Nov. 24, 1936. J. H. HOWARD 2,061,657

WELL BIT

Filed May 13, 1933

Fig. 1

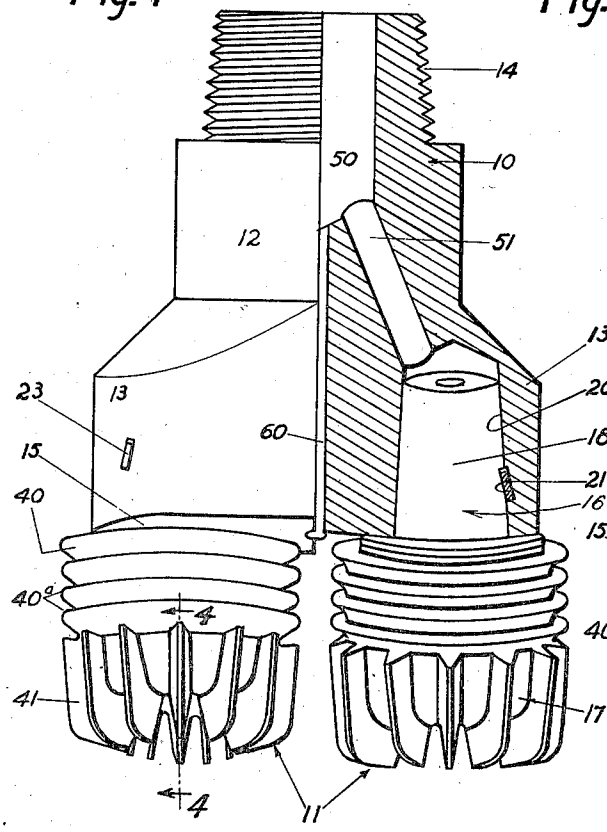


Fig. 2

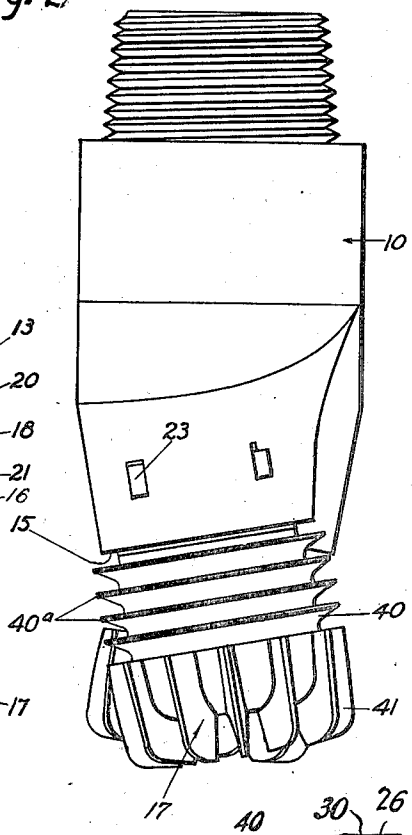


Fig. 3

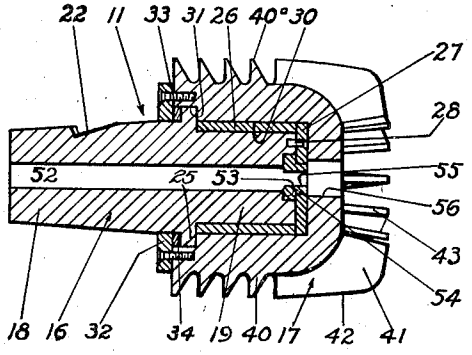
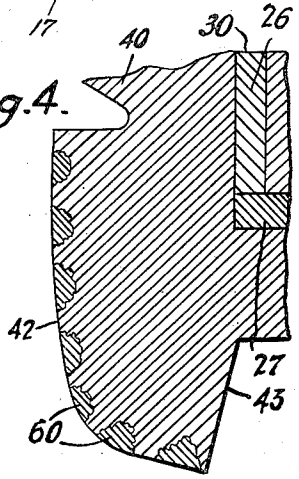


Fig. 4.



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WELL BIT

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Application May 13, 1933, Serial No. 670,845

11 Claims. (Cl. 255—71)

This invention relates to a well drilling tool and relates more particularly to a well bit for use in the rotary method of well drilling. It is a general object of the invention to provide a simple, practical well bit involving novel, improved and particularly effective roller cutters.

