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J. C. LAWRENCE ET AL

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APPARATUS FOR ANCHORING THE PILOT MEMBER IN A PILOT BORE

Filed April 1, 1966

3 Sheets-Sheet 1

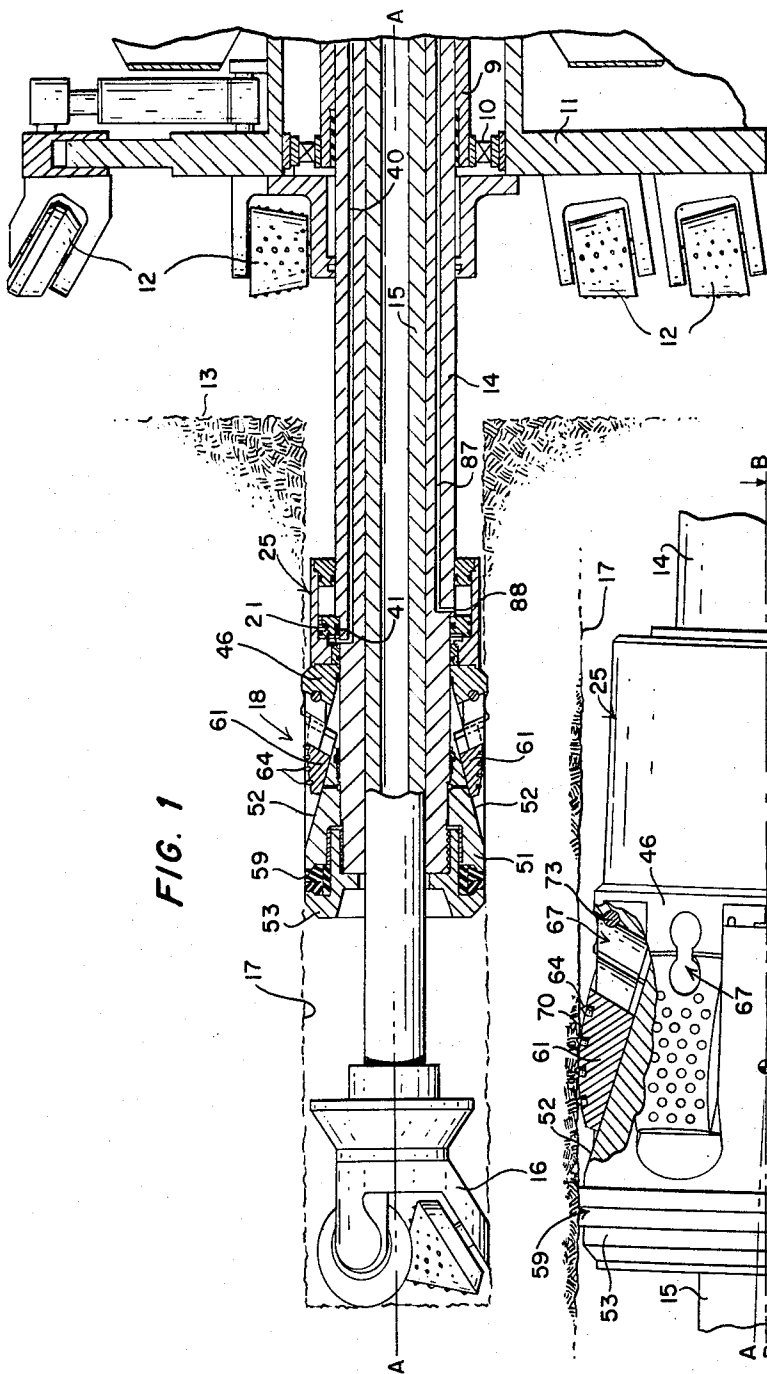


FIG. 1

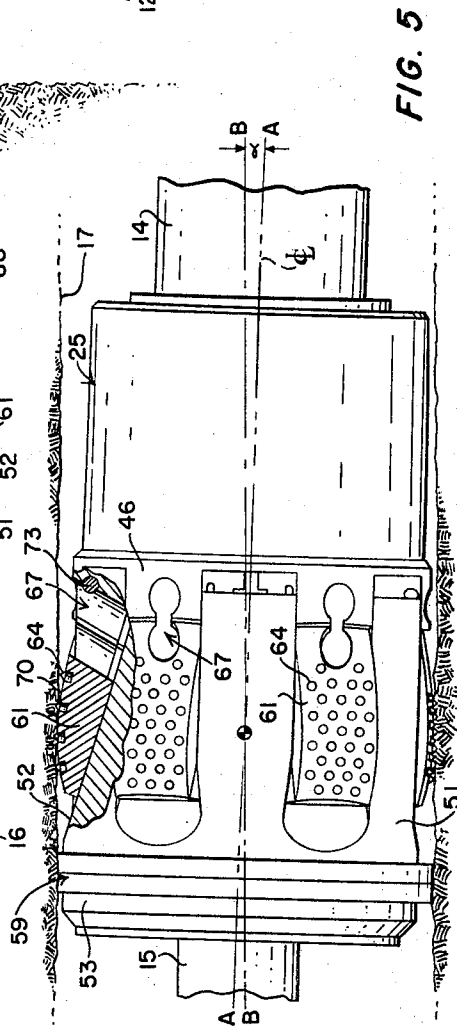


FIG. 5

INVENTORS
