Jan. 5, 1932. W. N. PACKER 1,839,771

EXPANSIVE UNDERREAMER

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Fig. 1.

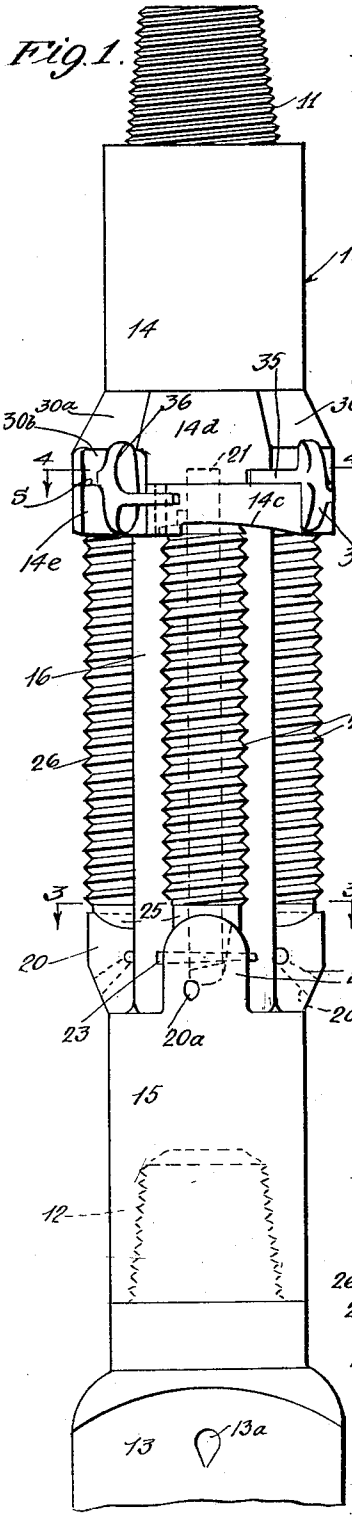


Fig. 2.

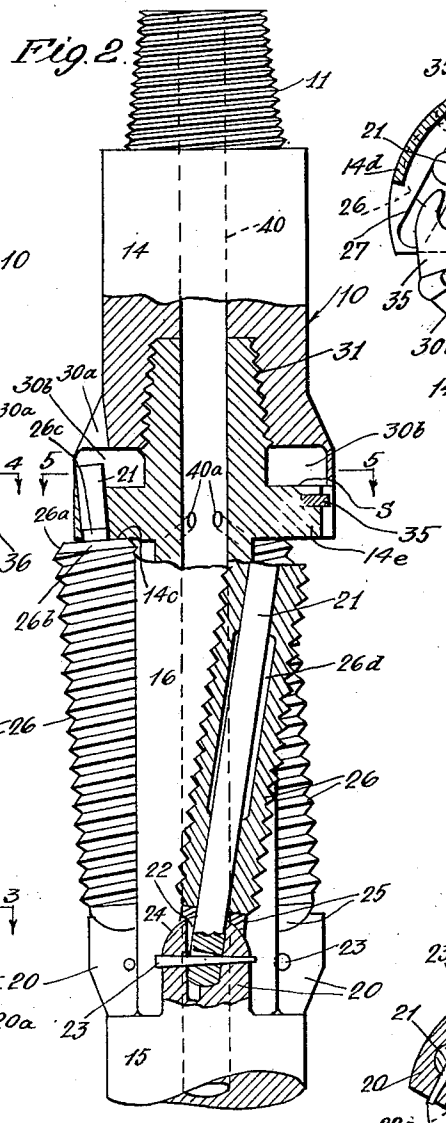


Fig. 4.

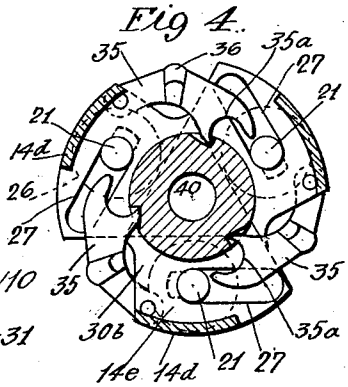


Fig. 3.

