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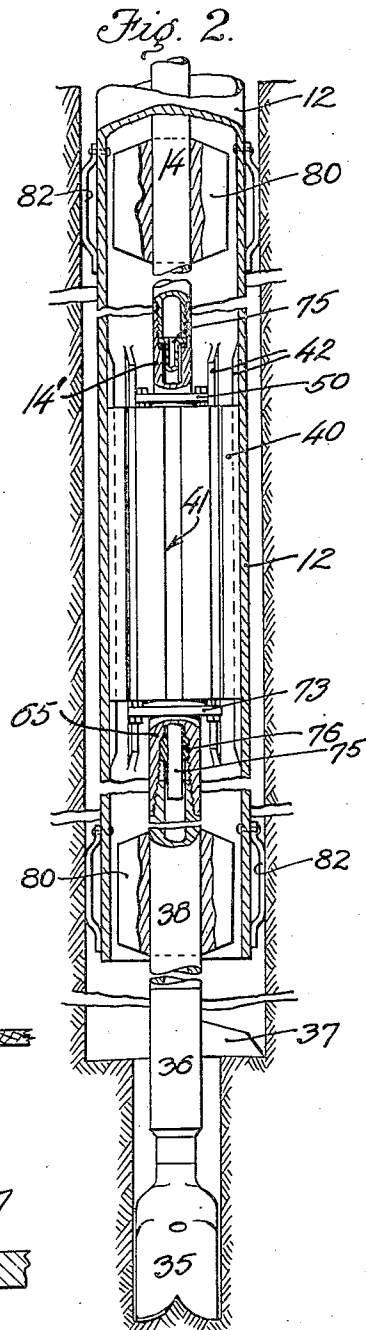
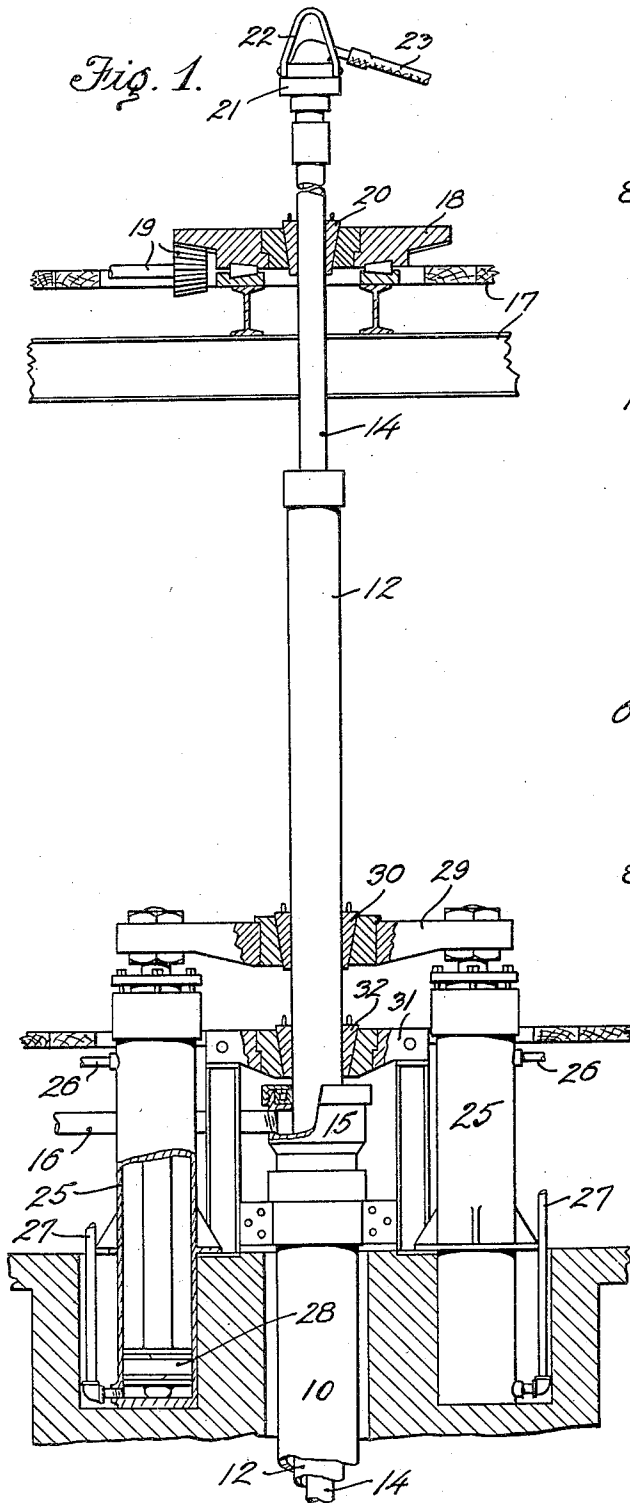
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1,894,039

APPARATUS FOR THE STRAIGHT DRILLING OF WELLS

Filed March 6, 1929

2 Sheets-Sheet 1



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Fig. 3.