JAMES C. LAWRENCE
BY WILLIAM H. HAMILTON
*Strauch, Nolan, Neale,
Nies & Bronaugh*
ATTORNEYS

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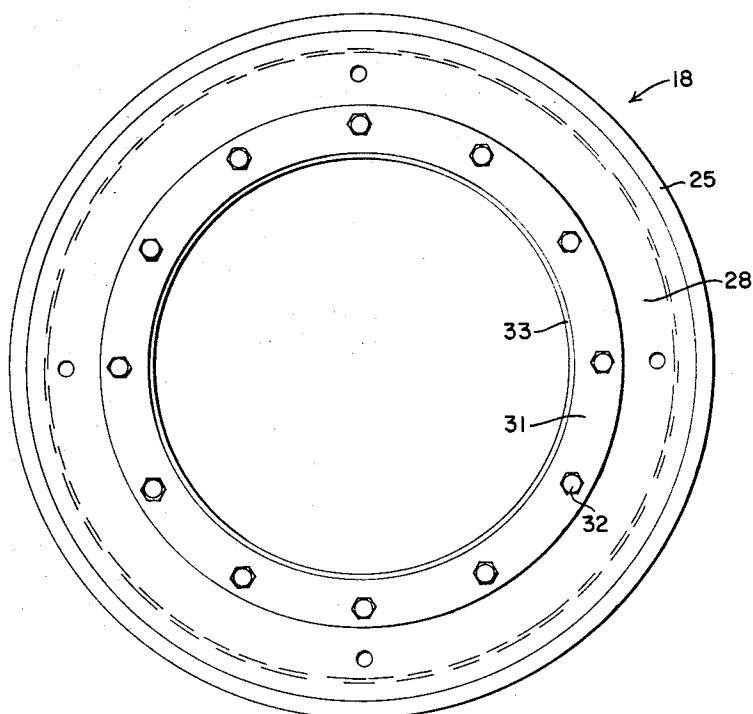


FIG. 3

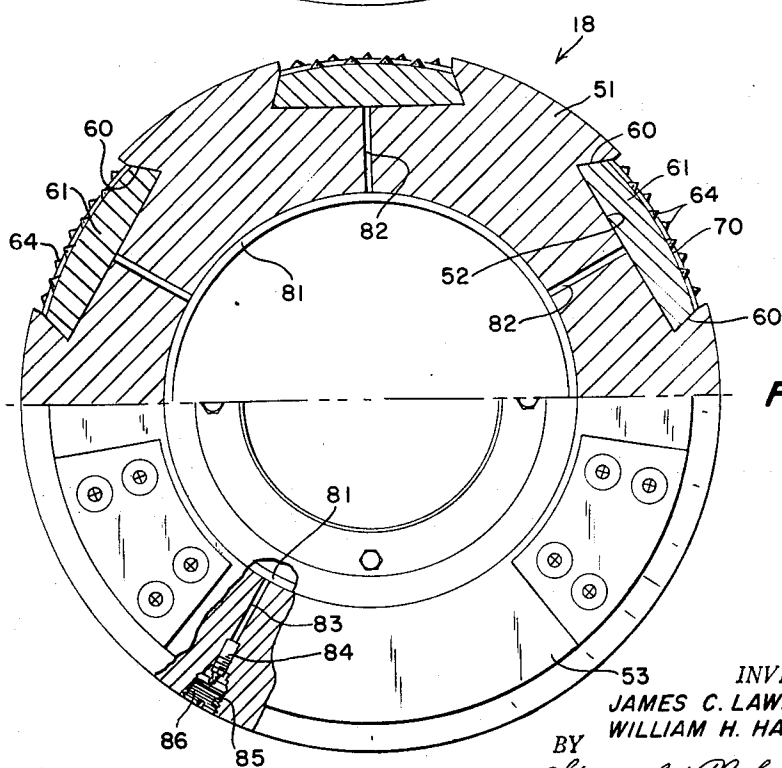


FIG. 4

INVENTORS
JAMES C. LAWRENCE
WILLIAM H. HAMILTON
BY
*Strauch, Nolan, Neale,
Nies & Bromough*
ATTORNEYS

