March 3, 1953 V. EMANUEL 2,630,300

ROTARY UNDERREAMER

Filed Jan. 3, 1950

Fig. 1.

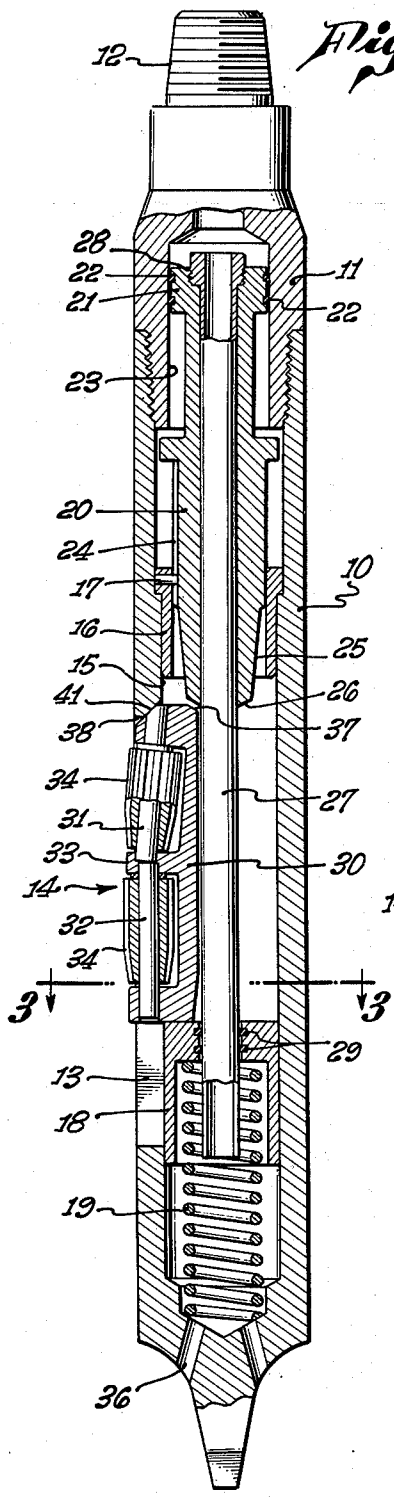


Fig. 2.

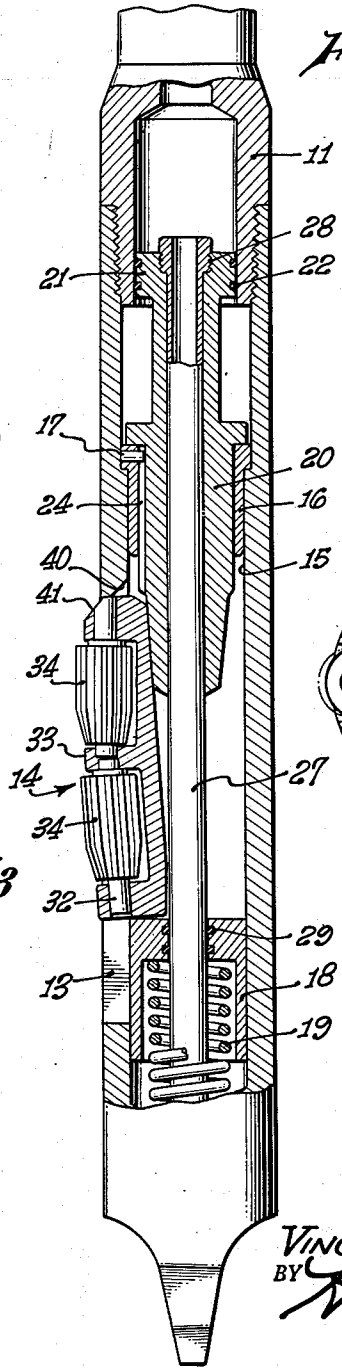
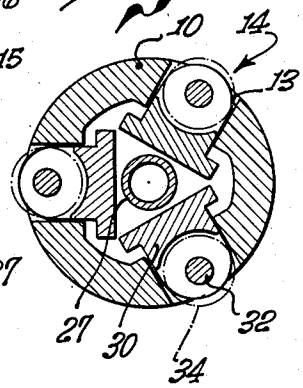


Fig. 3.



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Patented Mar. 3, 1953

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UNITED STATES PATENT OFFICE

2,630,300

ROTARY UNDERREAMER

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Application January 3, 1950, Serial No. 136,497

6 Claims. (Cl. 255—74)

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This invention has to do with improvements in rotary oil well underreamers of the general type comprising a body supporting a plurality of cutters mounted on carriers capable of movement axially and radially of the body to radially expand and contract the cutters. More particularly, the invention is directed to the maintenance of the cutter positions in tools of the type in which the cutters normally or initially are urged toward a contracted position, from which and after the tool has cleared the casing, the cutters are expansively displaceable.

For obvious reasons, it is desirable to run the tool down through the well casing with the cutters in contracted condition, capable however of ready expansibility after the underreamer passes into open hole. As indicated, unless restrained by means other than the working tool itself, the cutters and their carriers have been displaceable during lowering of the underreamer so that at times the tool may become obstructed. Accordingly, the practice has been to confine the cutters against expansion by an encircling wire or the like, which is releasable when the tool reaches working position.