One class of rotary well drilling bit that has gone into extensive use includes roller cutters mounted to rotate about axes inclined downwardly and forwardly relative to the direction of rotation of the drill and having longitudinally extending reaming blades and downwardly projecting teeth for acting on the formation at the bottom of the bore. It has been found that the rotation of the cutters is not continuous and that there are times when the cutting teeth on the lower ends of the cutters are dragged through the formation with their outer or reaming edges in trailing positions. When this occurs, the diamond substitutes or hard cutting inserts on the edges of the teeth or cutting parts are often displaced or broken loose as there is no material or backing for supporting them against the outward dragging forces.

It is an object of the present invention to provide a well bit including roller cutters mounted to rotate about axes inclined downwardly and rearwardly relative to the direction of rotation of the drill so that the diamond substitutes or inserts of hard cutting material on the edges of the teeth are not broken loose in the event that the cutters stop rotating. In accordance with the invention, the independently rotatable cutters are inclined downwardly and rearwardly so that the diamond substitutes on the edges of the cutting teeth are subjected to forces acting inwardly toward the axes of the cutters when the cutters stop rotating so that there is little or no tendency for the diamond substitutes to be torn from the teeth.

Another object of the invention is to provide a roller cutter for a well bit having novel and particularly effective reaming and cutting parts.

An object of the invention is to provide a well bit including a roller cutter having reaming cutting parts that have an effective cutting or shearing action on the formation on the sides of the well bore and that act to urge or feed the cutters downwardly into the formation.

Other objects and features of the invention will be best and fully understood from the following detailed description of a typical form and application of the invention, throughout which description reference is had to the accompanying drawing, in which:

Fig. 1 is a front elevation of the bit provided by the invention showing it in one-quarter longitudinal cross section. Fig. 2 is a side elevation of the bit. Fig. 3 is a longitudinal detailed sectional view of one of the cutters and its mounting means, and Fig. 4 is an enlarged fragmentary detailed sectional view of a cutter taken substantially as indicated by line 4—4 on Fig. 1.

The bit includes, generally, a shank or body 10 and cutter assemblies or cutter units 11 on the lower end of the body.

The shank or body 10 of the bit includes an upper cylindrical portion 12 and two enlargements or bosses 13 carrying the cutter units 11. The body 10 is adapted to be operated on the lower end of a string of drill pipe, or the like, and a tapered screw threaded pin 14 is provided on the upper end of the portion 12 to facilitate connection of the body with a drill collar or other part of an operating string. The bosses 13 constitute the lower portion of the body 10, and in accordance with the invention, the bosses are inclined downwardly and rearwardly relative to the forward direction of rotation of the bit. The lower ends 15 of the bosses 13 are flat and are normal to the inclined axes of the bosses. The bosses 13 project outwardly from substantially diametrically opposite sides of the body 10 and their upper ends are inclined downwardly and outwardly.

The cutter assemblies or cutter units 11 each include a stem or pin 16 and a roller cutter 17 rotatable on the pin. The pins 16 have longitudinally tapered upper portions 18 and cylindrical lower portions 19 for carrying the cutters 17. The tapered upper portions 18 of the cutter carrying pins are carried in correspondingly shaped openings 20 in the bosses 13. The openings 20 extend upwardly in the bosses from their lower ends 15 and their axes are inclined downwardly and rearwardly relative to the direction of rotation of the bit and are normal to the lower ends 15 of the bosses. In the particular case illustrated in the drawing, the axes of the pin carrying openings 20 are inclined at approximately 15° to a vertical plane including the central longitudinal axis of the body 10.

Means are provided for removably or detachably retaining the cutter carrying pins 16 in the openings 20. Transverse openings 21 are provided in the bosses and intersect the openings 20. The openings 21 are rectangular or elongate in transverse cross section and are disposed so that their major cross sectional axes are tipped or inclined at slightly greater angles than the walls of

the tapered openings 20 so that the upper portions of the openings 21 intersect the openings 20, while the lower portions of the openings 21 merely join the openings 20. The openings 20 are comparatively narrow and are longitudinally tapered or of diminishing cross section. Notches 22 are provided in the tapered portions 18 of the cutter carrying pins to register with the openings 21 where they intersect the openings 20. Retaining members or wedges 23 are driven through the openings 21 to cooperate with the notches 22 in the pins 16. The inclination of the openings 21 and their tapering walls cause the wedges 23 to force the pins 16 upwardly into openings 20. The retaining member or wedges 23 are comparatively thin and are sufficiently long so that their small ends project from the openings 21. The projecting small ends of the wedges 23 may be distorted or bent over to prevent accidental displacement of the wedges. It will be apparent how the wedges 23 may be driven from the openings 21 to permit the removal of the cutter carrying pins 16 from the openings 20.