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APPARATUS FOR ANCHORING THE PILOT MEMBER IN A PILOT BORE

James Clifton Lawrence and William Haut Hamilton, Seattle, Wash., assignors to Alkirk, Inc., Seattle, Washington, a corporation of Delaware

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11 Claims. (Cl. 175—230)

ABSTRACT OF THE DISCLOSURE

Apparatus for anchoring a pilot member of a tunnelling machine in a pilot bore. There is a conically shaped support mounted on the pilot member with a plurality of bore engaging elements slidably mounted thereon. A fluid pressure operated piston-cylinder arrangement moves the bore engaging elements on the conically shaped support so that the bore engaging elements move outwardly to engage the bore and anchor the pilot member. The bore engaging elements are shaped to permit rocking of the pilot member.

This invention relates to an anchor assembly and particularly to an anchor assembly of special construction for fixing the pilot tube of a rock or earth boring machine within a pilot bore with sufficient holding action to withstand the reaction forces exerted on the anchor as the machine is pulled forwardly to cut a main bore in the material in which the pilot bore is formed.

The invention refers in general to the type of earth or rock machine disclosed in Reissue Patent No. 24,965. Many different types of anchor units have been proposed for the various forms of this machine, and where the material being cut is relatively soft such as coal expandable resilient means has been found adequate. However, as the hardness of the material to be cut increases the demands on the anchor correspondingly increase, and in cutting into rock it has been found that hitherto available anchors are entirely inadequate. It was not until the present invention was made that an anchor assembly for such a machine capable of withstanding the forces exerted on it during rock tunnelling became available. It has been found that the steering or directional changes of the bore is an essential function of a modern and versatile boring machine. Hitherto types of pilot anchors have not been suitably constructed to allow for this all important motion.

It is therefore the major object of the invention to provide a novel pilot tube anchor assembly for a rock and like boring machine.

A further and basic object of the invention is to provide a pilot anchor so constructed as to allow the pilot anchor to swing about its gripping shoes as the boring machine's directional axis is changed.

Another object of the invention is to provide a novel pilot anchor assembly wherein pilot bore gripping slips or shoes are wedged forcibly outwardly in a novel manner.

It is a further object of the invention to provide a pilot tube anchor assembly of novel construction wherein a series of circumferentially arranged bore gripping elements are displaced outwardly by fluid pressure.

A further object of the invention is to provide a novel pilot tube anchoring arrangement wherein a relatively fixed piston is mounted on the tube surrounded by an axially slidable cylinder that moves in the forward direction along the pilot tube to outwardly displace bore gripping elements, and particularly the novel mounting of these bore gripping elements and their motion transmitting connections with the cylinder.

It is a further object of the invention to provide a novel pilot tube anchor assembly having correlated but

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distinct bore gripping means and bore sealing means located forwardly therefrom, both being actuated in unison by the same fluid pressure means.

In general, the foregoing and other objects are carried out by providing in combination with a rock boring machine having a pilot member adapted to project forwardly from the machine into a pilot bore, an expansible anchor assembly carried by said pilot member for fixing said pilot member within said bore comprising: an annular support mounted on said pilot member having a plurality of circumferentially spaced longitudinally extending forwardly upwardly inclined guideways, bore wall engaging elements slidably mounted in said guideways, an actuator member axially slidably mounted on said pilot member, means for displacing said actuator member axially along said pilot member whereby forward axial movement of said actuator member on said pilot member results in outward displacement of said bore wall engaging elements relative to said annular support, the surface of said elements being shaped in a direction parallel to the longitudinal axis of the pilot member to facilitate rocking of said pilot member about said anchor assembly.

Further objects of the invention will appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

FIGURE 1 is a fragmentary view partly in section showing the front end of an earth or hard rock boring machine according to a preferred embodiment of the invention;

FIGURE 2 is an enlarged elevation partially broken away and in section showing the pilot anchor assembly details;

FIGURE 3 is an end view of the anchor assembly;

FIGURE 4 is a partially sectioned end view of the anchor assembly, mainly along line 4—4 of FIGURE 2; and

FIGURE 5 is an elevation partially broken away and in section showing the angular capabilities of the pilot anchor.

