June 16, 1931. S. L. CAMPBELL 1,810,201

RENEWABLE REAMER

Filed Dec. 5, 1928 2 Sheets-Sheet 1

Fig. 1.

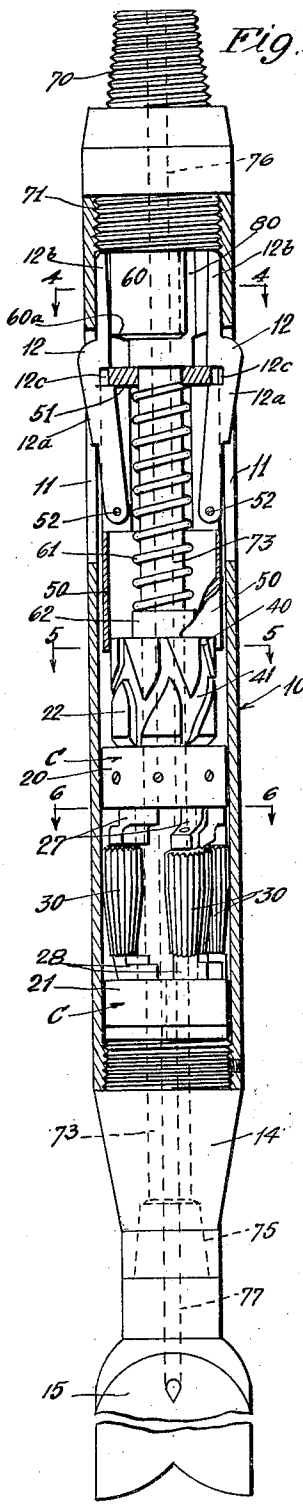



Fig. 2.

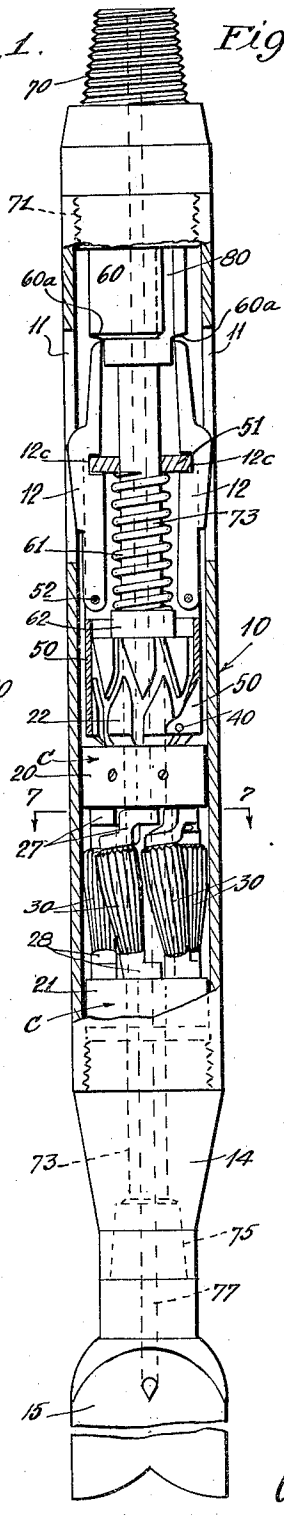
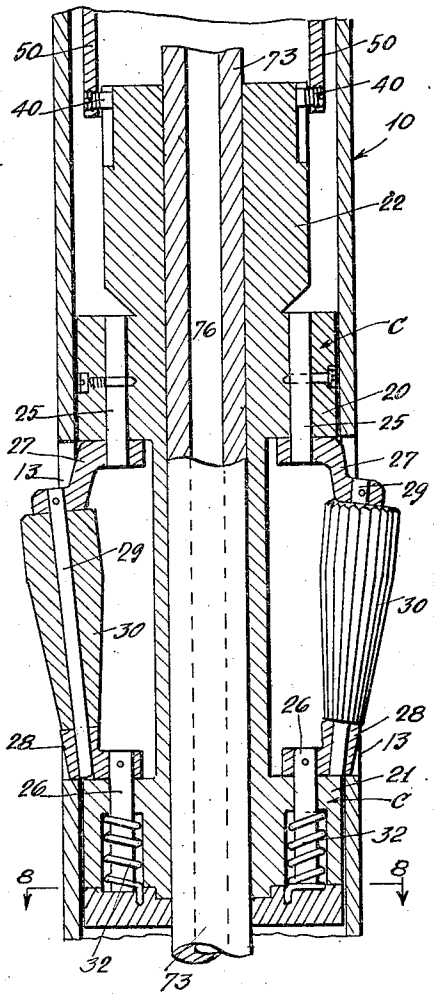



