Dec. 16, 1924. 1,519,641

W. N. THOMPSON

ROTARY UNDERREAMER

Filed Oct. 12, 1920 2 Sheets-Sheet 1

Fig. 1

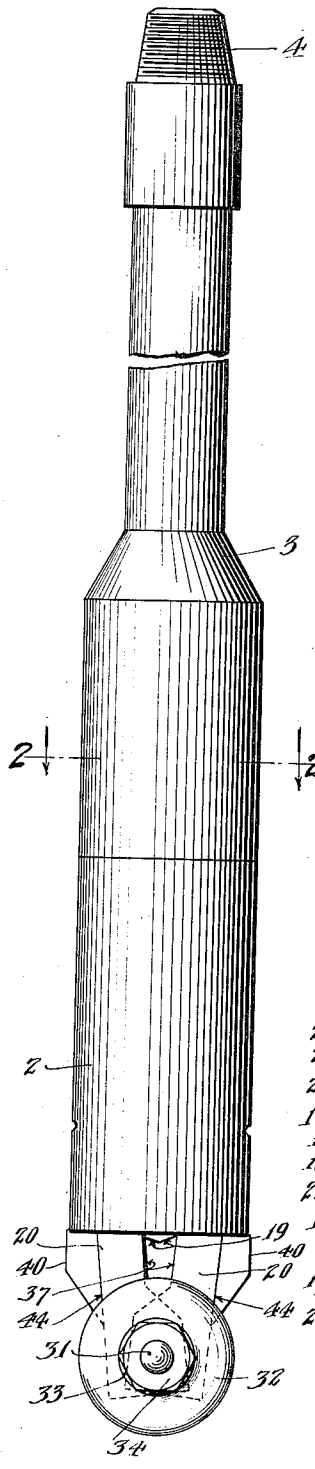


Fig. 3

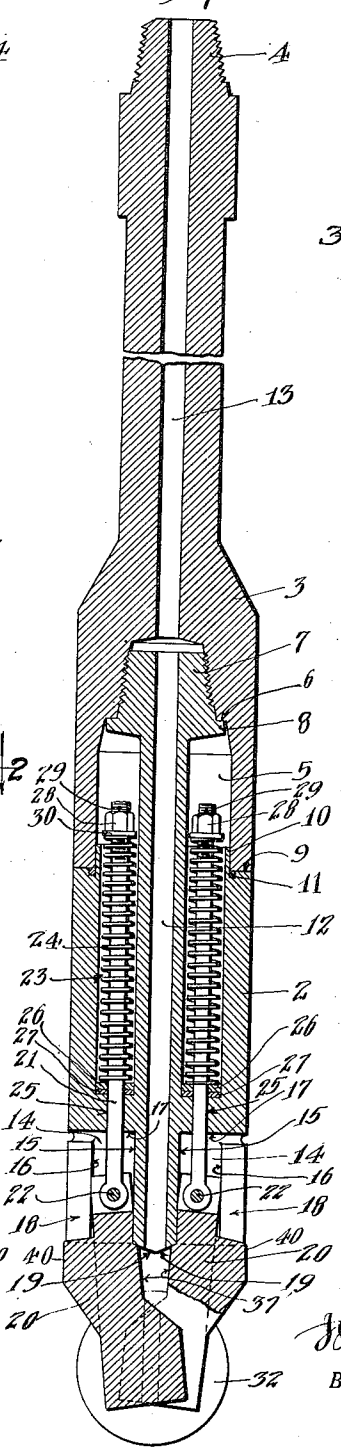


Fig. 2

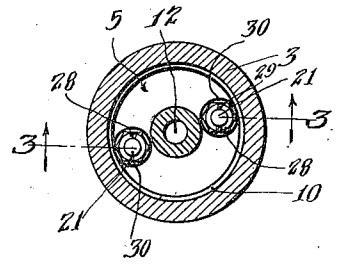
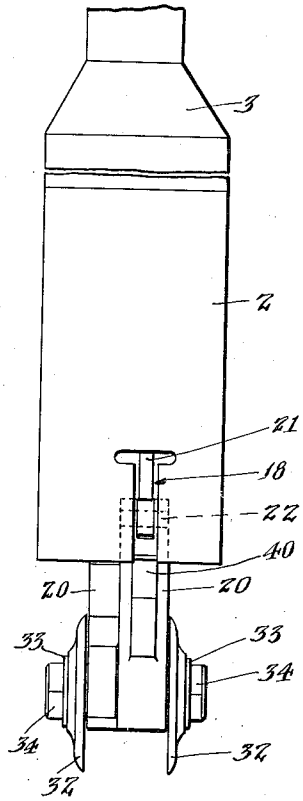


Fig. 4



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2 Sheets-Sheet 2

Fig. 5

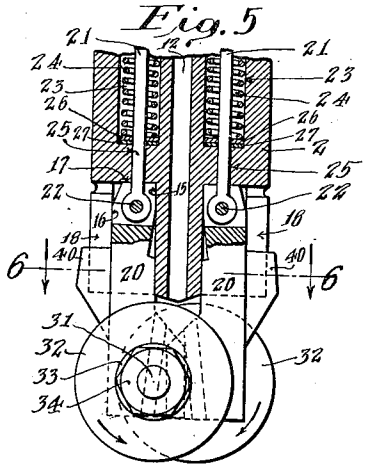