Referring to FIGURE 1, the machine comprises a frame 9 having bearings such as at 10 for rotatably mounting a main cutter head 11. Cutter 11 is suitably power driven to rotate about the axis A—A and it carries on its front surface a series of roller cutter elements 12 that are adapted to engage and cut the main tunnel or bore face 13.

A hollow cylindrical pilot tube 14 coaxial with axis A—A projects freely through a central aperture in cutter head 11, and tube 14 is non-rotatable but is axially slidable with respect to head 11.

A pilot cutter shaft 15 projects coaxially freely through the bore of tube 14 and carries at its front end a pilot cutter head 16.

As illustrated in FIGURE 1, the pilot cutter extends into a pilot bore 17 that it forms ahead of the main cutter, and the pilot tube carries an anchor assembly 18 that anchors the pilot tube 14 rigidly within the pilot bore 17, the diameter of pilot bore 17 being larger than the relaxed anchor 18.

The machine comprises a mobile frame on which main cutter head 11 is suitably mounted and rotatably driven. The pilot tube is axially slidably mounted on the frame independently of cutter head rotation, as by a suitable hydraulic cylinder and piston arrangement, and the pilot cutter shaft 15 is rotatably mounted and driven by suitable means on the frame. Preferably the pilot cutter moves axially with the pilot tube during machine operation. In operation, the pilot cutter 16 forms ahead of the machine a relatively small pilot bore such as that at 17, as it rotates and advances to the left of material face 13. Then, or concurrently, pilot tube 14 is thrust into

pilot bore 17, and the anchor assembly 18 is expanded to grip the wall of bore 17. Now the main cutter 11 is rotated and, reacting from the anchor at 18, is pulled bodily toward and into face 13 to cut the main bore during entry.

The foregoing is generally of the same construction and mode of operation as disclosed in U.S. Reissue Patent No. 24,965 and Ser. No. 416,075 filed Dec. 4, 1964, and the essential improvement to be more specifically disclosed hereinafter and claimed is the novel anchor assembly at 18, shown in enlarged detail in FIGURES 2-4.

FIGURES 2-4 show anchor 18 on the end of pilot tube 14. Anchor 18 comprises an annular piston assembly 21 that is axially fixed on tube 14 by snap ring and groove assemblies at 22 and 23 and is surrounded by the bore 24 of a cylinder 25. The rear end of cylinder 25 is closed by an annular bushing 26 that slidably engages the periphery of cylindrical tube 14 at 27 and is retained on the cylinder by annular nut 28 threaded into the cylinder at 29. A retainer ring 31 secured to bushing 26 as by screws 32 holds a compressible seal ring 33 in peripheral engagement with pilot tube 14.

The outer periphery of piston 21 comprises an annular bushing 34 having resilient O-ring seals 35 with cylinder bore 24 and removably mounted on the piston as by screws 36, and a static O-ring 37 is provided at the internal bore of piston 21. Suitable peripheral O-ring seals 38 and 39 are also provided between bushing 26 and the concentric surfaces of the cylinder bore 24 and pilot tube 14.

Hydraulic fluid may enter the cylinder through either of ports 41 or 88 for operation as will appear.

Forwardly of piston 21 cylinder 25 is closed by a bushing 43 fixed to cylinder 25 and slidably surrounding tube 14 and having O-ring seals at 44 and 45.

An actuator ring 46 is secured to cylinder 25, as by bolts 47, and the rear end of ring 46 is piloted at 48 into the cylinder end for radial restraint.

Forwardly of ring 46 is an annular support member 51 having inclined flat longitudinally extending guide-way surfaces 52 lying tangential to a cone of revolution about the axis of the pilot tube. As shown in FIGURE 4, these surfaces 52 are equally circumferentially spaced about the axis of the anchor, and they are radially equidistant from that axis. An annular nut 53 is secured upon the end of tube 14 as by the threaded connection 54. Member 51 is interiorly slidably supported by a bushing 55 on tube 14 and a bushing 56 on nut 53, there being an axial clearance between the cone and nut at 57 for a purpose to appear.

Nut 53 and the adjacent end of member 51 are formed to define between them an annular groove 58 which contains a packing ring assembly 59 of compressible resilient material such as synthetic rubber.