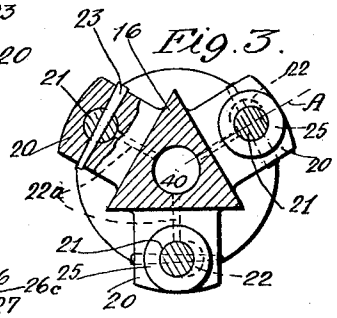
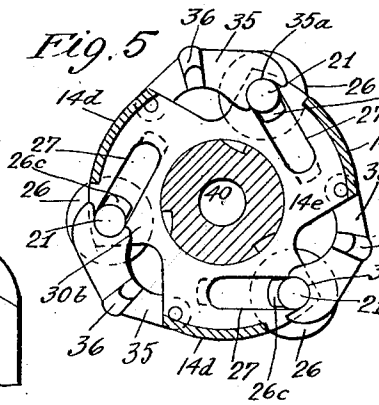


Fig. 5



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Fig. 6.

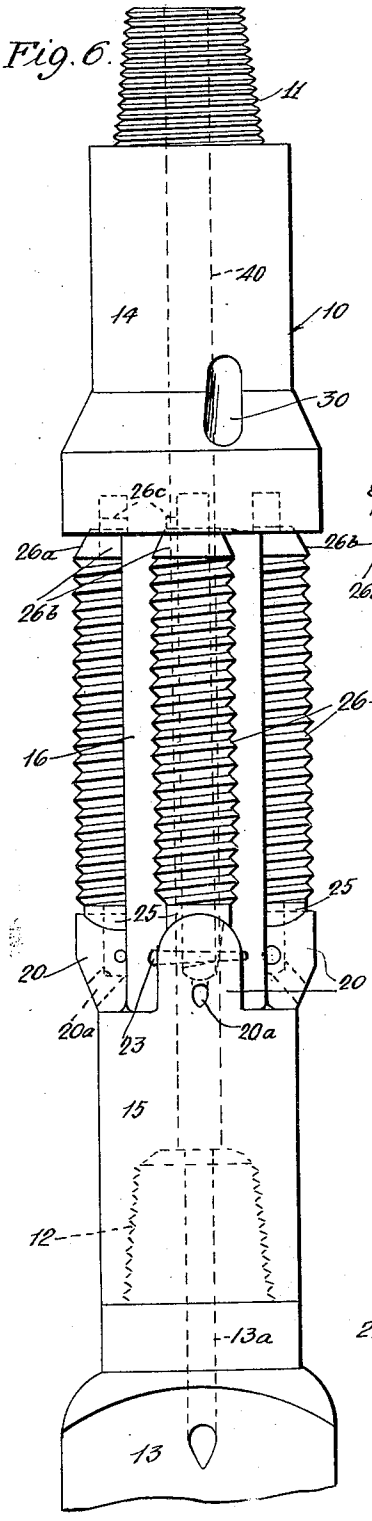


Fig. 7.