Fig. 6

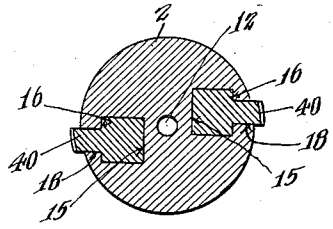


Fig. 10

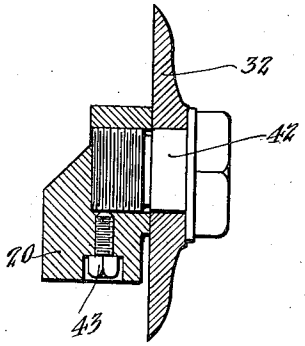


Fig. 7

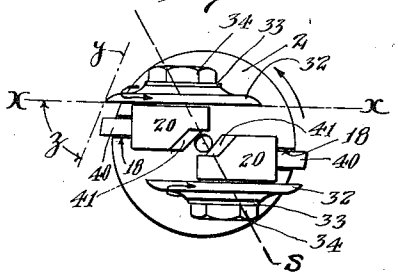


Fig. 11

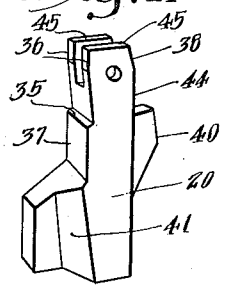


Fig. 8

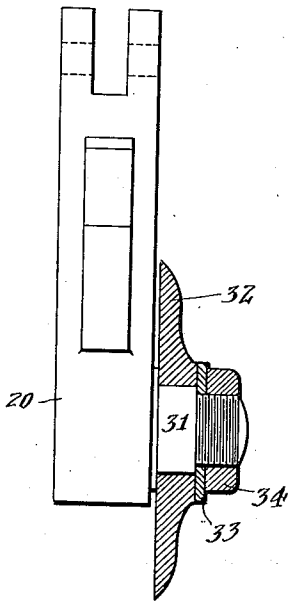
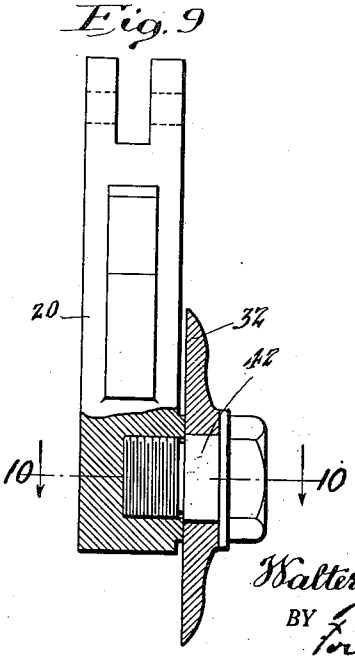


Fig. 9



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Patented Dec. 16, 1924.