Fig. 3.

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RENEWABLE REAMER

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Fig. 10.

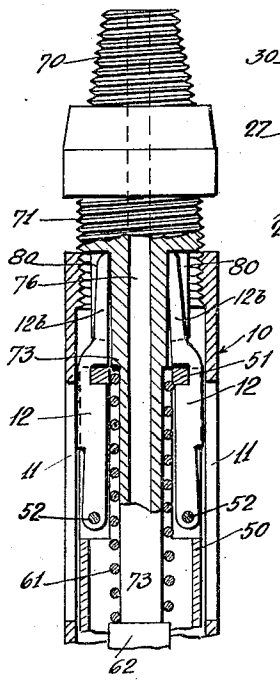



Fig. 7.

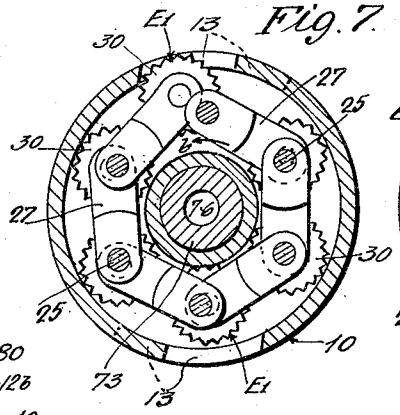



Fig. 6.

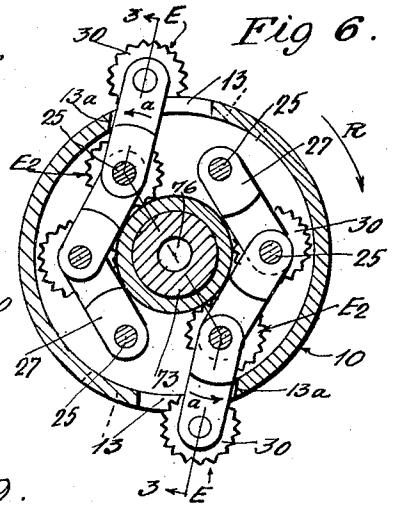



Fig. 9.

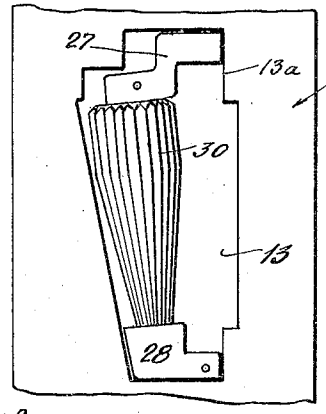



Fig 8

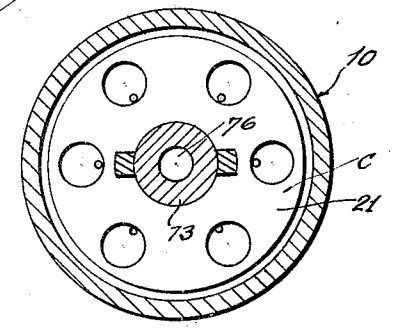



Fig 11.