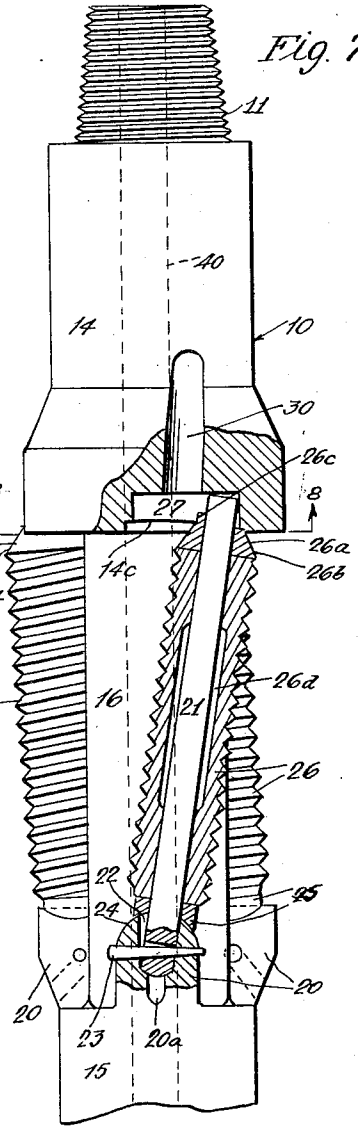
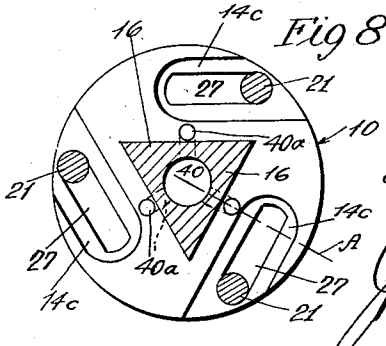


Fig 8.



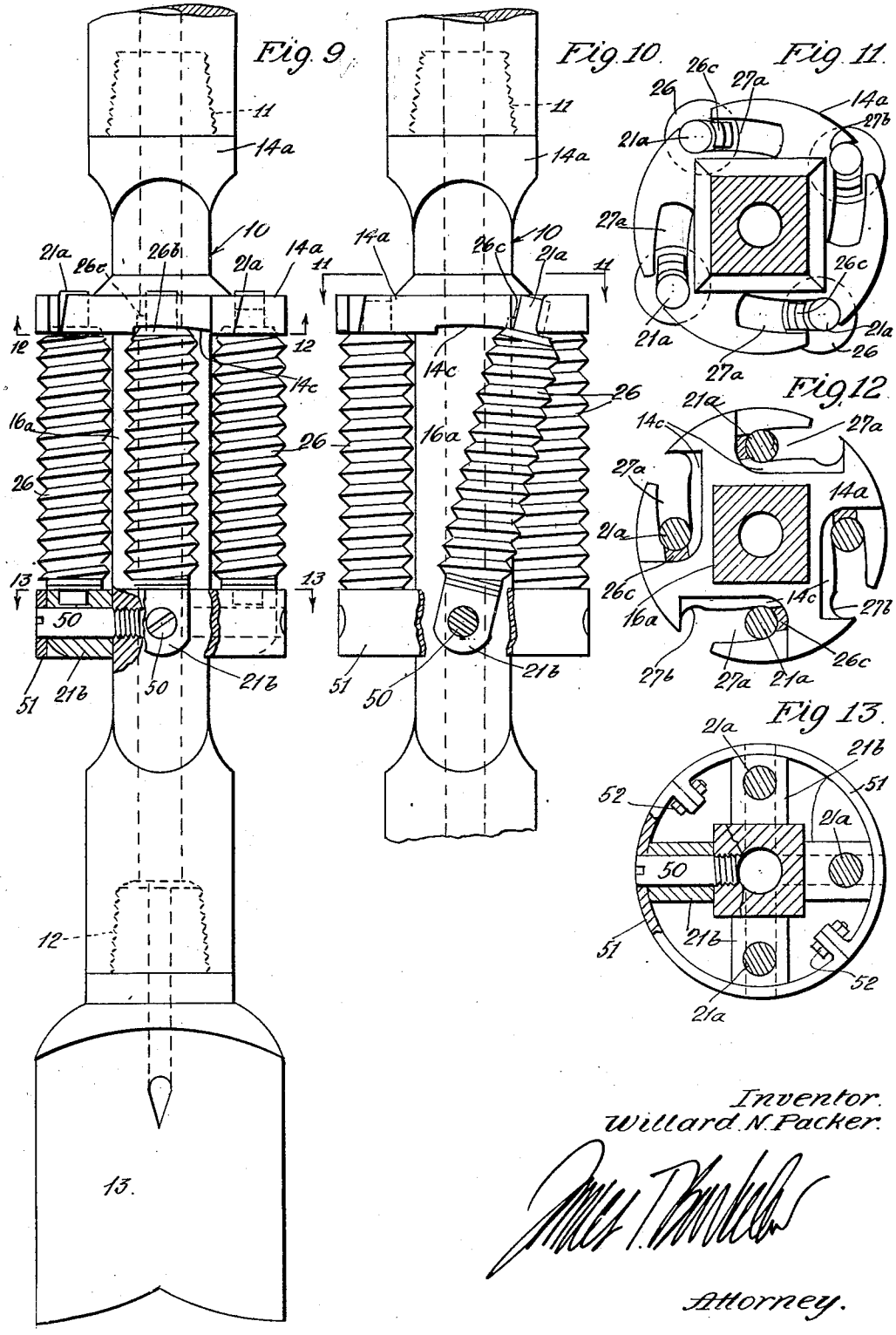
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Patented Jan. 5, 1932 1,839,771

