

Sept. 20, 1932.

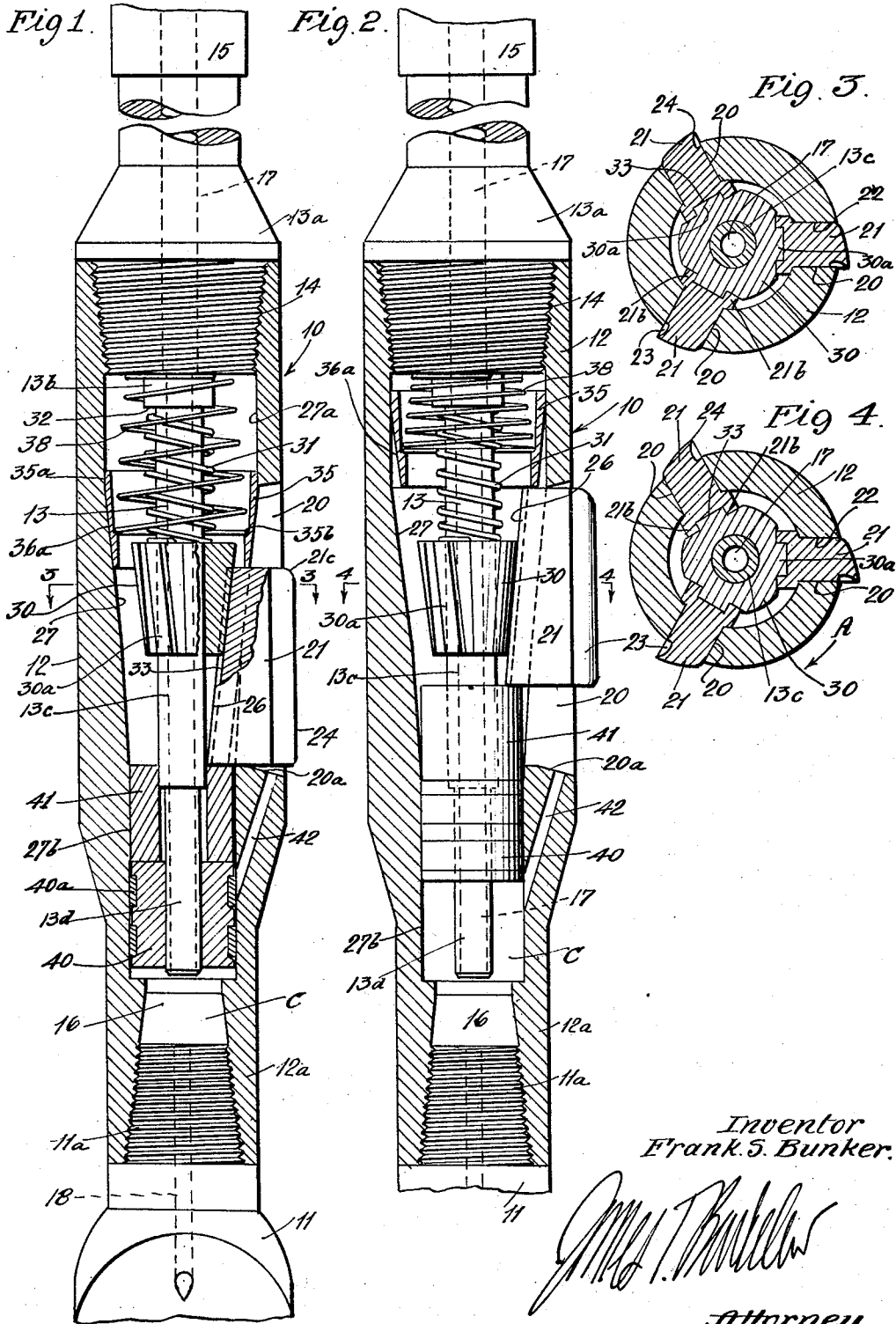
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UNDERREAMER