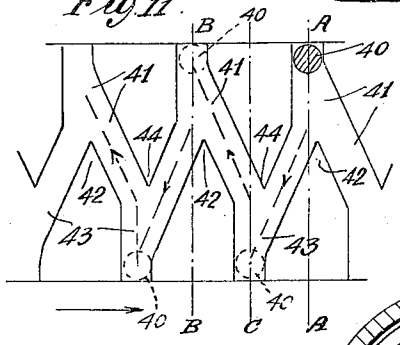
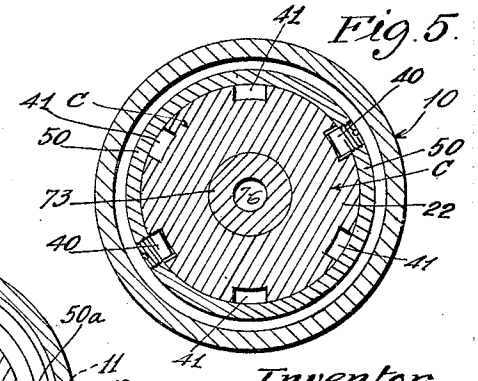



Fig. 5.



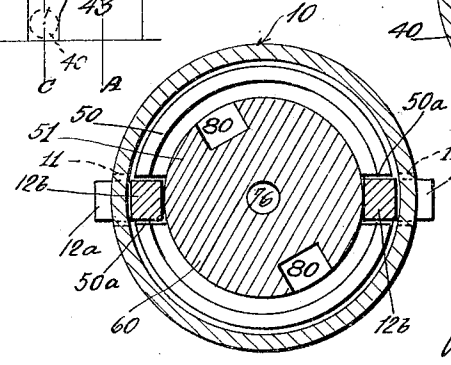




Fig 4.

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Patented June 16, 1931 1,810,201

# UNITED STATES PATENT OFFICE

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## RENEWABLE REAMER

Application filed December 5, 1928. Serial No. 324,007.

This invention has to do with reamers or underreamers such as are used for reaming or underreaming in deep wells; and a general object of the invention is to provide a mechanism wherein the cutters are changeable or substitutable while the reamer is in the well, so that fresh or new cutters may be substituted for those which may have become worn.

In my application, jointly with John Grant, Serial No. 108,520, filed May 12th, 1926, Renewable cutter underreamer, there is set out a changeable cutter reamer in which new cutters are moved laterally (swung horizontally) into operative position specifically by virtue of vertical movement of the cutters or cutter-carrier with relation to the body or mandrel of the tool. The general object of the present invention is the same as that of the prior application; but the mode of accomplishing the object is somewhat different; and the invention of the present application is therefore, in some aspects at least, to be looked upon as an improvement upon the prior invention.

In the present invention, the several cutters or cutting elements are mounted so as to be movable only laterally for their movement of change or renewal; that is, as shown in the specific illustrative embodiment herein described, these cutters or cutting elements are rotated in a transverse plane about a vertical axis of the tool, and are moved step by step to bring fresh cutters into operative position.

The step by step rotation for change of the cutters is accomplished by the relative vertical motion or what may be termed a trip mechanism, the trip mechanism being engageable with the casing so as to be pushed down relative to the body or mandrel (the part that is attached to the drill stem) when the tool is pulled upwardly against the lower end of the casing or the casing shoe. This relative downward movement of the trip mechanism causes the relative rotation of the cutters that throws a fresh cutter into operative position to take the place of a cutter that has previously been in operative position.

For the purpose of enabling those skilled in the art to comprehend the invention itself by way of a complete and specific understanding of an illustrative embodiment of the invention, I shall describe such an illustrative embodiment in detail in the following specification, reference for this purpose being had to the accompanying drawings in which

Figure 1 is a vertical central longitudinal section of the reamer with the parts in operative position to project one set of cutters.

Fig. 2 is a similar view showing the parts in position where all cutters are retracted, this position being that in which the tool rides through the well casing and also being the intermediate position which is assumed while the cutters are being changed.

Fig. 3 is an enlarged vertical central section of the cutter-carrying parts of the tool.

Fig. 4 is an enlarged cross-section on line 4—4 of Fig. 1.

Fig. 5 is an enlarged cross section on line 5—5 of Fig. 1.

Fig. 6 is an enlarged cross section on line 6—6 of Fig. 1 and showing a pair of cutters projected.

Fig. 7 is a cross section on line 7—7 of Fig. 2, similar to the section of Fig. 6, but showing the cutters all retracted.

