described units, the wide ball race 50 cooperates with the retaining balls 58 to permit the shank 47 and bit body 53 to move relative to each other so that these two elements may be angularly adjusted.

The bit disclosed in this Fig. 5 is of the conventional drag type which includes a threaded upper end 61 to be coupled to the threaded portion 56 of the bit body. This bit includes a suitable number of cutting wings 62 which are provided with bottom forming edges 63 and side wall forming edges 64.

If desired, the weight of the bit body 53 and the drag bit may be relied upon to disconnect the clutch parts 51 and 55 when the drill pipe and the drill shank are lifted. It is believed to be more desirable, however, to employ a heavy compression spring 65 for breaking the clutch connection when the drill pipe is elevated. This compression spring is located in a pocket 66 formed in the shank 47 and bears against the inner end of this pocket and a suitable washer 67 which is applied to the inner end of the threaded part 61 of the bit.

A suitable duct 68 is formed in the shank 47 to deliver the rotary mud to the duct of the drill for application to the several wing cutters 62. The axis of the hole 6 and the upper threaded portion 48 of the shank are represented by the dash line 69. The axis of the shank pin and the bit body, with its cutters, is represented by the dash line 70. It is apparent, therefore, that the axis of the bit is tilted relative to the axis of the hole.

It should not be necessary to explain in detail that the shank 47 and the bit body may be adjusted relative to each other by elevating the drill pipe and the shank to break the connection between the clutch parts 51 and 55 of these two elements and then rotating the drill pipe. This adjustment of the bit relative to the shank will function to vary the angle of attack of the various cutters 62 and to vary the cutting action of the same while always maintaining a reserve in cutting edge area which may be successively brought into operative relation with respect to the bottom of the hole until the effectiveness of all of the edges has been lowered to a point where replacement is necessary or desirable.

In the units disclosed in Figs. 1 and 4, it is necessary, or at least very desirable, to stop the drilling operation when an adjustment is to be made between a drill shank and a bit body. With the unit illustrated in Fig. 5, the drilling operation may be stopped when an adjustment is to be made or an adjustment can be accomplished while drilling proceeds. When the latter type of adjustment is desired, the weight of the drill pipe, the drill collar, and the shank may be released from the body 53 and its bit a sufficient extent to permit slippage between the clutch parts 51 and 55. By varying the amount of slippage allowed, the increments of adjustment may be varied in any manner desired.

It is to be understood that the forms of this invention herewith shown and described are to be taken as preferred examples of the same, and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described the invention, I claim:

1. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe for

rotation thereby, a bit body member means for connecting said members so that the axis of the bit body member will be inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative, while others will be inoperative as a result of the inclination of the bit body member axis, means operating to rotate said bit body member with said shank member about the axis of the hole at a speed substantially equal to the rotative speed of the shank member, and means for effecting angular adjustments between said two members to change the operative and inoperative relationship between the said cutting edges.

2. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe for rotation thereby, a bit body member, a telescopic connection between said members allowing for limited relative longitudinal movement, said bit body member being arranged with its axis inclined to the axis of a hole formed by the drill, means operative to rotate said bit body member with said shank member about the axis of the hole at a speed substantially equal to the rotative speed of the shank member, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustment between said two members to change the inoperative and operative relationship between the said cutting edges.

3. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe, a bit body member, means for connecting said members so that the axis of the bit body member will be inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative, while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustments between said two members to change the operative and inoperative relationship between the said cutting edges, comprising cooperating clutch elements carried by both members which are releasable to allow for and are connectable to prevent such adjustment.

4. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe, a bit body member, a telescopic connection between said members permitting relative longitudinal movement, means for limiting said relative longitudinal movement, said bit body member being arranged with its axis inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustments between said two members to change the operative and inoperative relationship between the said cutting edges, comprising cooperating clutch elements carried by both members which are released and connected as a result of said limited relative longitudinal movement between the members.

5. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe, a

bit body member, means for connecting said members so that the axis of the bit body member will be inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative, while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustments between said two members to change the operative and inoperative relationship between the said cutting edges, comprising cooperating sets of clutch teeth carried by both members which are releasable to allow for and are connectable to prevent such adjustment.

6. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe, a bit body member, means for connecting said members so that the axis of the bit body member will be inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative, while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustments between said two members to change the operative and inoperative relationship between the said cutting edges, comprising interfitting pin and socket portions having cooperating flats carried by both members which are releasable to allow for and are connectable to prevent such adjustment.

7. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe, a bit body member, a telescopic connection between said members allowing for limited relative longitudinal movement, said bit body member being arranged with its axis inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustment between said two members to change the inoperative and operative relationship between the said cutting edges, comprising interfitting pin and socket portions having cooperating flats formed as parts of the telescopic connection between said members, said pin and socket parts being released and connected as a result of said limited relative longitudinal movement between the members.

8. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe, a bit body member, means for connecting said members so that the axis of the bit body member will be inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative, while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustments between said two members to change the operative and inoperative relationship between the said cutting edges, comprising a cone clutch having its cooperating parts carried by both members, and means for breaking the connection provided by said cone clutch parts when the shank member is elevated with respect to the bit body member.

9. In a rotary drill for oil wells, or the like, a shank member adapted to be attached for movement with a rotatable drill pipe, a bit body member rotating at the same speed as the shank mem-

ber during normal drilling performance and having its axis inclined to the axis of the shank member, a plurality of cutting edges carried by the bit body member in such a manner that some of the said edges will be operative while others will be inoperative as a result of the inclination of the bit body member axis, and means for effecting angular adjustment between said two members to change the operative and inoperative relationship between the said cutting edges.

10. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe for rotation thereby, a bit body member, means for connecting said members so that the axis of the bit body member will be inclined to the axis of the hole formed by the drill, a plurality of cutting edges carried by the bit body member in such manner that, as a result of the inclination of the body member axis, some of the said cutting edges will carry a preponderance of the drilling load, means operating to rotate said bit body member with said shank member about the axis of the hole at a speed substantially equal to the rotative speed of the shank member, and means

for effecting angular adjustments between said two members to change the load relationship between said cutting edges.

11. In a rotary drill for oil wells, or the like, a shank member for attachment to a drill pipe for rotation thereby, a bit body member, means for connecting said members so that the axis of the bit body member will be inclined to the axis of a hole formed by the drill, a plurality of cutting edges carried by the bit body member in such manner that some of the said edges will be in drilling contact with the formation being drilled while others of said cutting edges will be in less effective contact with the formation as a result of the inclination of the bit body member axis, means associated with said connecting means operative to rotate said bit body member with said shank member about the axis of the hole at a speed substantially equal to the rotative speed of the shank member, and means for effecting angular adjustments between said two members to change the effective drilling relationship between said cutting edges.

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