UNITED STATES PATENT OFFICE

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EXPANSIVE UNDERREAMER

Application filed October 8, 1928. Serial No. 310,961.

This invention has reference to the art of rotary under-reaming in wells and the art of expansive reaming tools; and the general object of the invention is the provision of a simple, reliable, and rugged form of underreamer or expansive reamer.

The difficulties encountered in practical operation of rotary underreamers are many. The tool must not only be capable of efficient reaming action, but must be dependable to the point of infallibility and must be rugged and strong. The space in which the tool must work is severely limited, especially in the smaller sizes of drill holes; and a large majority of rotary underreamers which have been proposed or designed in the past have failed for various reasons but perhaps chiefly because of complications of parts and structures, which complications and multiplicity of parts inevitably leads to smallness and weakness of parts.

It is an object of this invention to provide a design of underreamer of a type expanded by relative rotation and which is very simple and is composed of relatively large strong parts, with cutting elements strongly supported; and these objects are, speaking generally, accomplished in my invention by the provision and use of cutters or cutter carriers which, extending in a general longitudinal or vertical direction, are tiltingly mounted at one end, as their lower ends, and so mounted at their upper ends that tilting movement of the cutter or cutter carrier causes the upper end to move outwardly to an expanded and operative position. In the designs hereinafter described the ultimate cutting element is shown in the form of a cutting roller surrounding a cutter-carrying pin or mandrel; and although this at present is the preferred specific design and embodiment of the invention, it will be recognized that the specific form of the ultimate cutting element is not necessarily a restriction upon the invention in its broader aspects.

Other objects and corresponding accomplishments of the invention will appear from the following detailed specification describing the preferred and illustrative forms and embodiments of the invention, and for this purpose reference is had to the accompanying drawings in which:

Fig. 1 is a side elevation of one form of my improved reamer showing the cutting elements in their collapsed or inoperative position.

Fig. 2 is a fragmentary side elevation and vertical section showing the cutters in their expanded positions.

Fig. 3 is a cross section on line 3—3 of Fig. 1.

Fig. 4 is a cross section on line 4—4 of Fig. 1.

Fig. 5 is a cross section on line 5—5 of Fig. 2.

Fig. 6 is a side elevation of another form in collapsed position;

Fig. 7 is a fragmentary side elevation with parts in section showing the same reamer in its expanded position.

Fig. 8 is a cross section on line 8—8 of Fig. 7.

Fig. 9 is a side elevation of another form of the reamer.

Fig. 10 is a fragmentary side elevation showing the reamer of Fig. 9 in expanded position.

Fig. 11 is a cross section on line 11—11 of Fig. 10.

Figs. 12 and 13 are cross sections on lines 12—12 and 13—13, respectively of Fig. 9.