My primary object is to improve the tool so that by virtue of its structure, and to the exclusion of extraneous tying or holding means, the cutters become releasably confined against expansion until the cutter carriers are actuated by operational control of the tool to outwardly displace the cutters. As specifically employed, this feature may be incorporated in a known general type of underreamer construction having the cutter carriers accommodated for longitudinal and radial movement within slots in the body, and actuable by downward movement within the slots to expand the cutters. It is found that normally, the cutters may be confined against accidental expansion by engaging the cutter-carrier assembly, and preferably the top end of the carrier, against a downwardly and outwardly inclined body surface, the latter being most advantageously located at the top of the carrier receiving body slot. By virtue of its angularity, the inclined body surface acts to displace or cam the carrier to its radially inner position, and to so retain the carrier until it is displaced in response to such actuating control as may be employed.

The invention will be understood further and to better advantage from the following detailed description of an illustrative embodiment shown by the accompanying drawing, in which:

Fig. 1 is a view showing the underreamer in longitudinal section with the cutters in radially contracted positions;

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Fig. 2 is a similar view showing the cutters expanded; and

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

Referring to the drawings, the tool comprises a tubular body 10 having at its upper end a tubular sub or coupling 11 connectible at its pin end 12 with the drill string. The body contains a plurality of longitudinal slots 13, typically three, within which are contained the cutter and carrier assemblies, generally indicated at 14 which are displaceable vertically within the slots between the Fig. 1 and Fig. 2 positions in moving the cutters from contracted to their expanded positions. Above the slots 13 and within a reduced section 15 of its bore, the body contains a cylindrical liner 16 carrying one or more key pins 17, the purpose of which will later appear. At the lower ends of the slots the body contains a vertically movable sleeve 18 which is urged upwardly by coil spring 19 in a cutter expanding direction, all as will be presently explained.

The body 10 contains a tubular mandrel 20 having a head 21 carrying seal rings 22 and workable vertically within bore 23 of the sub 11. The lower portion of the mandrel is externally recessed at 24 to receive the key pin 17, and below the keyways the mandrel has a relatively elongated and gradually tapered wedge face 25 terminating at bottom wedge surface 26 of relatively great angularity. The mandrel carries a pilot or circulation conducting pipe 27 threaded at 28 into the head of the mandrel and extending downwardly through the sleeve 18 in engagement with seal rings 29 carried by the latter.

Each of the body slots 13 contains a cutter carrier or holder 30 movable both longitudinally and radially within the slot in response to relative movement between the carrier and mandrel 20. The carrier 30 may be of a usual general type supporting a pair of pins 31 and 32 terminating within the end portions of the carrier and within a central rib portion 33. Rotatable cutters 34 are carried by the pins. Being engaged at the lower ends by the spring urged sleeve 18, the cutter and carrier assemblies 14 are urged upwardly within the slots 13 and to the limiting (cutter contracting) position illustrated in Fig. 1.

In considering the general mode of operation of the underreamer, assume the tool to be lowered through the casing into the open hole with the tool parts in the positions illustrated in Fig. 1. After the tool clears the casing fluid circulation down through the drill collar 11, mandrel 20 and the bottom body openings 36 is increased to the point of developing pressure sufficient to

force the mandrel and pipe assembly down to the Fig. 2 position and against the resistance of spring 19. Initial engagement of the mandrel face 26 with the inclined cutter carrier surfaces 37 displaces the cutter and carrier assemblies 14 downwardly to the extent of permitting their outward movement within the slots 13. Thereupon, continued downward movement of the mandrel engages its tapered surface 25 against the carriers, with resultant expansion of the latter to the Fig. 2 positions. Thus during the remaining operation, the cutter carriers are spring urged and supported against the mandrel face 25 and the body shoulders 38 at the upper ends of the slots.

As previously indicated, in this type of underreamer, the cutter carriers have been confined against outward radial displacement from their contracted positions. Accordingly, in order to prevent such obstruction to lowering of the tool through the casing as might result from looseness or expansion of the cutters and their carriers, it has been customary to initially hold the assemblies 14 in contracted position by an encircling wire which becomes removed or loosened upon forced expansion of the cutters. In accordance with the invention, the tool itself is now so constructed as to effectively retain the cutters against expansion until such time as they are positively actuated for expansion, in this instance by fluid pressure displacement of the mandrel. Such confinement of the assemblies 14, accomplished by providing the body at the upper ends of the slots 13 with downwardly and outwardly inclined shoulders 40 at the inside of shoulders 38, and which are engageable by the correspondingly inclined faces 41 of the cutter carriers. In order that the upper pins 31 may be given full length support within the end portions of the carrier, the pin face may be bevelled at 41 as illustrated.