A plurality of bore gripping elements in the form of shoes or slip members 61 have flat inner surfaces 62 slidably engaged with surfaces 52 and are circumferentially distributed about member 51 at the bottoms of longitudinal surface channels 63 that are cut in equally spaced relation around member 51 to provide surfaces 52. As shown in FIGURE 4 the opposite sides 60 of channels 63 are inclined to diverge outwardly from surfaces 52 and the opposite sides of slip members 61 are correspondingly inclined, to provide for longitudinal slide guiding and radial retention of slip members 61 on member 51. Each slip member bears on its outer surface a number of pointed teeth or projections 64 for gripping the material bore as will appear. It will be particularly observed that the outer tooth bearing surfaces 70 of slip members 61 are arcuately convex both in the longitudinal direction (FIGURE 2) and transversely (FIGURES 2 and 4), to provide rocking surfaces facilitating the steering operation of the machine disclosed in said Ser. No. 416,075 in that these surfaces facilitate shift of the ma-

chine about the anchor as a pivot during such steering, as best shown in FIGURE 5.

As shown in FIGURE 2, each slip member 61 is arcuately formed at its rear end 65 to fit with a corresponding arcuate surface 66 on actuator ring 46, and all of the slip members 61 are connected to actuator ring 46 by similar dumbbell-shaped rigid motion transmitting members 67 that have enlarged arcuate ends 68 and 69 disposed in similarly shaped sockets 71 and 72 in the slips and actuator ring respectively.

Sockets 71 and 72 have their walls similarly inclined, preferably at the same angle relative to the axis of the pilot bore, and radial outward displacement of members 67 from their sockets is prevented by a series of retainer pins 73 extending between grooves 74 and 75 in the slips and the actuator ring.

In operation of anchor assembly 18, with the pilot tube disposed in pilot bore 17, hydraulic fluid from passage 40 in the pilot tube is introduced at port 41 into the cylinder at the forward side of relatively fixed piston 21, whereby the entire cylinder assembly 25 is slidably displaced forwardly or to the left in FIGURES 1 and 2. Actuator ring 46, which is fixed to cylinder 25, transmits force through the connecting members 67 to slips 61 all of which are simultaneously displaced to the left in FIGURE 2.

Because of the sliding inclined wall socket connection at 68 slips 61 are permitted to become simultaneously displaced radially outwardly as they travel longitudinally forwardly along surfaces 52 so that projections 64 are forced into the wall of the surrounding pilot bore in the material to be cut. As slips 61 proceed up the inclines 52 on member 51, the resistance encountered progressively increases as the carbide tips 64 penetrate deeper into the surface of the pilot bore. This force is transmitted to the front cone assembly and during the initial stages of penetration of projections 64 into the bore 17 the force is sufficient to axially move member 51 forwardly, to the left in FIGURE 2, sufficiently to compress the resilient packer ring assembly 59 while the carbide tips of projections 64 are initially slipping at the bore surface, until such time as the clearance 57 between member 51 and the nut 53 is used up and member 51 abuts nut 53. This axial compression of packing ring 59 causes it to expand radially outwardly into a fluid tight peripheral sealing fit with the pilot bore. As can be seen in FIGURE 2 the relative travel between member 51 and the nut 53 can be regulated by using different lengths of bushings 56. This seal prevents water and the like from leaking through the pilot bore to decrease the holding action of the anchor and otherwise interfere with operation of the machine. As this occurs, slips 61 proceed further along the inclines 52 of the cone member 51 and outwardly until carbide tips 64 becoming embedded with their radial penetration force being equal to the lateral component of the actuation force. This sets the anchor 18 so that the pilot tube 14 is now fixed within bore 17 and becomes rigid with the material being cut.

When anchor 18 is thus expanded and set, the axial force necessary for cutting originating in the machine is transmitted solidly through the pilot tube 14, the body nut 53 and support member 51. The lateral component of this axial force increases the effective friction coefficient between the slips and the pilot bore at the same rate as the axial force is increasing by tending to displace the slips outwardly so that after setting the anchor 18 becomes self energizing.

In order to introduce lubricant between the relatively sliding surfaces 52 and 62, an annular recess 81 is provided around the interior of member 51 and recess 81 is connected by radial passages 82 to each surface 52. As shown in FIGURE 4, member 51 is provided with a radial passage 83 leading from recess 81 to a grease

fitting 84 recessed into a small threaded bore 85 normally closed by a removable plug 86.