Fig. 8 is a cross section on line 8—8 of Fig. 3.

Fig. 9 is an enlarged fragmentary side elevation of the exterior tubular body of the tool and showing the parts in the position of Fig. 7.

Fig. 10 is a fragmentary longitudinal central section of the upper part of the tool, showing the positions assumed by the parts when being assembled or disassembled and

Fig. 11 is a fragmentary diagrammatic development showing the cam action which operates between the trip mechanism and the rotative cutter carrier.

It will be understood that the tool here illustrated and described may be used either as an expansive reamer or as an expansive underreamer; and it will also be understood that the specific details of structure which are now to be described are not to be taken as necessary limitations upon the invention except as specifically so expressed in the ap-

pended claims. The structural details are to be described only for the purpose of giving those skilled in the art a full and complete understanding of one typical embodiment of the invention, and not for the purpose of limiting the invention.

As thus shown in the accompanying drawings the tool has a tubular body 10 provided near its upper end with a pair of longitudinally extending slots 11 through which the two trips 12 are adapted to project for the operation of the mechanism. It will be readily understood that the number of such trips may be selected as any one may desire, and that likewise the number of cutters in a simultaneously operating set may be as desired; I have merely chosen here to illustrate a mechanism having two casing engaging trips and arranged so as to throw a set of two cutters into operative position at one time. Thus the tubular body has two opposite trip slots 11 in its upper part and has two opposite cutter slots 13 in its lower part.

The lower end of the body is shown as having a sub 14 to which the usual drill bit 15 is attached. This sub 14 closes the lower end of the tubular body and serves also to support the rotatable cutter carrier C which is here shown as made up of upper and lower cutter-carrying heads 20 and 21, and also an upper cam head 22. Lower carrier head 21 rests upon the upper end of the sub 14, and the whole carrier C is capable of rotation on a vertical axis within the tubular body 10.

Mounted on and carried by the carrier C is a series of cutters, the cutters being equidistantly circumferentially spaced about the carrier and being adapted, by rotation of the carrier, to be successively brought to position behind the cutter slots 13 of body 10; and being so mounted on carrier C that, when in position behind slots 13, the cutters may move outwardly through the slots to project beyond the exterior surface of the body and thus be in operative position for reaming. In the specific design here shown the cutters are illustrated as being swingingly mounted on the cutter carrier, so as to swing outwardly horizontally to their projected operative position. I have also chosen here to illustrate cutters having cutting elements of the roller, or rock cutting, type. Thus, although it will readily be seen that all these details are not a necessary restriction upon the invention, I show each cutter mounted upon a vertical axis made up of an upper axis pin 25 and a lower axis pin 26. Upper swinging arms 27 are mounted on the upper axis pins, and lower swinging arms 28 are mounted on the lower axis pins, and a roller shaft 29 is carried by each set of upper and lower arms, the roller cutting elements 30 being rotatively mounted on the shafts. As shown here, the lower arms 28 are of shorter radial length than the upper arms, and the upper arms have their outer ends downwardly offset, as is best shown in Figure 3, so that when these relatively long upper arms swing inwardly to the collapsed positions, as shown in Figure 7, the arms may overlap each other. As a result of the upper arms being longer than the lower arms, the cutters when in projected position have their upper ends projected further outwardly than their lower ends, as is clearly shown at the right hand side of Figure 3.

In order to make sure that the cutters swing outwardly through the body slots 13 to their protracted positions, a spring may be applied to each cutter. For instance, I show in Figure 3 a coil spring 32 applied to the lower end of each axis pin 36, tending to turn the axis pin, and therefore the cutter which is rotatively fixed to this axis pin, in the relative direction indicated by the arrow *a* applied to the arms 27 of the two protracted cutters as shown in Figure 6. In this extended or protracted position of the cutters, the arms 27 and 28 bear back against the side wall 13*a* of slot 13. The rotation of the tool for reaming is in a right-handed direction looking down on it, or in the direction indicated by the arrow R thereof in Figure 6; and therefore the cutters are supported by their back bearings against the wall of slots 13, against the circumferential or tangential thrusts which are imposed upon them by reason of rotary cutting.