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UNITED STATES PATENT OFFICE.

WALTER N. THOMPSON, OF TAFT, CALIFORNIA.

ROTARY UNDERREAMER.

Application filed October 12, 1920. Serial No. 416,491.

To all whom it may concern:

Be it known that I, WALTER N. THOMPSON, a citizen of the United States, residing at Taft, in the county of Kern and State of California, have invented a new and useful Rotary Underreamer, of which the following is a specification.

This invention relates to well boring tools and is more particularly directed to underreamers utilized for enlarging the bore of a well to permit the lowering of the well casing.

The object of the invention is to provide an underreamer adapted for use in connection with the rotary system of well drilling.

Another object is to provide an underreamer in which the cutting elements are freely rotatable and are carried by relatively expansible carriers adjustably supported on the tool body, the carrier being associated with means for automatically translating said carriers to and yieldingly maintaining them in expanded relation for underreaming and adapted to be positively translated to collapsed positions for an insertion of the tool into a well or a withdrawal of the tool therefrom.

Another object is to provide an underreamer having freely rotatable disc cutters capable of being separately removed from their carriers without disturbing any of the other elements of the tool.

Another object is to position the disc cutters in such relation to the wall of the well bore as to cause their individual rotation about their axes by the rotation of the tool within the well bore in an underreaming operation.

Among the several other objects of the invention is the provision of adequate cooperating bearing surfaces of body and carriers to maintain the carriers against displacement, to withstand the various strains to which the parts may be subjected, and to guide the carriers during their translation on the body; efficient and simple means for holding the carriers in expanded position; independent tension means translating each carrier in its automatic operation; disc cutters which as parts for replacement are exceedingly economical of manufacture, are of great durability and may be quickly and conveniently disconnected from or connected to their carriers; and such a construction and arrangement of parts as shall be very strong and durable, positive in operation and efficient in function.

Various other objects and advantages will be fully set forth in the following description of the accompanying drawings, which form a part of this disclosure, and which illustrate a preferred form of embodiment of the invention.

Of the drawings:

Figure 1 is a front elevation of the underreamer of the present invention, showing the cutters in collapsed position.

Fig. 2 is a plan section on line 2—2 of Fig. 1.

Fig. 3 is a longitudinal section on line 3—3 of Fig. 2.

Fig. 4 is a side elevation of the lower portion of the underreamer looking at the right hand side of Fig. 1.

Fig. 5 is a section of the lower portion of the underreamer, similar to Fig. 3, showing the cutters in expanded position.

Fig. 6 is a plan section on line 6—6 of Fig. 5.

Fig. 7 is a bottom plan view of Fig. 6.

Fig. 8 is an enlarged edge elevation of one of the carriers and disc cutters illustrating one form of disc pivot.

Fig. 9 is a similar elevation illustrating a second form of disc pivot.

Fig. 10 is a plan section on line 10—10 of Fig. 9.

Fig. 11 is a detail perspective view of one of the cutter carriers looking at the inside face thereof.

With reference to the drawings, 2 designates the body proper which carries the operating elements of the tool, and 3 the "sub" which has the usual form of tapered screw-threaded head 4 for connection with the drill tubing in the well known manner.