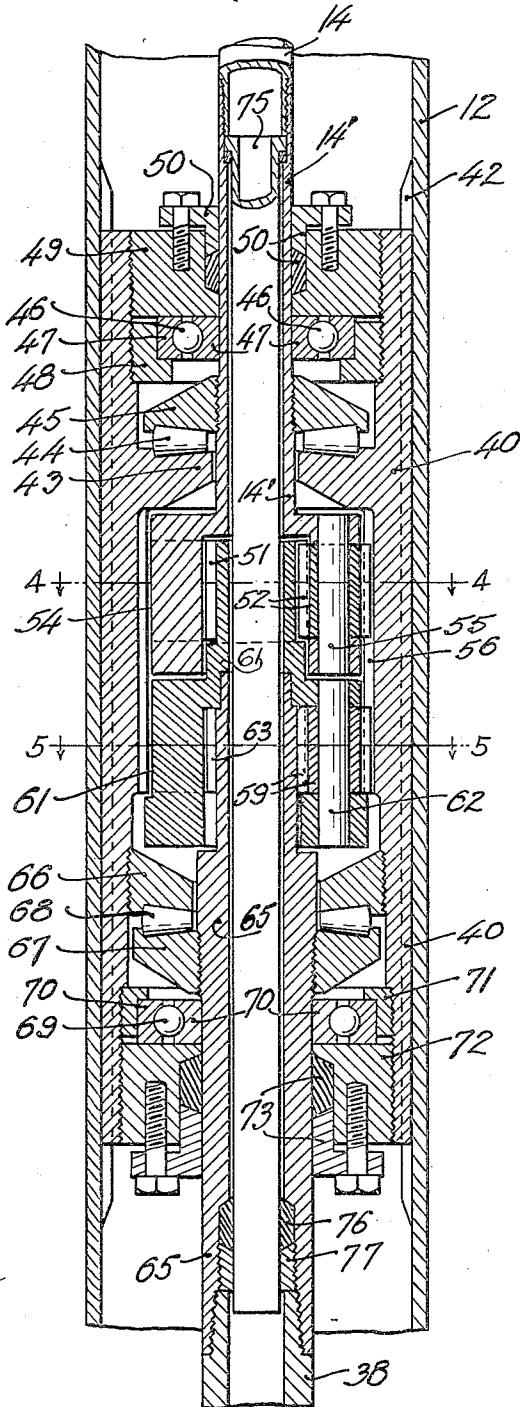


Fig. 4.

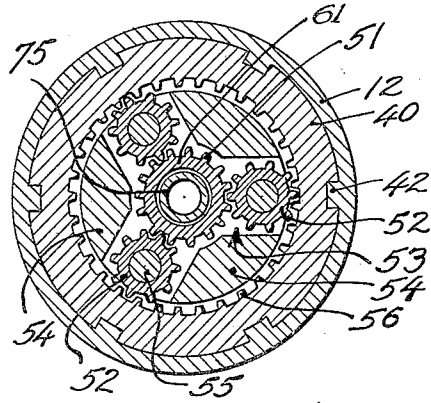
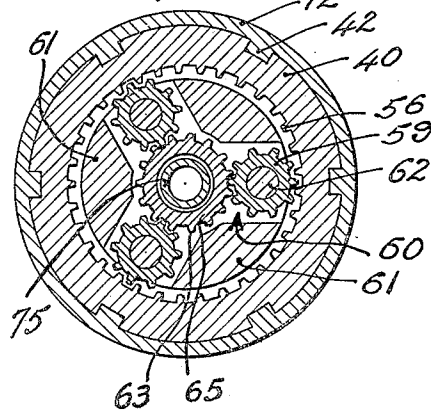


Fig. 5.



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## UNITED STATES PATENT OFFICE

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## APPARATUS FOR THE STRAIGHT DRILLING OF WELLS

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This invention relates to drilling operations, and while not especially limited thereto has been primarily developed for use in the drilling of oil wells.