Referring first to Figures 1 to 8, the numeral 10 designates a suitable body provided at its upper end with the usual tool joint pin 11 for connection with a rotary drilling string, and at its lower end with the usual tool joint box 12 for connection with a drilling bit 13. The body, in the design herein shown, comprises an upper enlarged portion or head 14 and a lower enlarged portion or head 15, and an intermediate reduced part 16 which is here shown as triangular in cross section; the reamer being here illustrated as having three cutting elements, although any suitable number of cutting elements may, of course, be used. The lower head 15 is provided with a plurality of bosses 20 which form the supports for the lower end of the cutter mandrel pins 21. These mandrel pins are so supported at their lower ends that they may swing

or tilt on their lower ends; and for that purpose the simple design shown in the drawings involves a vertically extending pin-receiving aperture 22 which extends down into the boss 20, the lower end of pin 21 extending down into this aperture and being held loosely in place by a transverse dowel pin 23 which is driven tightly through the boss 20. Apertures 22 are elongated, see Fig. 3, to allow the tilting motion of mandrel pins 21. The upper end surface of boss 20 is cylindric, to provide the cylindric bearing surface 24 preferably concentric with the rounded lower end of pin 21, as shown in the drawings. The axis of this cylindric bearing surface is, in the specific design herein shown, radial to the center of the whole tool, that axis being represented by the broken line indicated at A in Figures 3 and 8. On this cylindric bearing surface is a bearing washer 25 which has a correspondingly cylindric under surface; and the lower end of the roller cutter 26 rests and bears upon the flat upper surface of this bearing washer 25. The construction is such as to give a good tilting bearing for the lower end of the cutter element to tilt or swing about the horizontal axis A*l*, also a good end thrust bearing for the cutter rollers 26.

The upper ends of the roller cutters 26 extend substantially to the under face of the upper body head 14, and the upper ends of mandrel pins 21 extend on up so that they project into slots 27 which are formed in the under face of head 14. These slots 27 are arranged, in their longitudinal extent, at right angles to the axis A about which the cutter elements tilt or swing at their lower ends; and, by the upper ends of the cutter elements swinging from the vertical positions shown in Figure 6 to the tilted positions shown in Figure 9, the upper ends are moved outward from the center of the tool and the cutters are thus expanded. In thus moving to their tilted positions, the upper ends of the cutters not only move outwardly, but also move circumferentially of the tool; they may be said to move in a tangential direction. And thus moving tangentially, right-handed rotation of the body causes the upper ends of the cutters to move not centrifugally and, coming into contact with the wall of the hole, the drag on the cutters then drags them out to their fully expanded positions. When it is desired to contract the cutters they may be contracted merely by pulling them up against the lower end of the casing. This may be done either while the tool is rotating or when the tool is rotatively still. It is not necessary to revolve backwardly (left-handedly) to collapse the cutters. The upper beveled surfaces 26*a* striking the casing or shoe causes the cutters to be moved back to their contracted positions and the tool may then be withdrawn through the casing.

At the upper ends of the roller cutters up-thrust bearing washers 26*b* are provided. The rollers 26 thrust up against the washers; and the washers thrust up against the up-thrust bearing faces 14*c* which lie around the slots 27 and are preferably curved and concentric, or substantially so, with the centers of tilting at the lower ends of the cutter elements. The washers, however, do not rotate with the cutters 26; they have lugs 26*c* which project into the slots 27 and thus prevent the washers from rotating. The rotary bearing faces for up-thrust are thus at the lower faces of washers 26*b*; just as the down-thrust rotary bearing faces for the rollers 26 are at the upper face of washers 25. Thus, grease or other lubricant packed into the roller cavities 26*d* will work out between the end thrust rotary bearing faces, keeping them lubricated and preventing entry of mud etc. to all the bearing surfaces of the rollers.