From what has been so far described it will now be readily understood that when the cutters are in the relative rotative position shown in Figure 6, one set of the cutters will swing outwardly through the body slots 13 and thus swing out into expanded operative position; that when the cutters and cutter carrier have been relatively rotated to the position of Figure 7, the cutters are then so situated that no cutter can swing out through the slots 13, and that therefore the cutters are retracted; and that when the cutters and cutter carrier have again been rotated on to such a relative position as shown in Figure 6, the next set of cutters is then in position to swing outwardly through the body slots to operative expanded position. Thus a relative rotation of the cutter carrier C through an angle corresponding to the circumferential spacing of the cutters on the cutter carrier will withdraw one set of cutters and substitute the next set in operative position; and in all intermediate positions all of the cutters will be contracted. The relative rotation of the cutter carrier step by step between its successive positions is the function of the cam head and the trip mechanism now to be described.

The cam head 22 has a series of cam slots which may perhaps best be understood by reference to Figure 11. Assuming first that

the mechanism stands in the relative position shown in Figures 1 and 6, with the vertically movable cam actuating lug 40 in the upper end of the cam groove 41, downward movement of the cam actuating pin will make the pin move vertically downwardly along the path indicated by the dotted line, through the upper part of the cam groove 41; and then, deflected by the cam point 42, the pin then moves downwardly into and along the cam groove 43 until it reaches the bottom of the diagonally placed groove 43. See the diagram of Fig. 11. When the cam pin 40 thus reaches the position shown in dotted lines at the bottom of groove 43, and assuming that the pin 40 is restricted to vertical movement and cannot move laterally, the cam head has been moved laterally through a distance measured by the distance between line A—A and the line C (Fig. 11). This distance is equal to half the angular distance between adjacent cutters on the cutter carrier; and therefore, when the cam actuating pin has moved down to its lowermost position in the cam groove 43, the cutter carrier and cutters have been moved to the inoperative or contracted position of Figure 7.

Upon subsequent upward movement of the cam actuating pin 40 it moves vertically upward through the lower end of cam groove 43 and then, deflected by the cam point 44, moves upwardly into and through the diagonal cam groove 41, moving along the relative path indicated by the dotted line in Figure 11, and thus, by upward movement finally reaches again an uppermost position. But the pin is then located in the upper end of a cam groove 41 which is adjacent to the cam groove 41 from which it originally started as herein described. Thus when the cam actuating pin 40 has reached its uppermost position as shown in dotted lines as shown in Figure 11, the cam head 22 and therefore the carrier C has been rotated through a distance corresponding to the distance between the lines A—A and B—B in Figure 11; and this distance corresponds to the angular distance between adjacent cutters mounted on carrier C.

The complete cam slot of cam head 22 is made up of a series of the cam grooves, one series or complete element of which has now been explained; so it will be readily understood that successive downward and upper movements of the cam actuating pin will cause successive angular advancements of the cutter-carrier C in the relative direction of rotation indicated by the arrow *b* in Figure 7. Whenever the cam actuating pin is moved down to its lowermost position the cutter carrier is rotated through half the cutter spacing angle and the cutters are all thrown to the contracted positions of Figure 7, and whenever the cutter actuating pin is subsequently moved up to its uppermost position, the cutter carrier is again relatively rotated through an angle equal to half the cutter spacing, and the next set of cutters is brought into position opposite the body slots 13, to move out into operative expanded position.

The function of the trip mechanism is to move the cam actuating pin 40, or any suitable number of such pins, up and down. As will be readily understood, the cam groove elements of the cam head 22 are symmetrically spaced around the circumference of the cam head, and therefore any desired number of cam actuating pins 40 may be utilized. I have here chosen to show merely two such pins (see the section of Figure 5) but any number of pins, up to the total number of cam groove elements, will have the same action as described.