As deep well drilling operations have been conducted commonly heretofore, a drill stem carrying a bit on its lower end has been rotated with more or less freedom within a casing extending from the surface to a point somewhat above the drill bit. This free positioning of the drill stem and the bit with respect to the casing and the axis of the hole has permitted variation in the direction of the bit under influences tending to change its direction, with the result that nearly all oil wells which have been surveyed show great variations from the perpendicular and many are badly twisted.

I have found that most of the difficulty above mentioned can be avoided and that a substantially straight hole can be obtained by rotating the drill bit at a much higher rate of speed than has been employed heretofore, and that this is especially effective when a speed step-up transmission is employed in the hole at a relatively short distance above the bit. I have also found that the accuracy of the drill's path may be still more closely defined if positioning means are interposed between the drill stem and the casing in such manner as to maintain a substantially constant relation between the axis of the casing and the axis of the drill. In the latter instance the relation of this positioning means is maintained by lowering the casing approximately as the drill advances. Since the step-up mechanism requires a relatively stationary element, this may be conveniently guided and non-rotatably held by the casing, and its vertical position with respect to the casing is maintained by the mentioned lowering of the casing. The speed step-up transmission per se consists primarily of a compound or double planetary gear system in which a head carrying the planet gears of one system is rigidly connected with the pinion or sun gear of the other system. The drill stem proper drives the ring gear of the upper system and the drill bit stem depending therefrom is driven from the sun gear

of the lower system. Various thrust bearings and other bearings are employed together with suitable packing means, and the housing for the whole is non-rotatably held by a splined connection with the casing. Mud is circulated through the drill stem in the usual manner but in view of the positioning of the transmission its return takes place between the casing and the walls of the hole.

In its broad aspect the invention may be considered to reside in rotating a drill bit at an unusually high rate of speed, for example 400 or 500 R. P. M. The invention resides further in employing a speed step-up transmission at a short distance above the bit to accomplish such high rate of drive. The invention resides also in driving the bit at such high rate of speed while maintaining the axis of the bit in a substantially constant relation to the axis of the hole. Since the high rate of speed tends greatly to offset displacing influences such as relatively inclined planes of stratification, the completeness with which the axis of the bit is held with respect to the axis of the hole need not be so closely adhered to as in those instances where the bit is driven at the customary low rate of speed approximating 50 or 100 R. P. M. The invention resides further in a transmission for the purpose stated wherein a compound planetary gear set is employed and a floating gear element acts as a part of and a transmission between the two sets.

In the accompany drawings where one embodiment of the invention is disclosed by way of illustration,

Fig. 1 is chiefly an elevational view of the mechanisms at the surface which are required for operating and handling the drill stem and the casing;

Fig. 2 is a detail partly in section and partly in elevation showing the relation of the speed step-up transmission to the bit and to the lower portion of the casing;

Fig. 3 is an enlarged vertical sectional detail through the transmission; and

Figs. 4 and 5 are cross sections taken on the lines 4-4 and 5-5 respectively of Fig. 3.

In these drawings a conventional outer conductor casing 10 is shown as being sup-

ported from the surface, this casing receiving an inner casing 12 through which a drill stem 14 extends, this drill stem being provided with the usual channel therethrough for the circulation of drilling mud and the casing 10 being provided with a conventional head 15 for the circulation of said mud through the annular space between the casings 10 and 12 and out by the exit pipe 16 leading from said casing head 15. At 17 there is indicated the usual derrick platform provided with a rotary 18 which may be driven through a shaft and gear 19 in order that the drill stem 14 may receive such rotary movement through the medium of slips 20 or other suitable mechanisms for transmitting the motion. The outer end of the drill stem 14 is equipped with a swivel 21 which is provided with a supporting bail 22 and with a mud circulation connection 23 as well understood in the art. By this means the drill stem 14 may be lowered into the well as it is rotated by the table 18 and mud may be simultaneously circulated.

For the purpose of lowering the inner casing 12 as the drilling proceeds, there is provided a pair of hydraulic jacks 25 having the requisite liquid connections 26 and 27 by means of which the liquid is introduced selectively to the opposite sides of the plungers 28, these plungers serving to actuate a spider 29 having rings and slips 30 to support said inner casing 12. Said rings and slips 30 preferably are reversible from the position shown, in order that said casing 12 may be forced downward into the hole if necessary. In order that said casing 12 may be supported independently of the jacks 25, a stationary support 31 provided with slips 32 is located below the spider 29. In this manner said inner casing 12 may be supported at any desired height during adjustment of the jacks 25 or the slips 30.