Filed Feb. 12, 1929

2 Sheets-Sheet 1



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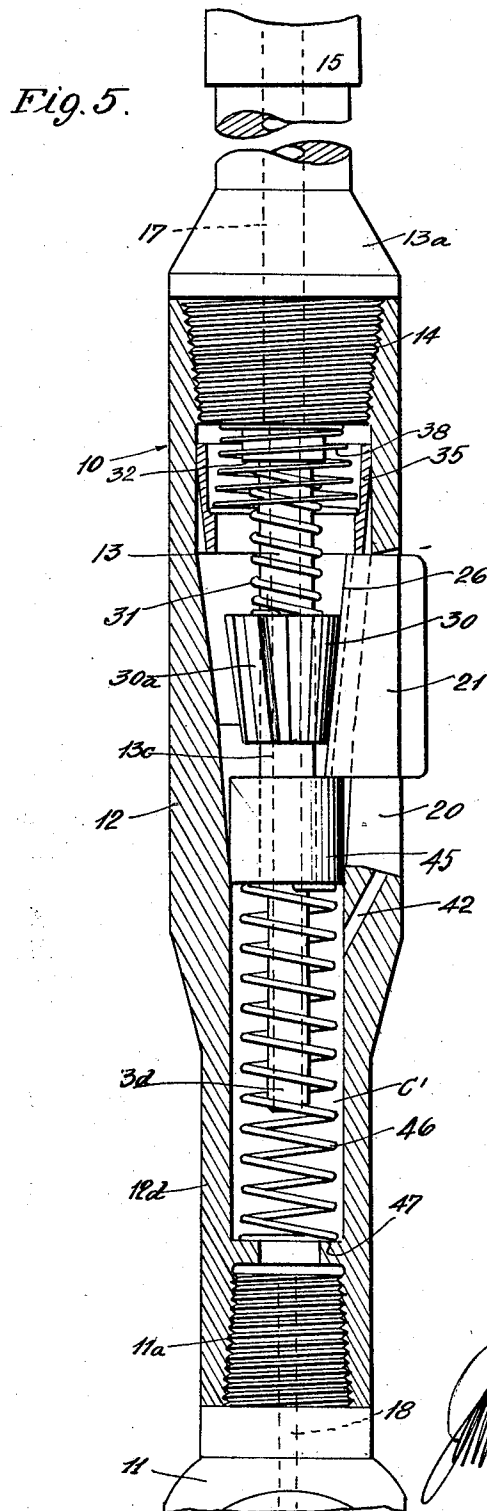
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UNDERREAMER

Application filed February 12, 1929. Serial No. 339,295.

The present invention is concerned generally with expansive drills or reamers for use in well drilling operation, and relates particularly to under reamers for enlarging a well bore below the casing, and for use in combination with a pilot drill.

The invention is characterized by an adjustable movable internal core or mandrel portion acting as an internal abutment between the cutters, and acting as a wedge to expand the cutters when they move upwardly with relation to the internal core. This characteristic of invention may be applicable to many different forms of expansible reamers or underreamers, and consequently I do not wish to be understood as limiting the invention to the particular form of underreamer which I have here chosen as a typical embodiment of the invention. However, my invention lends itself very readily to expansive reamers of the type shown in the Phipps patent on well apparatus, No. 1,678,073, issued July 24, 1928, and therefore I shall explain the invention as applied to that type of tool. Expanding reamers of that type involve a central mandrel or abutment core between the cutters, the cutters being movable vertically with reference to the central mandrel or core, and the tool being so shaped that by wedging action, the cutters move outwardly when they are moved upwardly.

As applied to that particular type of expansive tool, my invention involves not only relatively longitudinal movement and wedge action between the cutters and core for expanding the former, but also longitudinal adjustment of the wedge shaped mandrel portion or core for the purpose of taking up any looseness or wear and thus keeping the cutter tightly held at all times. Preferably the adjustment of the core is automatic and by spring actuation.

The above characteristics of the invention, as well as numerous additional features and advantages will be understood most clearly from the following detailed description of preferred and typical embodiments of the invention, reference being had to the accompanying drawings, in which:

Fig. 1 is a central longitudinal section of

an underreamer in accordance with the present invention, the cutter being shown in contracted position, and a drill being attached to the reamer;

Fig. 2 is a view similar to Fig. 1 but showing the cutters in expanded position;

Fig. 3 is a cross section on lines 3—3 of Fig. 1;

Fig. 4 is a cross section on line 4—4 of Fig. 2; and

Fig. 5 is a view generally similar to Fig. 2 but showing a variational form of cutter actuating means.

Although in the present embodiment of the invention the body of the tool is relatively stationary, and the cutters are movable longitudinally relatively to the body and cutter expanding wedge, it will be apparent that this may not necessarily be the case insofar as the relative movements of the wedge and cutter is concerned, for the expanding action of the cutter is dependent upon relative movement between the cutter and wedge core and not between the core and body. Therefore, in its broader aspects, the invention relates to tools of this character wherein the described relative movements between the cutters takes place, irrespective of the relative body movement.