The lower end of the "sub" is recessed to provide a chamber 5 with the upper portion of the chamber wall threaded and formed to provide an abutment seat 6. The body 2 has an axial shank projecting upwardly into the chamber 5 and provided with a screw-threaded head 7 engaging the threaded wall of the chamber and an annular shoulder 8 engaging the seat 6. The upper end of the body 2 is reduced in diameter to provide a seat 9 and to form a boss 10 fitting into the lower end of the chamber 2 and at the base of the boss the body is grooved to receive a packing ring 11. When the parts

are screwed together the lower edge of the "sub" engages and compresses the packing ring into the groove to form a fluid tight joint, the boss 10 assisting in maintaining the two parts in true axial alignment. The body 2 and the sub 3 are provided with relatively aligned longitudinal ducts 12, 13, the duct 13 communicating with the drill tubing and the duct 12 extending to the lower end of the body, the ducts entraining lubricating and flushing fluid, such as water, from the tubing to the cutters.

The lower end of the body 2 has two longitudinal pockets or ways 14, 14 disposed on opposite sides of the axis of the body and of substantially square cross-sectional contour. These ways define opposed inthrust bearing surfaces 15, 15 and outthrust bearing surfaces 16, 16, the top walls of said ways providing end thrust bearing surfaces 17, 17. The outer walls of the pockets are longitudinally slotted as at 18, 18 and the medial portion of the lower end of the body between the pockets is formed to provide beveled expanding surfaces 19, 19. It will be seen, by reference to Fig. 6, that the pockets 14, 14 are not diametrically aligned but are disposed in substantially parallel planes on opposite sides of the longitudinal axis of the body. The purpose of this disposition will be later pointed out.

Slidable within the pockets or ways 14, 14 are cutter carriers 20, 20 each having bifurcated upper ends, and positioned between the furcations of each carrier is the lower end of a spring rod 21, each rod being attached to its companion carrier by a transverse pivot pin 22. The body is provided with parallel longitudinal bores forming spring chambers 23, 23 to receive coil springs 24, 24, and secondary bores 25, 25 extending through the upper walls of the pockets 14, 14 and axially aligned with the chambers 23, 23. The rods 21, 21 extend upwardly through the bores 25, 25 and through the spring chambers 23, 23, said rods having a sliding fit in the bores 25, 25.

Each spring 24 surrounds its companion rod 21 and seats on a washer 26 loose on the rod, the washer engaging a packing ring 27 serving to prevent such fluid as may leak past the shank head 7 from entering the way 14. The upper ends of the rods 21 are threaded to receive nuts 28, 28, and are provided with transverse cotter pins 29, 29 preventing the nuts from working loose. The upper ends of the springs engage loose washers 30, 30 which in turn engage the nuts, the springs exerting their tensions to urge the rods upwardly.

Each of the cutter carriers has a substantially square shank adapted to slide in one of the pockets 14 of the body, and an enlarged lower end provided with a laterally disposed bearing stud 31 (see Fig. 8) upon which is rotatably journaled a cutter disc 32, a washer 33 and nut 34 retaining the disc on the stud. The inner vertical surface of each carrier is notched to provide an expansion shoulder 35 and also to provide clearance permitting the carrier being moved to collapsed position, as shown in Fig. 3. The portions 36, 37 above and below the shoulder 35 may be termed carrier inthrust surfaces, in that they engage the inthrust bearing surface 15 of the body when the carrier is in expanded position, as shown in Fig. 5, and transmit all inward transverse thrusts applied to the cutter, directly to the body. Likewise the outer vertical surfaces 44 of the carriers, may be termed carrier outthrust surfaces, in that they engage the outthrust bearing surfaces 16, 16 of the body, and the upper end surfaces 45 of the carriers may be termed carrier end thrust surfaces, for the reason that they engage and transmit to the end-thrust bearing surfaces 17, 17 of the body all vertical thrusts to which the cutters are subjected.

The upper end of the outer vertical surface of each carrier is angled, as at 38, to permit the tilting of the carrier in a collapsing operation.

Extending laterally from the outer vertical surfaces of the carriers 20, 20 are key wings 40, 40 which are adapted to slide in the respective slots 18, 18 of the body, and when the carriers are in expanded position these key wings project beyond the body in position to contact the end of the casing or casing shoe during a withdrawal of the underreamer from the well, said withdrawal causing the carriers to be lowered relative to the tool body and then forced inward to collapsed position. The key wings 40, 40 also serve as additional means for preventing an axial twisting of the carriers in their pockets or ways.