The function of the trip mechanism now to be described is to move the cam actuating pins 40 vertically. As here shown, the pins 40 are mounted in the lower end of a shell 50 which is vertically movable within the tubular body 10. The upper or head end of this shell is shown at 51. This shell carries the trips 12, pivoted at their lower ends at 52 to the shell and projecting upwardly from their pivots. The shell is slotted at 50*a* for accommodation of the trips 12 and the outwardly projecting parts 12*a* of the trips are adapted to project out through body slots 11 when the parts are in the position shown in Figure 1, with the shell and the trips in their uppermost position. In the uppermost positions the upper extensions 12*b* of the trips bear inwardly against a comparatively large mandrel part 60 and are thus held from being moved inwardly until they have been moved downwardly to the relatively lower elevation shown in Figure 2. The trips are normally held in their elevated positions of Figure 1 by the action of a spring 61 which is mounted at its lower end on a mandrel collar 62 and presses at its upper end upwardly against the head 51 of shell 50. When the tool is pulled upwardly into the casing or well pipe, the lower end of the pipe or the shoe engages the upper rounded corners of the projecting trip parts 12*a* and presses the trips relatively downwardly against the action of spring 61; and when the trips have moved so far down that their upper ends 12*b* can move in under the large mandrel part 60, then the trips are pressed in to the relative positions shown in Figure 2, with their exterior surfaces substantially flush with the exterior surface of body 10. In this position the shell 50 has been moved to its lowermost position, therefore cam actuating pins 40 have been moved to their lowermost positions, and the cutters have therefore been moved all of them, to their contracted positions of Figure 7. In this position of the parts spring 61 is urging shell 50 and trips 12 upwardly, and the angle of

the shoulders 60*a* at the lower end of large mandrel part 60 is such that, unless the trips are confined by the casing, the spring will tend to move the trips outwardly to the position where they can move up to the position of Figure 1. However, as long as the trips are within the casing or well pipe the trips cannot move outwardly and therefore cannot move upwardly; and in this condition of the parts the tool may be passed up and down through the well casing.

In order that the trip pivots 52 shall not be subjected to shearing strains, the trips have notches 12*c* that take the edge of shell head 51, so that longitudinal pressures or forces are transmitted directly to the shell from the trips.

Supposing that the tool is in its operative position below the well casing, with one set of cutters protracted, upward movement of the tool into the casing will cause relative downward movement of the trips, and cause movement of the cutters to the retracted positions of Figure 7. In this retracted position the set of cutters which has previously been in the expanded position, as shown at E in Figure 6, is moved to the contracted position as shown at E1 in Figure 7. Then upon a subsequent lowering of the tool, allowing the upward movement of the trips and shell 50 and the cam actuating pins 40, these same cutters are moved around to the relative positions shown at E2 in Figure 6, and the next set of cutters is then brought to the expanded position shown at E in Figure 6. Thus, by simple upward movement of the tool against or partially into the casing and subsequent downward movement, the cutters are rotated so that the set previously in use is contracted and the next set expanded. In the particular design here shown, I have illustrated six cutters, and therefore three sets of two. Consequently there are three sets of cutters available for reaming before the tool has to be withdrawn from the hole for substitution or sharpening of cutters. The total number of cutters, and also the number of cutters in each operating set, may, as hereinbefore indicated, be selected as desired.

The mandrel parts 60 and 62 which have been previously referred to are parts of an internal mandrel whose upper end is adapted at 70 for attachment to a drill stem, and which is screwed into the upper end of the body at 71 and depends centrally through the tubular body. The part 60 of this mandrel near its upper end is the relatively large part previously referred to. Extending downwardly from this relatively large part 60 there is a relatively small and long mandrel part 73 which extends down through the cam head 22 and the cutter carrier C and may also extend on down through the sub 14 and the end just above the tool joint 75 of the bit 15. The cam head and cutter carrier rotate around the mandrel part 73, and the mandrel has a longitudinal bore 76 extending from end to end and forming the circulation course which leads to the circulation passage 77 of the drill bit below.