In the drawings, the reamer generally indicated at 10, is shown attached to the pilot drill bit 11, the bit pin 11a being threaded into the lower reduced portion 12a of the reamer barrel 12. A mandrel 13 extends centrally within the body, the enlarged head 13a of the mandrel being threaded at 14 into the upper end of the body, the mandrel in turn being joined to the drill pipe collar 15. The reduced portions 13b, 13c, 13d, of the mandrel depend within the body from the head portion 13a, the lower end of the mandrel being spaced at 16 a suitable distance from the bit pin 11a. A fluid passage 17, communicating with the drill pipe interior, extends continuously through the mandrel to open into space 16, and a comparatively smaller passage 18 extends within the drill and serves to discharge fluid from space 16 through the bit.

Cutter slots 20, three being shown, are formed longitudinally in the barrel, the slots

being arranged symmetrically about the mandrel. The slots carry the radially and longitudinally movable cutters 21, the increased length of the slots being that necessary to permit the desired longitudinal movement of the cutter. It will be noted that the sides of the cutters bear flatly at 22 against the sides of the slots, this being desired in order to provide maximum lateral backing for the cutter within the body and to prevent the entrance of well liquid to the interior of the reamer around the sides of the cutter. The cutters are here shown in the form of blade cutters having vertical cutting edges 24, and recesses on their faces at 23, but it will be understood that the cutters may be made in any form desired. The cutters have the inner inclined wedge faces 26 and are adapted to provide the longitudinally extending flanges 21b adapted to bear against the inclined portion 27 of the inner body wall when the cutters are in the positions indicated at Fig. 2. The flanged portions obviously limit the outward movement of the cutters and prevent their removal outward through the slot.

The cutters are caused to move radially outward to expanded position by virtue of their upward movement relative to the downwardly tapered mandrel element or wedge core 30, the latter being slidably mounted on the mandrel and adapted to bear against the inner wedge faces 26 of the cutters at all times. Spring 31 is interposed between the wedge core and the mandrel shoulder 32 and serves to urge the core into engagement with the cutters at all positions thereof. Thus the core may be considered as being vertically and automatically adjustable to compensate for wear of the engaging wedge surfaces, and to assure proper expansion of the cutters even after the engaging surfaces have become severely worn. It is desirable that the wedge faces of the core be shaped to enable the inner ends of the cutter to bear substantially flatly thereagainst, and yet preclude the possibility of the core turning within the body so as to bring the wedge surfaces of the cutter and core out of register. Accordingly, I have formed rectangular slots in one, adapted to take similarly shaped projections on the other, and although it is immaterial upon which the projections and grooves are formed, I have, in the present instance, provided grooves 33 in the cutter to take projections 30a extending longitudinally on the core. In the drawings, one of the cutters has been omitted to illustrate the core projections more clearly.

It will be noted that during the movement of the cutter between the positions shown, no appreciable vertical movement of the core on the mandrel takes place. That this is actually the case will be apparent in that substantial upward movement of the core is prevented by spring 31, and since the inclined portion

27 of the inner wall surface and the engaging wedge faces of both the cutters and the core extending parallel in all positions of the cutters, it is evident that downward movement of the core cannot take place upon either upward or downward movement of the cutters. Insofar as the wedge action between the cutters and core is concerned, it will readily be seen that the mandrel serves mainly as a mounting and guide for the core. Preferably, the mandrel takes substantially no stress imparted to the wedge core by the cutters, and it may be desirable for the core to more or less loosely fit the mandrel in order that forces may be transmitted between cutters directly through the wedge without imposing strain on the mandrel. Insofar as the expansion and contraction actions of the cutters is concerned, the mandrel part 13c might be eliminated, but it serves very readily as a guide for the wedge 31, and also as a circulation duct to carry the circulation fluid longitudinally through the tool.

It may be stated that the angle of the wedge core 30 should be sufficient to give the desired cutter expansion upon upward movement of the cutter within reasonable limits, and that the wedge angle should be sufficiently large that there is no marked tendency of the cutters to move upwardly and wedge automatically by reason of their frictional engagement with the well casing as the tool is lowered. The wedge angle may be varied, and can be increased over that shown, to take care of any tendency of the cutters to wedge in the pipe or hole. It will be noted, however, that since the wedge is pressed downward by spring 31, the spring preferably being strong, the wedge first clamps the cutter by wedging action between the wedge and body wall, this being an effective deterrent in preventing the cutters from moving up and wedging outwardly.