The lower portions 19 of the pins 16 for carrying the cutters 17 project downwardly from the lower ends 15 of the bosses 13 to rotatably support or carry the cutters 17 at the lower end of the body 10. An annular radial flange 25 is provided on each pin 16 on the upper end of its cutter carrying portion 19. Wear plates and bushings are provided on the pins 16 that are capable of being replaced so that the cutter carrying pins do not require early replacement. Tubular bushings 26 surround the cylindical portions 19 of the cutter carrying pins and extend from the flanges 25 to the lower ends of the pins. Thrust plates or wear plates 27 are provided on the flat lower ends of the pins 16. The plates 27 may be detachably connected to the pins by dowels 28.

The cutters 17 are in the nature of roller cutters rotatable on the projecting lower portions 19 of the rearwardly inclined pins 16. The bodies of the cutters 17 are substantially cylindrical in their general configuration and have flat upper ends. Central longitudinal sockets 30 extend into the cutters 17 from their upper ends and receive the projecting portions 19 of the cutter carrying pins. The sockets 30 have cylindrically curved walls for cooperating with the bushings 26 and flat bottoms or inner ends for cooperating with the thrust plates 27. Enlargements 31 are provided in the upper ends of the sockets 30 to receive the flanges 25. Means is provided for removably retaining the cutters 17 on the pins 16 and for transmitting longitudinal thrusts from the cutters to the pins. A lock ring or retaining ring 32 is attached to the upper end of each cutter 17 by cap screws 33. The attaching members or screws 33 may be retained against displacement by spot welding. The rings 32 project inwardly over the flanges 25 and washers 34 are interposed between the rings 32 and the flanges. The rings 32 positively hold the cutter 17 against downward movement on the pins 16 and are adapted to transmit downward thrusts from the cutters to the pins.

Each cutter 17 is provided with a set or series of reaming cutting parts 40 and a plurality of lower cutting parts or teeth 41 for acting on the formation at the bottom of the well bore. The reaming parts 40 are important features of the invention as they operate to shear or cut away the formation at the side walls of the well bore and to feed or urge the cutters downwardly. The reaming parts 40 are in the nature of a plurality of longitudinally spaced annular ridges or sharpened flanges surrounding the upper portions of the cutters 17. In the particular embodiment of the invention illustrated in the drawing, the reaming parts 40 are of equal diameter and are continuous or unbroken. The tops or upper sides of the reaming parts 40 are flat and lie in planes substantially normal to the axes of rotation of the cutters 17. The lower sides of the reaming parts 40 are inclined downwardly and inwardly and almost join the upper sides of the reaming parts at their peripheries to provide them with comparatively sharp cutting edges 40a.

When the bit is operated, the body 10 is rotated in a forward or clock-wise direction and the engagement of the cutters 17 with the formation causes them to independently rotate in a counter-clockwise direction. The reaming parts 40 cut a thread or a plurality of grooves in the wall of the well bore and the rotation of the cutters 17 causes the reaming parts to shear off the earth or formation between the thread or grooves they have formed by moving upwardly due to the rearward and downward inclination of the cutters. This threading or cutting of the reaming parts 40 into the side walls of the well bore tends to force or urge the cutters 17 downwardly so as to maintain the teeth 41 in effective cutting engagement with the formation at the bottom of the bore. The inclined lower sides of the reaming parts 40 provides for the ready cutting or threading of the parts into the formation, while the flat upper sides of the parts terminating in the outer peripheral edges 40a are effective in shearing or cutting away the formation between the threads or cuts.