By reference to Figs. 7 and 11, it will be noted that the inner corners of the enlarged portions of the carriers are cut away as at 41 so as to avoid interference of the carriers, one with the other, when in collapsed positions. Figs. 9 and 10 illustrate a modified form of journal connection for the cutter discs, and in this form instead of having a stud integral with the carrier, as previously described, a detachable screw-threaded shouldered screw 42 is provided, said screw being maintained in set position by a set screw 43 tapped into the body of the carrier and engaging the threaded portion of the screw 42.

From the above it will be evident that with the cutter carriers in collapsed position as shown in Fig. 3 and with the expansion shoulders 35 engaging beneath the beveled expansion surfaces 19, 19 of the body, upward movement of the rods 21, 21 of the springs 24, 24 will cause the expanding or

wedging apart of the cutter carriers, the shoulders 35 riding outwardly and upwardly on the expansion surfaces 19, 19 of the body and the carriers then being vertically translated upwardly in the pockets or ways 14, 14, to the expanded positions shown in Fig. 5. In a collapsing operation the engagement of the well casing or casing shoe with the key wings 40, 40 of the carriers 20, 20 will cause the carriers to be lowered relative to the tool body, to collapsed or folded in position, first moving down in a straight vertical direction until the shoulders 35 reach the expansion surfaces 19, 19 and then said shoulders ride inwardly and under the surfaces 19, 19, the carriers swinging about the pivot pins 22, 22 to the collapsed positions shown in Fig. 3. The adjacent faces of the carriers are cut away to permit them to overlap when in their collapsed position.

With reference to Fig. 7 it will be pointed out that the cutter discs 32, 32 are disposed in spaced relation and in relatively parallel planes on opposite sides of the vertical axis of the tool. That is to say, each disc is located in a plane approximately parallel with the longitudinal axis of the body 2. Hence when the body 2 rotates, the edges of the discs sweep through the earth with a lateral movement. It may also be said that each cutter disc is disposed in a vertical plane X which is transversely angled relatively to a tangent y coincident to the cutting edge of the cutter and the circumference of rotation of the tool, this angle z being 90° less an angle greater than the angle of repose. The effect of this angular disposition will be to cause the disc cutters to rotate in the directions indicated by the arrows in Figs. 5 and 7, with the cutter edges engaging the well wall, traveling downwardly and inwardly to continuously present to the wall different portions of said cutting edges and to cause the cutters to wear evenly and maintain their true circular form. Any decrease of the angle z will result in an increase in the speed of rotation of the cutter discs.

In other words, it may be pointed out that if the plane of a rotary disc cutter of this character were coincident to the radius of rotation the cutter would engage the wall of the well bore with a scraping action, whereas, when positioned in a plane which is transversely angled relative to the radius of rotation a cutting action is produced which has a tendency to rotate the cutter. If we may consider that a line s which intersects the axial centers of the cutters designates the radial disposition of the cutters, the cutters may be said to be disposed in planes which are angled relative thereto, that is, the cutters are disposed in relative planes which are angularly disposed relative to the plane of their radial disposition.

In referring to the cutter discs as being each located in a plane approximately parallel with the longitudinal axis of the body 2, it should be understood that I mean to say that the plane of each disc should extend in the same general direction as the axis of the body. In order to get the best effect it is advisable to have the plane of each disc disposed substantially parallel with this axis but it is obvious that an underreamer in which the plane of each disc merely extends in the same general direction as the axis could operate very effectively and in operating would function so that the edge of each disc would sweep in a direction lateral to the plane of the disc through the earth.

As stated above, the direction of rotation should be that indicated in Figure 7; with this direction of rotation the cutting edge of the disc is disposed toward the rear with respect to the direction of rotation and with respect to the medial vertical plane parallel with the discs and passing through the axis of the body 2.