In order to prevent the entrance of well fluid to the tube through the upper portions of the slot when the cutters are in contracted positions, I have provided a protector sleeve 35, the lower edge of which rests flatly on the tops of the cutters. The upper and outer cylindrical surface 35a of the sleeve has a snug sliding fit within the upper cylindrical portion 27a of the body bore, the inclined surface 36a of the sleeve being adapted to snugly fit the inclined bore wall 27 when the parts are in the position shown in Fig. 1. The sleeve is caused to seat firmly on the cutter by means of a relatively weak spring 38 seated in an annular recess 35b within the sleeve and bearing upwardly against the mandrel head. Thus the protector sleeve follows the cutters through their vertical movement and prevents the entrance of fluid carrying abrasive particles that would cause undue wear on the interior parts of the tool. This feature involving the use of the protector sleeve, how-

ever, is not my invention, but is included under the subject matter of a copending application by John Grant on protected reamer, Ser. No. 260,713, filed Mar. 10, 1928.

The body bore portions 27b, below the inclined surface 27, is cylindrically shaped and provides a plunger chamber to contain the plunger 40 and the propeller 41. The propeller 41 has a plunger fit with the chamber wall 27b and is adapted to slide longitudinally along the mandrel portion 13c and to engage the lower ends of the cutter to move them upwardly within the slots and into wedging engagement with the core. It will be noted when the cutters are in expanded position, the propeller effectively prevents the entrance of large solid particles from the well to the tool interior. Plunger 40 is adapted to slide along the tool interior. Plunger 40 is adapted to slide along the lowermost portion 13d of the mandrel, the plunger being provided with suitable packing or rings 40a to prevent the escape, around the plunger, of actuating fluid delivered to chamber C through the mandrel. Fluid passages 42 are formed in the body and extend from intermediate points in the sides of the plunger chamber wall to the lower inclined ends 20a of the body slots, the purpose of these passages being to discharge a certain amount of circulating fluid into the working region of the cutters during reaming operations. As shown in Fig. 2, passages 42 open into the plunger chamber to be uncovered by the plunger only when the latter is in its upper position and the cutters are expanded. The combined cross section area of these passages is, as will be seen, less than the area of the mandrel bore 17.

In the embodiment of my invention shown in Figs. 1 and 2, the plunger and cutter propeller are actuated by fluid pressure in chamber C, and in this regard it will be noted that fluid passage 18 in the drill bit is comparatively smaller than the mandrel bore 17. The relative sizes of these passages are such that upon discharge of fluid through the mandrel, the restriction to flow offered by passage 18 is such as to cause the pressure to be built up in chamber C, and this pressure being sufficient to move plunger 40 upward and to hold the cutters in expanded position. When the plunger raises to uncover the fluid passages 42, circulating fluid is discharged below the cutters, but these passages are of such size as to restrict the flow from chamber C sufficiently to retain suitable pressure on the lower end of the plunger, this pressure being sufficient to maintain the cutters in expanded position.

During the lowering of the tool assembly through the casing (not shown) the cutters are in the contracted position of Fig. 1, no fluid being pumped through the mandrel to

actuate the plunger. When the tool is lowered to the working region below the casing, however, the actuating fluid is pumped through the mandrel to expand the cutters, and operation is started. And as previously mentioned, during operation the circulating fluid is discharged at the working regions of the cutters and the drill bit through passages 42 and 18, respectively. To remove the tool from the well, pumping of the circulating fluid through the mandrel is stopped and the cutters permitted to lower to contracted position either by virtue of their own weight or by engagement with the lower end of the casing shoe, the upper corners of the cutter being rounded at 21c to enable them to slip readily within the casing.

The form of the invention shown in Fig. 5 is generally similar to the previously described embodiment, but differs somewhat with respect to the cutter actuating means. More specifically, in this embodiment, the operation of the tool insofar as actuating the cutters is concerned, is not dependent upon fluid pressure, and although fluid is introduced to the tool as in the previous instance and the fluid pressure, in itself, may be sufficient to actuate the cutters, operation of the latter is assured should the fluid pressure be no more than that necessary to effect the desired circulation.