The lower cutting parts or teeth 41 project downwardly from the lower ends of the cutters 17 and are operable to act on the formation at the bottom of the bore. In the preferred construction, there is a plurality of circumferentially spaced teeth 41 on each cutter 17. The cutting teeth 41 extend longitudinally of the cutters 17 and have their upper ends spaced below the lowermost reaming parts 40. The teeth 41 project radially outward from the bodies of the cutters 17 and have outer cutting edges 42 inclined downwardly and slightly inwardly. The lower portions of the teeth 40 projecting from the lower ends of the cutters converge inwardly toward the centers of the cutters and have their inner ends 43 spaced from the central axes of the cutters. The cutting teeth 41 are operable to engage the formation at the bottom of the well bore and operate to cause rotation of the cutters. As the cutters 17 rotate about axes inclined downwardly and rearwardly relative to the direction of rotation of the bit, the teeth 41 are dragged across the formation at the bottom of the bore to have a shearing or dragging action. The cutting edges of the reaming parts 40 and the teeth 41 may be provided with inserts 60 of hard cutting material or diamond substitutes.

Means is provided for discharging circulation fluid from the lower ends of the cutters 17. A central fluid passage 50 extends downwardly into the upper end of the body 10. Branch passages 51 extend downwardly and outwardly from the main passage 50 to the upper ends of the openings 20. The cutter carrying pins 16 are tubular, being provided with central longitudinal openings 52. Enlargements 53 are provided in the lower ends of the passages 52, and the replaceable plates 27 are provided with bosses or nozzle parts 54 which extend upwardly into the

enlargements 53. Restricted fluid openings 55 are provided in the nozzle portions 54 of the plates 27 to discharge the circulation fluid downwardly through central openings 56 in the lower ends of the cutters 17. The comparatively small nozzle openings 55 materially increase the velocity of the circulation fluid as it is discharged under pressure from the lower ends of the cutters. A central fluid discharge passage 60 of reduced diameter extends downwardly from the main fluid passage 50 to discharge from the lower end of the body 10 at a point between the cutters. The cutter mounting means and the fluid handling means are fully claimed in my divisional application entitled Well drilling tool, Serial No. 14,118.

It is believed that the operation of the roller bit provided by the invention will be readily apparent from the foregoing detailed description. During operation of the bit, the engagement of the teeth 41 with the formation causes the cutters 17 to be rotated in a counter-clockwise direction. The reaming parts 40 of the cutters cut into the formation at the side wall of the well bore to form threads or circular cuts, and the advancing and rotating cutters cause the reaming parts 40 to shear off the formation between the threads or cuts thus formed. The cutting engagement of the reaming parts 40 with the formation urges or forces the cutters 17 downwardly. As the reaming parts 40 are continuous or annular and the wear is evenly distributed on their circumferences, they are very long wearing. The teeth 41 on the downwardly and rearwardly inclined cutters are effective in cutting away the formation at the bottom of the well bore as they are dragged over the surface of the formation during the rotation of the bit and cutters to successfully shear away the formation. In the event that the cutters 17 stop rotating, the teeth 41 on the forward parts of the cutters relative to the clock-wise direction of rotation of the bit have their cutting edges leading so that the diamond substitutes 60 embedded therein are not likely to be broken loose. Due to the inclination of the cutters 17, the teeth 41 on the rear of the cutters relative to the direction of rotation of the bit are clear of the bottom of the bore and are not subjected to any wear or dragging action in the event that the cutters stop rotating.

The combination of the annular reaming parts 40 and the radial circumferentially spaced teeth 41 on the downwardly and rearwardly inclined cutters 17 produce a very rapid and efficient cutting action, and insures the smooth steady operation of the bit. The cutter assemblies 11 are detachably connected with the body 10, by the wedges 23 so that they cannot become accidentally displaced during operation. The wedges 23 may be easily removed when it is desired to detach the cutter assemblies for replacement of the cutters or the like. The cutters 17 may be easily dismounted from the pins 16 by removing the rings 32. The bushings 26 and plates 27 take the wear on the pins and may be replaced when worn. The provision of the wear taking bushings 26 and plates 27 permits the pins 16 to be used to carry the new or replacement cutters The flanges 25 and rings 32 provide comparatively large thrust surfaces for taking the downward thrusts on the cutters. The circulation fluid in being discharged downwardly and rearwardly from the lower ends of the cutters 17 during the rotation of the drill, effectively flushes the cutters and causes considerable turbulence in the lower end of the well bore. The circulation fluid discharging from the central outlet 60 effectively washes the reaming parts 40. The bit provided by the present invention is extremely simple and inexpensive of manufacture, and is rapid and effective in its operation.