The description so far given applies to both forms shown in Figures 1 to 8, inclusive, both forms being fundamentally similar. In the form shown in Figures 6 and 7, the body is designed as one integral piece and the cutter pins 21 are removed by removing the dowel pins 23 and then moving the cutter pins upwardly through the openings 30 which extend through the upper head 14. In the form of Figures 1 and 2 the mandrel pins are removed upwardly through recesses 30*a* which are positioned over the mandrel pins and communicate with the annular recess 30*b* into which the mandrel pins project. The recess 30*b* accommodates the cutter contacting fingers which will be explained; and this recess is formed in the lower and the upper head part 14*d*. In order conveniently to form this recess the tool body is made in two parts, joined by the tool joint 31, the surface of juncture S dividing the upper head 14 as shown in Figs. 1 and 2. The recess 30*b* is shown as formed in the upper part 14*d*; and the slots 27 are formed in the lower part 14*e*, of the upper head 14.

In the form of Figures 1 to 5 special members are provided for facilitating contraction of the cutters by pulling the tool up into the lower end of the casing. The upper ends of the mandrel pins 21 play in the tangential slots 27 as before described, and the motion for contraction and expansion is the same as before described. But in the upper head 14 there are three pivoted fingers 35, one for each cutter, and each of these fingers is provided with a lug 36 having at its outer edge an inclined face which, upon being pulled up against the lower end of the casing, causes the fingers to be pressed inwardly. The expanded position of the parts is shown in Figure 5 and it will be apparent how the inward swinging movement of the fingers 35 causes movement of the upper ends of the cutter elements to their collapsed positions, the parts moving to the positions shown in Fig-

ure 4. In the collapsed positions the upper ends of the cutter pins 21 have left the notches 35*a* in the outer ends of the fingers, but the arrangement is such that outward expansive movement of the pins 21 from the positions of Figure 4 toward the position of Figure 5 will swing the fingers 35 around toward their expanded positions and the upper ends of the mandrel pins enter the finger notches. These finger notches, and the other details of design of the collapsing fingers are, of course, not specifically necessary to the operation of the device; it being only necessary that the pivoted fingers contact with the upper ends of the mandrel pins so that inward swinging movement of the fingers will cause collapsing movement of the mandrel pin. But the pin receiving notches in the outer swinging ends of the fingers provides a simple and effective means for limiting the outward swinging movements of the fingers, without the necessity of providing special stops for the fingers on the body.

The body, in the form which has been described is provided with the usual longitudinal watercourse 40 extending through it to feed circulating fluid to the water-course 13*a* of the drill bit below. Also, if desired, holes 40*a* may be drilled in the upper part of the body (see particularly Figures 2 and 8) for directing a certain amount of water or circulating fluid outwardly against the cutters 26. The bosses 20 may be provided with slots or openings 20*a* which lead from the pin-receiving apertures 22; so as to facilitate lifting the mandrel pins for removal and so as to allow circulation of fluid through the apertures 22 and around the lower ends of mandrel pin 21, to make those parts self-cleaning. And, if desired, circulation holes may also be provided, as shown at 22*a* in Figure 3, leading from the passage 40 to each of the boss apertures 22, to provide positive circulation through the aperture 22 and around the lower ends of pins 21.

In Figures 9 to 13 a somewhat modified structure is illustrated, involving the same principles of design and operation, as hereinbefore described, but showing a different detail of structure and assembly. Here the body 10 is also made preferably in one integral piece with an upper enlarged part or head 14*a* in which are provided the tangential slots 27*a*. The reamer here is shown as having four cutter elements and the central portion 16*a* of the body is therefore shown as square in cross section. The lower ends of the cutter mandrel pins 21*a* are mounted on hubs 21*b* which swing on the radial pivot pins 50. These hubs 21*b*, and the lower ends of the mandrel pins, are held inwardly by a confining ring 51 which encircles the hubs 21*b*, fits over the outer ends of the pivot pins 50, and thus strengthens the whole structure and prevents outward movement of the hubs 21*b*. This encircling ring 51 may be made in any suitable form; and is shown here as being formed in halves and bolted together as at 52. The up-thrust of the cutters is taken in the same manner as before described—through bearing washers 26*b* which bear against the thrust surfaces 14*c*.