I claim:

1. A rotary underreamer having a body providing opposed ways, relatively expansible carriers slidable in said ways, cutter discs journaled on the carriers, and means for translating the carriers, the body being provided with means causing an expanding separation of the carriers during their upward translation, the cutter discs being positioned in relative spaced vertical planes on opposite sides of the vertical axis of the body, each cutter disc lying in a plane substantially parallel to the plane in which the carriers move in their collapsing and expanding movement, the parts being so arranged that, when the device is reaming, if a horizontal line be drawn from the axis of the reamer to the remotest point of the cutter, and a second horizontal line be drawn through the said remotest point perpendicular to the first line and extending forwardly therefrom in the direction in which the body rotates, this second line will make an obtuse angle with the forwardly advancing face of the cutter.

2. A rotary underreamer having a body providing opposed ways, relatively expansible carriers slidable in said ways, cutter discs journaled on the carriers, and means for translating the carriers, the body being provided with means causing an expanding separation of the carriers during their upward translation, the cutter discs being positioned in respective planes which are substantially parallel, each cutter disc lying in a plane substantially parallel to the plane in which the carriers move in their collapsing and expanding movement, the parts being so arranged that, when the device is reaming, if a horizontal line be drawn from the axis of the reamer to the remotest point of the cutter, and a second horizontal line be

drawn through the said remotest point perpendicular to the first line and extending forwardly therefrom in the direction in which the body rotates, this second line will make an obtuse angle with the forwardly advancing face of the cutter.

3. A rotary underreamer comprising a body having opposed slideways, carriers slidable in said ways, means for translating the carriers, the body being provided with means for transversely expanding the carriers during their upward translations, and cutter discs journaled on the carriers and lying in planes substantially parallel to the direction of expansion of the carriers, the parts being so arranged that, when the device is reaming, if a horizontal line be drawn from the axis of the reamer to the remotest point of the cutter, and a second horizontal line be drawn through the said remotest point perpendicular to the first line and extending forwardly therefrom in the direction in which the body rotates, this second line will make an obtuse angle with the forwardly advancing face of the cutter.

4. A rotary underreamer comprising a body having opposed ways defining inthrust bearing surfaces, opposite out thrust bearing surfaces, and upthrust bearing surfaces, carriers slidable in said ways, means for translating the carriers upwardly to engage the bearing surfaces and expanding outwardly, and cutter discs journaled on the carriers and lying in planes substantially parallel to the direction of travel of the carriers, the parts being so arranged that, when the device is reaming, if a horizontal line be drawn from the axis of the reamer to the remotest point of the cutter, and a second horizontal line be drawn through the said remotest point perpendicular to the first line and extending forwardly therefrom in the direction in which the body rotates, this second line will make an obtuse angle with the forwardly advancing face of the cutter.

5. A rotary underreamer, comprising a body having opposed ways and intermediate expanding surfaces, carriers slidable in said ways and having expansion shoulders cooperating with the expanding surfaces, means for translating the carriers over the expanding shoulders to expand the carriers, and disc cutters journaled by the carriers to move in a direction substantially parallel to the plane of their cutting edge upon expansion of the carriers, the parts being so arranged that, when the device is reaming, if a horizontal line be drawn from the axis of the reamer to the remotest point of the cutter, and a second horizontal line be drawn through the said remotest point perpendicular to the first line and extending forwardly therefrom in the direction in which the body rotates, this second line will make an obtuse angle with the forwardly advancing face of the cutter.

6. A rotary underreamer having a body with opposed slideways, carriers slidable in the ways and provided with surfaces to expand the carriers when upwardly translated, means for translating the carriers, and disc cutters having a diameter substantially the size of the body and journaled on the carriers, said disc cutters mounted to move with the carriers in a direction substantially parallel to the plane of their cutting edge.

Signed at Taft, California, this 20th day of September, 1920.

WALTER N. THOMPSON.

Witnesses:

R. L. BURNS,

CHAS. O'NEIL.