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

Having described my invention, I claim:

1. A roller cutter for a well bit including, a body, cutting parts projecting from the lower end of the body, and a series of spaced annular circumferential cutting parts of substantially equal diameter on the body above the first mentioned parts, the first mentioned cutting parts and the second mentioned cutting parts having their cutting edges spaced substantially the same distance from the longitudinal axis of the body.

2. A roller cutter for a well bit including a body, cutting parts projecting from the lower end of the body and having cutting edges extending in substantially the same direction as the longitudinal axis of the cutter, and longitudinally spaced annular cutting parts on the body above the first mentioned parts and lying in planes substantially normal to the longitudinal axis of the cutter.

3. A well drilling tool including, a body to be rotated in a well bore, and a cutter projecting from the lower end of the body and rotatable about an axis inclined downwardly and rearwardly relative to the direction of rotation of the body, the cutter having longitudinally extending radial cutting parts projecting longitudinally from its lower end to engage the formation at the bottom of the well bore and longitudinally spaced annular cutting parts projecting from its periphery to engage the formation at the side walls of the bore.

4. A well drilling tool including, a shank to be rotated in a well bore, and cutters carried by the shank and rotatable about axes inclined downwardly and rearwardly relative to the direction of rotation of the shank, the cutters each including a body, and spaced annular cutting parts of substantially equal diameter surrounding and projecting from the body to engage the formation at the side wall of the bore.

5. A well drilling tool including, a body to be rotated in a well bore, and a cutter projecting from the lower end of the body and rotatable about an axis inclined downwardly and rearwardly relative to the direction of rotation of the body, the cutter including cutting blades projecting from its lower end and having cutting edges extending in substantially the same direction as the longitudinal axis of the cutter, and a series of longitudinally spaced circumferentially extending cutting parts for threading into the formation at the side wall of the bore to shear away the same and urge the tool downwardly.

6. A well bit including, a body to be rotated in a well bore, and two substantially diametrically opposite roller cutters projecting from the lower end of the body and rotatable about axes inclined downwardly and rearwardly relative to the direction of rotation of the body, each cutter including a plurality of longitudinally spaced cutting parts extending circumferentially around the

cutter for acting on the formation at the side wall of the well bore, the cutting edges of the cutting parts being comparatively sharp to thread into the formation.

7. A well bit including, a body to be rotated in a well bore, and a roller cutter on the lower end of the body rotatable about an axis inclined downwardly and rearwardly relative to the direction of rotation of the body and including longitudinally extending substantially radial cutting parts projecting from its lower end, hard cutting inserts in the cutting edge portions of said parts, and annular peripheral cutting parts lying in planes substantially normal to the axis of rotation of the cutter to thread into the formation at the side wall of the well bore.

8. A well bit including, a body adapted to be rotated in a well bore, and a roller cutter on the lower end of the body rotatable about an axis inclined downwardly and rearwardly relative to the direction of rotation of the body, the cutter including cutting parts for engaging the formation at the bottom of the bore and reaming parts extending circumferentially around the cutter to be operable through their engagement with the formation to urge the cutter downwardly.

9. A roller cutter for an earth boring tool including a substantially cylindrical cutter body, a multiplicity of longitudinally spaced annular cutting parts surrounding and projecting from the body, and longitudinally extending circumferentially spaced cutting blades projecting from the body below said cutting parts, the blades having longitudinal cutting edges following a substantially cylindrical path.

10. A cutter for an earth boring tool including, a cutter body adapted to rotate about a longitudinal axis, a plurality of spaced annular cutting parts extending around the body, and spaced axially extending cutting blades projecting outwardly from the periphery of the body and downwardly from its lower end, the outer edges of the blades being substantially the same distance from the axis of rotation of the body as the outer edges of said cutting parts.

11. A rotary well drill including a body to be rotated in a well bore, and a cutter at the lower end of the body supported for rotation about an axis inclined downwardly and rearwardly relative to the axis of the rotation of the body, the cutter including a plurality of longitudinally spaced circumferentially extending cutting parts adapted to thread into the side wall of the bore to urge the drill downwardly and shear away the formation, and spaced projecting axially extending blades projecting beyond the lower end of the cutter to act on the formation at the bottom of the bore and having longitudinal outer edges spaced substantially the same distance from the axis of rotation of the cutter as the cutting edges of the said cutting parts.

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