The mandrel pins 21*a*, and the roller cutters 26 thereon swing on the horizontal radial axes of pivot pins 50; but the fit of the hubs 21*b* on the pivot pins may be somewhat loose so as to allow the upper ends of the mandrel pins a little loose play. Thus, with such loose play, it is not necessary that the slots 27*a* in the upper head 14*a* be made exactly straight or exactly at right angles to the axes of pins 50, and the slot 27*a* may also be provided with inwardly extending notches 27*b* at their outer ends, into which notches the upper ends of the mandrel pins 21*a* are pressed back by the forces which tend to press the cutter elements inwardly when the tool is in operation. The notches thus operate to prevent the mandrel pins and the cutting elements from moving back to their collapsed positions as long as the cutting elements are being pressed inwardly by pressure against the wall of the hole. And the somewhat inward curved formation of the outer ends of the slots 27*a* may also have the same general effect, as will readily be recognized from an inspection of Figures 11 and 12. Generally speaking, either the curvature of the slots or the provision of notches at their outer ends, provides a slot which extends generally tangentially or generally in a direction substantially at right angles to the swinging axis of the cutter, but at its outer end extends somewhat inwardly of that tangential direction (inwardly toward the center of the tool). The outer ends of the slot 27*a* are open so that when the mandrel pins 21*a* are in substantially the expanded positions of Figure 11 they may be removed directly outwardly from the slots 27*a* after the encircling band 51 is taken off and the lower hubs 21*b* are slipped outwardly on the pivot pin 50.

The cutting teeth on rollers 26 are of spiral formation; they are here shown as a coarse spiral V-shaped thread. Depending on the pitch of the thread, whether right or left-handed, the action of the cutter on the formation tends to force the cutter endwise in one direction or the other. For instance, in the drawings, the threads being shown right-handed and the tool being normally rotated right handed viewed from above, and contact with the formation causing the roller cutters to rotate left-handed viewed from above; the cutters tend to screw themselves up in the formation and the shearing action of the spiral on the formation cuts the earth downwardly.

This upward pressure on the cutters throws them up against their upper end thrust bearings at the surfaces 14*c*, and, by creating friction at that point, tends to hold the cutters in their expanded positions against any accidental collapsing movement.

On the other hand, if the tool be reversely rotated to collapse, the cutters then roll right-handedly and tend to screw themselves down onto the lower thrust bearings at 21*b*, relieving the friction at the top and making easy the collapsing action.

It will thus be seen that the direction of endwise movement of the cutters depends upon two things; the direction of rotation of the tool and the direction of pitch of the spiral tooth. Reversal of tool rotation reverses the endwise thrust; and likewise reversal of tooth pitch will reverse the thrust.

I claim:

1. In an expansive reaming tool, a vertically elongate body adapted to be rotated about a central vertical axis, a cutter element mounted on the body and extending vertically, the lower end of the cutter element being mounted on the body for tilting about its lower end, in a plane tangential of the body, the cutter element being substantially immovable longitudinally of the body, and upthrust bearing means for the cutter element including a downwardly facing thrust surface on the body.

2. In an expansive reaming tool, a vertically elongate body adapted to be rotated about a central vertical axis, a cutter element mounted on the body and extending vertically, the lower end of the cutter element being mounted on the body for tilting about its lower end, in a plane tangential of the body, the cutter element being substantially immovable longitudinally of the body, and upthrust bearing means for the cutter element including a downwardly facing thrust surface on the body, substantially concentric about the lower end of the cutter element.

3. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a vertically extending mandrel pin, a rotatable roller cutter surrounding the mandrel pin, the mandrel pin projecting above and below the upper and lower ends respectively of the roller cutter, means mounting the lower end of the mandrel pin on the body for swinging movement of the mandrel pin about its lower end as a center, the upper part of the body having a slot in a plane substantially tangential to the body, the upper end of the mandrel pin entering and being guided by said slot, and upthrust bearing means for the roller cutter including a downwardly facing surface, on the upper part of the body around the guide slot and above the upper end of the cutter.

4. In an expansive reaming tool, a body, a cutter carrying member mounted at one end on the body to swing about an axis transverse of the body, the body having a cylindrical bearing surface near and concentric with said transverse axis, a bearing washer on the cutter carrier and having a cylindric bearing surface contacting with the bearing surface of the body, and a cutter on the carrier resting upon the washer.

5. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a vertically extending mandrel pin, means loosely connecting the lower end of the mandrel pin with the body to allow tilting of the mandrel pin about the lower end, a cylindric bearing surface on the body substantially concentric with the lower end of the mandrel pin, a washer surrounding the mandrel pin and having a lower cylindric bearing surface adapted to bear upon the cylindric bearing surface of the body, and a rotatable roller cutter carrier upon the mandrel pin and resting upon the upper surface of the washer.

6. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a cutter element extending vertically along the exterior of the body and mounted on the body at its lower end for tilting movement, means in the body for guiding the upper end of the cutter element in such tilting movement, and a pivoted finger mounted in the upper part of the body and engaging the upper end of the cutter element and having an outer diagonal face adapted to be engaged by the lower end of a well casing whereby to move the finger and the upper end of the cutter element inwardly.

7. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a cutter element extending vertically along the exterior of the body and mounted on the body at its lower end for tilting movement, means in the body for guiding the upper end of the cutter element in such tilting movement, and a horizontally swinging pivoted finger mounted in the upper part of the body and engaging the upper end of the cutter element and having an outer diagonal face adapted to be engaged by the lower end of a well casing whereby to move the finger and the upper end of the cutter element inwardly.

8. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a cutter carrying mandrel pin extending vertically of the body and having its lower end mounted in the body for tilting motion, a cutter mounted on the mandrel pin, means in the upper part of the body guiding the upper end of the mandrel pin in movement in a plane nonradial of the body, and a member movably mounted on the body, having a casing contacting part movable substantially radially of the body,

and engaging the mandrel pin to move it non-radially.

9. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a cutter element extending vertically of the body and having its lower end mounted in the body for tilting motion, means in the upper part of the body guiding the upper end of the cutter element, in movement in a plane non-radial of the body, and a member movably mounted on the body, having a casing contacting part, movable substantially radially of the body, and engaging the cutter element to move it non-radially.

10. In an expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a cutter element extending vertically of the body and mounted thereon to be movable non-radially with respect to the body, and a member movably mounted on the body, having a casing contacting part movable substantially radially of the body, and engaging the cutter element to move it non-radially.

11. In an expansive reaming tool a vertically elongate body rotatable about a central vertical axis, a vertically extending cutter carrying axis pin mounted in the body, a roller cutter mounted directly on said axis pin to revolve thereon as a bearing, the body having a slot extending transversely of the body axis and substantially tangentially of the body, and an end of the axis pin entering into and guided directly by said body slot.

12. In a rotary expansive reaming tool, a vertically elongate body adapted to be rotated about a central vertical axis, a cutter carrying mandrel pin extending vertically of the body and mounted in the body for tilting motion, a roller cutter on said mandrel pin having end thrust support on the body, and said roller cutter having a spiral cutting tooth around its periphery.

13. In a rotary expansive reaming tool, a vertically elongate body rotatable about a central vertical axis, a cutter carrying mandrel pin extending vertically of the body and having one end mounted in the body for tilting motion, a roller cutter on the mandrel pin and having the end thrust support on the body at the other end of the mandrel pin, and said roller cutter having a spiral cutting tooth around its periphery.

In witness that I claim the foregoing I have hereunto subscribed my name this 16 day of August, 1928.

WILLARD N. PACKER.