When a well is being drilled, drill stem 14 carries at its lower end a drill bit 35 of any desired type which is mounted on a section 36 equipped with a reaming element 37, both the bit 35 and the reamer 37 being driven through the medium of a high speed drill bit section 38 carried in the lower part of the casing 12 and driven from the main drill stem 14. Normally the bit 35 and the reamer 37 are positioned only a relatively short distance below the lower end of the said inner casing 12. Usually projection of four or five feet is most efficacious although in some instances comparatively straight holes can be drilled with a projection of as much as twenty feet.

The speed step-up transmission which constitutes an essential element of the present invention comprises a housing 40 adapted to be non-rotatably carried in the lower end of the casing 12 in order that the desired transmission from the drill stem 14 to the bit stem 38 may be accomplished. The pre-

vention of rotation of said housing 40 is accomplished through the medium of grooves 41 in the housing in which longitudinally disposed splines 42 on casing 12 engage. The housing 40 is provided with a transversely disposed wall or partition 43 which is apertured to receive a section 14' which constitutes an extension of the drill stem 14. The upper face of the wall 43 is provided with a track for plurality of cone bearings 44 upon which there travels a circular bearing 45 fixed upon the stem section 14' as by threads as indicated. In this manner the weight of the drill stem 14 is transmitted through the bearings 44 to the housing 40. In order that the stem section 14' may retain proper axial alignment, a ball bearing mounting is provided which comprises balls 46 working in a pair of annular ball races 47 the outer of which is positioned in a shouldered ring 48 threaded into the upper end of the housing 40 and by an upper retaining ring 49 also threaded into the housing 40 and closing the upper end thereof. The tubular section 14' is packed off by means of any suitable packing gland indicated at 50.

The lower end of the stem section 14' drives a pinion or sun gear 51 which engages with a plurality of planet gears 52 disposed in pockets 53 machined in a head 54 fixed on or integral with the section 14'. The sun gear 51 constitutes the upper portion of a floating gear element which will be generally considered as a floating member or gear element 61 presently to be described. Thus the top and bottom walls of each pocket are integral with said head and constitute rigid mountings for the pins 55 upon which the planet gears 52 are journaled. It is to be understood that such bushings and retaining means as may be required in actual practice are here omitted in order to avoid confusion, these features presenting no novelty and being common in the mechanical arts. After the fashion of the usual planetary gear systems, the planet gears 52 in turn mesh with an internal gear 56 provided on the inner walls of the housing 40.

The floating member comprises the sun gear 51 and an integrally connected head 61. A plurality of planet gears 59 are carried in pockets 60 machined in head 61 similar to the head 54 in such manner that the upper and lower walls of said pockets are integral with said head and constitute rigid mountings for pins 62 upon which the planet gears 59 are journaled. Said gears 59 also mesh with the internal gear 56 on the housing 40 whereby bodily rotation of the head 61 with its planet gears 59 causes rotation of a sun gear 63.

The sun gear 63 is secured upon or is integral with a sleeve 65 which passes through

an aperture in a bearing ring 66 threaded into the lower end of the housing 40, said sleeve 65 having secured thereupon as by means of threads an annular bearing 67 which cooperates with the member 66 to provide races for a series of cone bearings 68 which serve to transmit the load of the drill stem 14 from the housing 40 to the sleeve 65 by way of the bearing 67 and thence to the bit stem 38 which is secured on the lower end of said sleeve 65. Lateral thrust is taken by a series of balls 69 working in races provided in annular rings 70 which are positioned by means of an upper shouldered positioning ring 71 threaded into the lower end of the housing 40 and by an annular retaining block 72 also threaded into the lower end of the housing 40. A packing gland generally indicated at 73 serves to pack off the sleeve 65 and prevent entrance of mud or other foreign matter to the bearings 68 and 69.

In operating according to this invention the drill stem 14 is rotated from the rotary table 18 and drive 19 in the usual manner, the bit 35 working upon the bottom of the hole and the under reamer 37 acting to cut out below the casing 12 as indicated in Fig. 2. Drilling mud is introduced through the connection 23 at the surface and passed through the drill stem 14 to the bit 35. The entrance of mud to the joint between the stem 14' and the sleeve 65 may be prevented by any suitable means, that shown consisting of a "wash pipe" 75 flanged at its upper end so as to be bound between the shoulders on the threaded connected sections 14 and 14', said wash pipe extending to the lower end of the sleeve 65 and passing through a packing 76 compressed by a packing retainer 77 threaded into the sleeve 65 in advance of the threaded end of the bit stem 38. Since the housing 40 and associated parts serve to pack off the casing 12 so as to prevent entrance of mud thereto, the return of the mud is caused to take place between the casing 12 and the walls of the hole. As the bit advances in the hole the casing 12 will be lowered by corresponding operation of the hydraulic jacks 25, it being preferable to lower the casing as rapidly as the bit advances. However the casing may be lowered intermittently if the splines 42 are made long enough to permit of a corresponding amount of reciprocation of the housing 40 therealong without disengagement of said housing therefrom.