Thus while the tool is being lowered through the casing the spring thrust of the carrier face 41 against the inclined body shoulder 40 effectively maintains the cutter and carrier assembly in its innermost radial or contracted position and against unintentional outward displacement. When the tool reaches a location beneath the well casing, circulation fluid is supplied to the tool, to actuate the mandrel downwardly and the cutters outwardly and the tool may then be rotated to perform the desired reaming operation. After the reaming operation has been completed, the circulation fluid pressure is relieved, and the tool is withdrawn upwardly into the casing and from the well. As will be appreciated, the cutters are retracted inwardly during upward movement of the tool by virtue of the engagement of wedge surfaces 41 on the cutter pins and carrier with the bottom of the well casing. The resulting wedging action serves to move the cutters inwardly to an extent such that surfaces 41 are again brought into cutter confining engagement with inclined body shoulders 40. These shoulders will have such angularity, say 45 degrees, as will cause the cutter carriers to be cammed inwardly when engaged against the shoulders under the influence of the coil spring 19.

I claim:

1. In a rotary underreamer, the combination comprising a tubular body having a slot extending through a wall thereof, a cutter, a cutter carrier within said slot in the body and displaceable longitudinally and radially thereof during

expansive and contractive movements of the cutter and carrier, an angular guide surface on the body at one end of the slot and engaged by the carrier toward a corresponding limit of its travel and acting to displace the carrier radially inwardly of the body to cutter contracted position in response to movement of the carrier longitudinally of the body, means for moving the cutter carrier longitudinally of the body against said guide surface to effect said radially inward displacement of the carrier, and a member movable axially relative to said body and having a wedging engagement with said carrier acting upon said axial movement to wedge the carrier radially outwardly.

2. In a rotary underreamer, the combination comprising a tubular body having a slot extending through a wall thereof, a cutter, a cutter carrier contained within said longitudinal slot in the body and displaceable therein axially and radially of the body during expansive and contractive movements of the cutter and carrier, the body having at the upper end of said slot a downwardly and outwardly inclined surface engageable by the carrier and acting to displace the carrier radially inwardly of the body toward the upper limit of the cutter travel to radially contracted position in response to movement of the carrier upwardly within the body, means for elevating the carrier in the slot to engage said inclined surface and effect said radially inward displacement of the carrier, and a member movable axially relative to said body and having a wedging engagement with said carrier acting upon said axial movement to wedge the carrier radially outwardly against said surface.

3. In a rotary underreamer, the combination comprising a tubular body having a slot extending through a wall thereof, a cutter, a cutter carrier contained within said longitudinal slot in the body and displaceable therein axially and radially of the body during expansive and contractive movements of the cutter and carrier, said carrier including a pair of outwardly projecting end lugs and a cutter pin terminating in said lugs, the body having at and inside the upper end of said slot an inclined surface engageable by one of said lugs and acting to displace the carrier radially and inwardly of the body toward the upper limit of the cutter travel to radially contracted position in response to movement of the carrier longitudinally of the body, means for elevating the carrier in the slot to engage said inclined surface and effect said radially inward displacement of the carrier, and a member movable axially relative to said body and having a wedging engagement with said carrier acting upon said axial movement to wedge the carrier radially outwardly against said surface to be wedged downwardly thereby against the resistance of said elevating means.

4. In a rotary underreamer, the combination comprising a tubular body having a slot extending through a wall thereof, a cutter, a cutter carrier contained within said longitudinal slot in the body and displaceable therein axially and radially of the body during expansive and contractive movements of the cutter and carrier, the top portion of said carrier having a downwardly and outwardly inclined surface, a cutter pin terminating in said portion, the body having at and inside the upper end of said slot a downwardly and outwardly inclined shoulder engageable by said inclined carrier surface toward the upper limit of the cutter travel to displace the

carrier radially and inwardly of the body to contracted position in response to upward movement of the carrier, a spring urging the carrier upwardly, and a mandrel movable axially within said body and having a wedging engagement with said carrier acting to wedge the carrier radially outwardly against said body surface in response to axial movement of the mandrel.

5. In a rotary underreamer, the combination comprising a tubular body having a slot extending through a wall thereof, a cutter, a cutter carrier contained within a longitudinal slot in the body and displaceable therein axially and radially of the body during expansive and contractive movements of the cutter and carrier, the top portion of said carrier having a downwardly and outwardly inclined surface, a cutter pin terminating in said portion and having a bevelled face inclined in the plane of said inclined carrier surface, the body having at and inside the upper end of said slot a downwardly and outwardly inclined shoulder engageable by said inclined carrier surface toward the upper limit of the cutter travel to displace the carrier radially and inwardly of the body to contracted position in response to upward movement of the carrier, and a spring urging the carrier upwardly.

6. In a rotary underreamer, the combination comprising a tubular body member having a slot extending through a wall thereof, a cutter, a cutter carrier member within said slot in the body member and displaceable axially and radially thereof during expansive and contractive movements of the cutter and carrier member, one of said members having an angular guide surface engaged by a surface of the other member and acting to displace the carrier member radially inwardly of the body to cutter contracted position in response to movement of the carrier member axially of the body, means for moving the carrier member axially of said body member in a direction urging said surfaces of the members axially together to effect said radially inward displacement of the carrier member, and a member movable axially relative to said body member and having a wedging engagement with said carrier member acting to wedge the carrier radially outwardly.

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