The enlarged part 60 of the mandrel has two oppositely disposed grooves 80 which, in the assembled and operative position of the parts, are out of registration with the upper ends 12*b* of trips 12. With the parts thus in the relative position shown in Figures 1, 2 and 4, the trips cannot at any time move inwardly far enough to move wholly inside the interior of the tubular body, although the inner positions of the trips, as shown in Figure 2, is with the outer trip surfaces substantially flush with the outer surface of the tubular body. Thus, during operatively use of the tool, the trips never move out of engagement with the slots 11, the trips, and also the trip carrying shell 50, being thus held against relative rotation in the body.

When it is desired to disassemble the reamer, the mandrel is unscrewed and turned first to such a position that the grooves 80 register with trip extensions 12*b*. Then the trips can be moved back into grooves 80 far enough that the trips are then entirely within the body interior, assuming such a position as shown in Figure 10. With the parts in this position the mandrel can be rotated to unscrew it from the body, and then the mandrel, shell 50 and trips can be pulled upwardly out of the body. The cutter carrier, cutters, and cam head, may then be slipped out of the body longitudinally, as they are freely longitudinally removable when the mandrel is removed. When the parts are assembled in operative position, the cutter carrier, cutters and cam head are prevented from moving longitudinally by bearing at the bottom on the upper end of sub 14 and bearing upwardly against the mandrel collar 62.

I claim:

1. An expanding changeable cutter reamer, comprising a body, a cutter-carrier mounted on the body and adapted to be moved in a plane transverse of the body, a plurality of cutters mounted on the cutter-carrier and adapted to be selectively moved to expanding position by virtue of such movement of the cutter carrier, and means mounted on the body and movable longitudinally relative thereto and adapted to move the cutter-carrier step by step.

2. An expanding changeable cutter reamer, comprising an elongate body, a cutter carrier mounted on the body for rotation relative thereto about the longitudinal axis of the body, a plurality of cutters mounted on the carrier and adapted to be selectively moved to expanding position by such relative rotation of the carrier, and means to rotate

the carrier step by step said means including an actuating member movable longitudinally with reference to the body.

3. An expanding changeable cutter reamer, comprising a body, a plurality of cutters movable together as a set in a plane transverse of the body whereby the several cutters of the set may be selectively moved to expanding position, and means to move said set of cutters step by step said means including an actuating member which moves longitudinally relative to the body.

4. An expanding changeable cutter reamer, comprising a body, a plurality of circumferentially spaced cutters mounted on the body to be rotated as a unit with reference to the body, whereby said cutters may be selectively moved to expanding position, and means to rotate said cutters step by step with reference to the body, said means including an actuating member which moves longitudinally with reference to the body.

5. A changeable cutter reamer, comprising an elongate body, a cutter carrier mounted thereon for movement in a transverse plane relative to the body, a plurality of transversely spaced cutters mounted on the carrier and adapted, by such movement of the carrier, to be selectively moved one at a time into operative position, and means for moving the carrier step by step said means including an actuating member movable longitudinally with reference to the body.

6. A changeable cutter reamer, comprising an elongate body, a cutter carrier mounted on the body for rotation relatively to about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by relative rotation of the carrier to be selectively moved one at a time into operative position with reference to the body, and means for rotating the carrier step by step with reference to the body, said means including an actuating member movable longitudinally with reference to the body.

7. A changeable cutter reamer comprising an elongate body, a plurality of transversely spaced cutters movable as a unit in a plane transverse to the body and thereby movable selectively one at a time to an operative position with relation to the body, and means for moving said cutters as a unit step by step with relation to the body, said means including an actuating member movable longitudinally with reference to the body.

8. A changeable cutter reamer comprising an elongate body, a plurality of circumferentially spaced cutters mounted in the body for rotation as a unit around a longitudinal axis of the body, and means for rotating said cutters as a unit step by step with relation to the body whereby said cutters are selectively moved one at a time into operative position with relation to the body, said means including an actuating member movable longitudinally with reference to the body.

9. An expanding changeable cutter reamer, comprising a tubular body having a cutter projection slot through its wall, a plurality of spaced cutters within the body and movable as a unit past the projection slot, and means for moving the cutters as a unit and step by step to bring the cutters selectively into registration with the projection slot.