In Fig. 5, the lower portion 12d of the body 12 preferably is elongated somewhat to provide for taking the spring 46, the spring being confined between the annular body shoulder 47 and the propeller plunger 45, plunger 40 in the previously described type being dispensed with. Normally, the cutters are held in their upper expanded position due to the action of spring 46, the spring providing an upward thrust on the propeller in addition to the fluid pressure on its lower face. The spring is of such strength, however, that its upward thrust is, in itself, sufficient to hold the cutters expanded, and therefore the cutters are positioned regardless of the fluid pressure. In this form, passages 42 are covered by the propeller when the cutters are contracted, and are brought into communication with the cylindrical chamber C' when the parts are in the position shown. As in the previous instance, passages 42 serve to direct fluid discharged into the chamber from the mandrel against the cutters, and circulation to the bit takes place through passage 18. Obviously it is necessary to contract the cutters when the tool is inserted for lowering within the casing, the cutters bearing against the casing while the reamer is being lowered there-through. When the tool passes the lower end of the casing, the cutters of course are released to move to their expanded position.

The form of tool shown in Fig. 5 is also adapted to another condition of use in which

it may not be desired to impart a strong positive thrust against the propeller to expand the cutters, but to cause their expansion at the working region by virtue of their engagement with a barrier or a shoulder formed in the well bore at the top of the underreamed portion. Under these conditions relative vertical movement of the cutters is caused by their being retarded by the bore restriction or shoulder, while the body of the tool and the wedge core move downward, the latter serving to expand the cutters. In this case spring 46 would not serve to expand the cutters as in the previous case, but merely to support the propeller beneath the cutters to prevent the entrance of well fluid to chamber C'. Also spring 31 would be tensioned so as not to cause the cutters to expand, but only to compensate for wear on the cutters as in the previous instance.

I claim:

1. An underreamer having a vertical tubular slotted body, a central mandrel extending vertically through the longitudinal bore of the body, a cutter movable radially and longitudinally in the body slot, a wedge core mounted on said mandrel and adapted to yieldably engage the cutter, said core being substantially vertically stationary on the mandrel, and means for moving the cutter longitudinally against said core to cause the cutter to move radially in the slot.

2. An underreamer having a vertical tubular slotted body, a central mandrel extending vertically through the longitudinal bore of the body, a cutter movable radially and longitudinally in the body slot, a vertically adjustable core mounted on said mandrel and adapted to engage the cutter, means on said core and cutter preventing their relative lateral movement, said means embodying a projection on one adapted to extend within a recess in the other, and means for moving the cutter longitudinally against the core.

3. An underreamer having a vertical tubular slotted body, a central mandrel extending vertically through the longitudinal bore of the body, a cutter movable radially and longitudinally in the body slot, said cutter having an inner inclined wedge face, a downwardly tapered wedge core slidably mounted on said mandrel and adapted to engage said wedge face of the cutter, yielding means urging said wedge core downwardly to engage the cutters, a propeller on the mandrel below the core and adapted to engage the lower end of the cutter, and means for moving said propeller upward to bring said cutter into wedging engagement with the core.

4. An underreamer having a vertical tubular slotted body, a central tubular mandrel extending vertically through the longitudinal bore of the body, a cutter adapted to move radially and longitudinally in the body slot, a vertically adjustable wedge core

mounted on the mandrel and adapted to engage the cutter, said core normally being substantially vertically stationary on the mandrel, and means for moving said cutter upwardly against the core by virtue of fluid pressure directed through the mandrel.

5. An underreamer having a vertical tubular slotted body, a central tubular mandrel extending vertically through the longitudinal bore of the body, a cutter adapted to move radially and longitudinally in the body slot, a vertically adjustable wedge core mounted on the mandrel and adapted to engage the cutter, said core normally being substantially vertically stationary on the mandrel, means preventing relative lateral movement between the core and cutter, and means for moving said cutter upwardly against the core by virtue of fluid pressure directed through the mandrel.

6. In an underreamer, a vertical tubular slotted body, a central tubular mandrel extending vertically through the longitudinal bore of the body and adapted to discharge fluid into the lower end thereof, a cutter adapted to move radially and longitudinally in the body slot, a vertically adjustable wedge core mounted on the mandrel and adapted to engage the cutter, a tubular propeller slidably mounted on the mandrel below said wedge and adapted to engage the lower end of the cutter, a plunger slidably mounted on the mandrel below said propeller, and a fluid outlet in the mandrel below the plunger, said plunger being adapted to be forced upwardly by fluid pressure and to actuate said cutter through the propeller.

7. In an underreamer, a vertical tubular slotted body, a central tubular mandrel extending vertically through the longitudinal bore of the body and adapted to discharge fluid into the lower end thereof, a cutter movable radially and longitudinally in the body slot, a vertically adjustable wedge core mounted on the mandrel and adapted to engage the cutter, a plunger slidably mounted on the mandrel below said core, a comparatively large fluid outlet in the mandrel below the plunger, and a comparatively small fluid discharge opening through the barrel below said plunger, the plunger being forced upwardly to actuate the cutter by fluid pressure developed by virtue of the differential in size between said fluid outlet and the discharge opening.