As the stem 14 and the section 14' are rotated the head 54 causes the sun gear 51 to be rotated at a higher rate of speed together with its head 61, and this second head 61 causes rotation of the sun gear 63 and its sleeve 65 at a still higher rate of speed. For example, a speed step-up of 1 to 10 may be accomplished, so that with a rate of rotation of the drill stem 14 of 50 R. P. M., a speed

of rotation of the bit 35 of 500 R. P. M. may be obtained.

The high rate of speed under which the device is thus operated causes the bit to be less sensitive to all influences tending toward lateral displacement so that the tendency to maintain a straight axis is not materially influenced. Since the fit of the casing 12 within the hole permits of only a limited amount of lateral displacement, and since the transmission housing 40 and contained bearings serve to maintain the relation of the axis of the drill with respect to the casing, tendencies for the bit to become laterally displaced are still further reduced. In extreme cases the relation of the axis of the bit to the axis of the casing may be more positively insured by the provision of bearings 80 of any form at substantially spaced points above and below the transmission housing 40 and within the lower end of the casing 12, as indicated in Fig. 2. It is also within the range of the invention to provide if necessary some sort of positioning element below the casing 12 and the walls of the hole, such as any spring spacing means indicated at 82.

From the foregoing it will be clear that I have presented a desirable and efficient method for insuring straight drilling of deep wells and the like. It should be understood that these disclosures are made merely to illustrate the invention in one form and that I am to be limited only as defined by the appended claims which are capable of many variations within the abilities of those skilled in the art.

I claim:

1. Apparatus for earth boring comprising a drill stem depending within a hole being bored, means to rotate said stem from the surface, a bit connected with the lower end of the stem, and a speed step-up transmission at a short distance above the bit for rotating the bit at a relatively high rate of speed.

2. A construction according to claim 1 wherein the step-up device comprises a set of planetary gears.

3. A construction according to claim 1 wherein the step-up device comprises a plurality of interconnected planetary gear systems, one serving to step-up the speed delivered by the other.

4. A construction according to claim 1 wherein the step-up device comprises a pair of planetary gear systems having a common floating member carrying the planet gears of one set and the sun gear of the other.

5. In combination in drilling mechanism, a main drill stem, mechanical drive means extending from the surface to rotate the same from the surface, a drill bit to be driven from the inner end of said stem, and a speed change transmission interposed between the inner end of the main stem and the bit.

6. A construction according to claim 5

wherein said transmission comprises a double planetary gear system arranged to change the bit speed.

7. A construction according to claim 5 wherein the transmission comprises a double planetary gear system including a floating gear element carrying a set of planet gears of one system and a sun pinion of the other system.

8. In earth boring mechanism, a main drill stem, a casing within which said stem depends, a drill bit connected with the inner end of said stem, means to rotate said stem, a speed step-up transmission between said stem and said bit, including a housing, and a connection between said transmission housing and said casing permitting relative movement axially of the casing and preventing relative rotation between casing and housing.

9. A structure according to claim 8, and means to lower the casing as the bit advances.

10. In earth boring mechanism, a casing, a main drill stem depending within said casing from the surface, means at the surface to drive said stem, a drill bit connected with the inner end of said stem, a housing between said stem and bit, a splined connection between said housing and said casing, and a planetary gear transmission in said housing connected with the stem and adapted to drive the bit.

11. A construction according to claim 8 wherein the stem-rotating means is located at the surface.

12. In combination in earth drilling mechanism, a main drill stem, means to rotate the same, a drill bit to be driven from the inner end of the stem, and a speed step-up transmission interposed between the inner end of the main stem and the bit.

13. A construction according to claim 1, and means to position the axis of the transmission in substantially fixed relation to the walls of the hole.

14. A construction according to claim 12, and means to position the axis of the transmission and the axis of the bit in substantially constant relation to the axis of the hole being drilled.

15. A construction according to claim 12 wherein the step-up transmission comprises a planetary gear set, and means to position the axis of the transmission in substantially constant relation to the axis of the hole being bored.

Signed at Los Angeles, in the county of Los Angeles, and State of California, this 28th day of February, A. D. 1929.

FRANK F. HILL.