To release anchor 18, hydraulic fluid is pumped along pilot tube passage 87 into the cylinder at a port 88 at the rear (right hand) of fixed piston 21, this moving the cylinder assembly and actuator ring 46 rearwardly toward the position shown in FIGURE 2. This force is transmitted to slips 61 through the action of connecting members 67 pulling the slips down the inclined ways 52, and the resilient packer-ring 59 contracts radially as it expands axially simultaneously with slip movement.

As shown in FIGURE 2 the seal annulus 59 consists of an inner resilient annulus 91 and two side by side outer annuli 92 and 93 the reduced outer ends of which project through the restricted mouth 94 of an annular axial space 95 between the nut 53 and member 51. This arrangement has been found to provide adequate expansion for sealing and when worn only the outer rings 92 and 93 need be replaced.

FIGURE 5 shows the angular displacement capabilities of the anchor assembly. The machine is shown as disposed in pilot bore 17 on the pilot bore axis indicated at A—A. As disclosed in Ser. No. 416,075 the axis of the main cutting head 11 may be angularly incrementally shifted by displacement of the entire machine to change the direction of cutting of the main bore, and this incremental shift is indicated at angle α whereby the cutting head axis is shifted from axis A—A to axis B—B in FIGURE 5. This shift is facilitated greatly by the arcuate shoes 61 which permit the necessary tilt in the tube 14 while retaining the tube axially anchored within pilot bore 17.

The foregoing anchor may be used in any machine of this type wherein a projecting pilot tube is to be fixed within the pilot bore. Where the pilot bore may be cut by a separate drill or the like, tube 14 need not be hollow. In a rock tunneling machine having a main cutter about 12 feet in diameter for cutting a bore of that size in rock we have found that an anchor of the invention that expands between about 24 inches in outside diameter when relaxed and about 26 inches in diameter when expanded to grip the pilot bore wall will withstand a thrust force of about 1,500,000 pounds exerted to pull the main cutter into the rock face to be cut.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. In combination with a rock boring machine having a pilot member adapted to project forwardly from the machine into a pilot bore an expansible anchor assembly carried by said pilot member for fixing said pilot member within said bore comprising: an annular support mounted on said pilot member having a plurality of circumferentially spaced longitudinally extending forwardly upwardly inclined guideways, bore wall engaging elements slidably mounted in said guideways, an actuator member axially slidably mounted on said pilot member, means for displacing said actuator member axially along said pilot member whereby forward axial movement of said actuator member on said pilot member results in

outward displacement of said bore wall engaging elements relative to said annular support, the surface of said elements being shaped in a direction parallel to the longitudinal axis of the pilot member to facilitate rocking of said pilot member about said anchor assembly.

2. In the combination defined in claim 1, an annulus in said anchor assembly disposed forwardly of said elements and operably connected to be expanded into sealing relation with said bore by said forward axial movement of said actuator member.

3. In the combination defined in claim 1, said pilot member being a hollow tube, and a rotatable pilot cutter extending through said tube to cut said pilot bore.

4. In the combination defined in claim 1, said anchor assembly comprising a piston axially fixed on said pilot member and a fluid pressure cylinder surrounding said piston axially slidably mounted on said pilot member, said actuator member being rigid with said cylinder.

5. In the combination defined in claim 1, said support member being mounted on said pilot member for limited axial sliding movement relative to said pilot member and further comprising an annular end member fixed on said pilot member, a resilient annulus axially mounted between said end member and support members, said support member being forwardly displaced during initial forward movement if said actuator member is to compress said resilient annulus and expand it radially into sealing relation with the wall of said bore.

6. In the combination defined in claim 1, means for lubricating said guideways comprising an annular passage between said support member and pilot member connected to a radial lubricant introduction passage in the support member, and radial branch passages between said annular passage and said guideways.

7. In the combination of claim 1, the shape of the surface of said elements in the direction parallel to the longitudinal axis of said pilot member being arcuate.

8. In the combination of claim 1, said anchor assembly further comprising individual motion transmitting members extending longitudinally between said actuator member and each of said bore engaging elements, said elements and said motion transmitting members having abutting end surfaces in slidable engagement so that said bore engaging elements can move outwardly relative to said motion transmitting members.

9. In the combination defined in claim 8, said relatively slidable end surfaces between each motion transmitting member and its associated bore engaging element extending angularly from said guideways.

10. In the combination defined in claim 8, said motion transmitting members having enlarged ends disposed in sockets formed in said actuator member and said elements respectively.

11. In the combination defined in claim 10, said motion transmitting elements being of essentially dumbbell shape with said enlarged ends being rounded.

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ERNEST R. PURSER, *Primary Examiner*.