8. In an underreamer, a vertical tubular slotted body, a central tubular mandrel extending vertically through the longitudinal bore of the body and adapted to discharge fluid into a plunger chamber in the lower end thereof, a cutter movable radially and longitudinally in the body slot, a vertically adjustable wedge core mounted on the mandrel and adapted to engage the cutter, a vertically movable plunger on the mandrel below the

core and in said chamber, a liquid outlet in the mandrel below the plunger, said plunger being adapted to be forced upwardly by fluid pressure to actuate the cutter, and a fluid passage through the body wall and adapted to direct fluid from said chamber to the working region of the cutters, said passage being in communication with the chamber when the plunger is in its upper position.

9. In an underreamer, the combination of a vertical tubular slotted body, a tool threaded into the lower end of said body, a central tubular mandrel extending vertically through the longitudinal bore of the body and terminating above the lower end thereof, a plunger chamber in the lower portion of the barrel and about the lower end of the mandrel, a cutter movable radially and longitudinally in the body slot, a wedge core mounted on the mandrel and adapted to yieldably engage the cutter, a vertically movable plunger mounted on the mandrel below said core and within said chamber, a comparatively large opening in the mandrel for discharging fluid through the mandrel into said chamber below the plunger, and a comparatively small discharge opening in said tool for conducting fluid from the chamber, said plunger being actuated by fluid pressure developed by virtue of the differential in size between said openings.

10. In a reamer of the character described, a longitudinally slotted tubular body, cutters movable radially and longitudinally in the body slots, a vertically adjustable wedge core within said body and adapted to engage the cutters, means for effecting relative longitudinal movement between the core and cutters to cause the latter to move radially in the slots, and a vertically movable sleeve within the barrel and resting at its lower end on the upper ends of the cutters, said sleeve being adapted to close the upper ends of the slots when the cutters are in their lower positions.

11. An underreamer having a vertical tubular slotted body, a central mandrel extending vertically through the longitudinal bore of the body, a cutter movable radially and longitudinally in the body slot, said cutter having an inner inclined wedge face, a downwardly tapered wedge core slidably mounted on said mandrel and adapted to engage said wedge face of the cutter, yielding means urging said wedge core downwardly to engage the cutters, means for moving said propeller upward to bring said cutter into wedging engagement with the core, said body having inclined cutter engaging surfaces parallel with the wedge face of said wedge core.

12. In an underreamer, a body, a cutter movable longitudinally and transversely with relation to the body, a longitudinally movable cutter spreading wedge in the body behind the cutter, the cutter and wedge being formed so that relative movement of the cut-

ter in one longitudinal direction causes transverse movement of the cutter, means to move the cutter longitudinally in said direction, and means to move the wedge in the opposite longitudinal direction.

13. In an underreamer, a body, a cutter movable longitudinally and transversely with relation to the body, a longitudinally movable cutter spreading wedge in the body behind the cutter, the cutter and wedge being formed so that relative movement of the cutter in one longitudinal direction causes transverse movement of the cutter, fluid-pressure actuated means to move the cutter longitudinally in said direction, and spring means to move the wedge in the opposite longitudinal direction.

14. In an underreamer, a body having a diagonal cutter guide, a cutter movable along said guide, a longitudinally movable cutter spreading wedge in the body behind the cutter and having a wedge face substantially parallel to the diagonal cutter guide, means to move the cutter longitudinally toward the larger end of the wedge, and means to move the wedge longitudinally in the opposite direction.

15. In an underreamer, a vertical body, a cutter movable vertically and transversely therein, a vertically movable cutter spreading wedge in the body behind the cutter and adapted to cause outward expansive movement of the cutter when the cutter is moved upwardly, means to move the cutter up on the wedge, and means for pressing the wedge down behind the cutter to take up looseness between the wedge, cutter and body.

16. In an underreamer, a vertical body, a cutter movable vertically and transversely therein, a vertically yielding cutter spreading wedge in the body behind the cutter and adapted to cause outward expansive movement of the cutter when the cutter is moved upwardly, and means acting on the cutter to move it upwardly.

In witness that I claim the foregoing I have hereunto subscribed my name this 2 day of February, 1929.

FRANK S. BUNKER.