10. An expanding changeable cutter reamer comprising a tubular body with a cutter projection slot through its wall, a plurality of circumferentially spaced cutters within the tubular body and rotatable as a unit about the longitudinal axis of the body, and means for rotating said cutters as a unit step by step with reference to the body whereby the cutters are selectively brought to position registering with the cutter projection slot.

11. An expanding changeable cutter reamer comprising a tubular body with a cutter projection slot through its wall, a cutter carrier within the body and rotatable with reference thereto about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by carrier rotation to be successively moved into position registering with the cutter projection slot, and means to rotate the carrier step by step with relation to the body.

12. An expanding changeable cutter reamer, comprising a tubular body having a cutter projection slot through its wall, a plurality of spaced cutters within the body and movable as a unit past the projection slot, and means for moving the cutters as a unit and step by step to bring the cutters selectively into registration with the projection slot, said means including an actuating member movable longitudinally with relation to the body.

13. An expanding changeable cutter reamer comprising a tubular body with a cutter projection slot through its wall, a plurality of circumferentially spaced cutters within the tubular body and rotatable as a unit about the longitudinal axis of the body, and means for rotating said cutters as a unit step by step with reference to the body whereby the cutters are selectively brought to position registering with the cutter projection slot, said means including an actuating member movable longitudinally with relation to the body.

14. An expanding changeable cutter reamer comprising a tubular body with a cutter projection slot through its wall, a cutter carrier within the body and rotatable with reference thereto about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by carrier rotation to be successively moved into position registering with the cutter projection slot, and means to rotate the carrier

step by step with relation to the body, said means including an actuating member movable longitudinally with relation to the body.

15. An expanding changeable cutter reamer comprising a tubular body with a cutter projecting slot through its wall, a cutter carrier within the body and rotatable with reference thereto about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by carrier rotation to be successively moved into position registering with the cutter projection slot, and means to rotate the carrier step by step with relation to the body, said means including a cam head rotatively connected with the rotative carrier and a casing engaging member movable longitudinally with reference to the body and acting upon the cam head to cause its rotation by virtue of the relative longitudinal movement of the casing engaging member.

16. An expanding changeable cutter reamer comprising a tubular body with a cutter projecting slot through its wall, a cutter carrier within the body and rotatable with reference thereto about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by carrier rotation to be successively moved into position registering with the cutter projection slot, and means to rotate the carrier step by step with relation to the body; said means including a cam head mounted upon and rotatable with a carrier, a longitudinally movable member in the body and engaging said cam head so that relative longitudinal movement of said member causes rotation of the cam head and cutter carrier, and a casing engaging trip mounted upon and longitudinally movable with said member.

17. An expanding changeable cutter reamer comprising a tubular body with a cutter projecting slot through its wall, a cutter carrier within the body and rotatable with reference thereto about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by carrier rotation to be successively moved into position registering with the cutter projection slot, and means to rotate the carrier step by step with relation to the body; said means including a cam head rotatively connected with the rotative carrier and a casing engaging member movable longitudinally with reference to the body and acting upon the cam head to cause its rotation by virtue of the relative longitudinal movement of the casing engaging member, and a spring urging said casing engaging member longitudinally in one direction.

18. An expanding changeable cutter reamer comprising a tubular body with a cutter projecting slot through its wall, a cutter carrier within the body and rotatable with reference thereto about the longitudinal axis of the body, a plurality of circumferentially spaced cutters mounted on the carrier and adapted by carrier rotation to be successively moved into position registering with the cutter projection slot, means to rotate the carrier step by step with relation to the body, said means including a cam head mounted upon and rotatable with a carrier, a longitudinally movable member in the body and engaging said cam head so that relative longitudinal movement of said member causes rotation of the cam head and cutter carrier, a casing engaging trip mounted upon and longitudinally movable with said member, and a spring urging said member and said casing engaging trip longitudinally in one direction.

In witness that I claim the foregoing I have hereunto subscribed my name this 8 day of November 1928.

STEWART L. CAMPBELL.