May 29, 1962 J. E. ECKEL ET AL 3,036,646

RETRACTABLE TURBINE DRILL

Filed Oct. 11, 1957 2 Sheets-Sheet 1

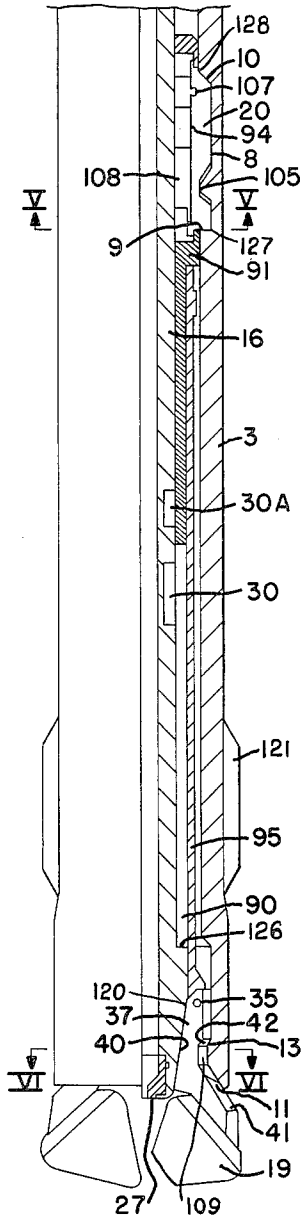


FIG.-1A

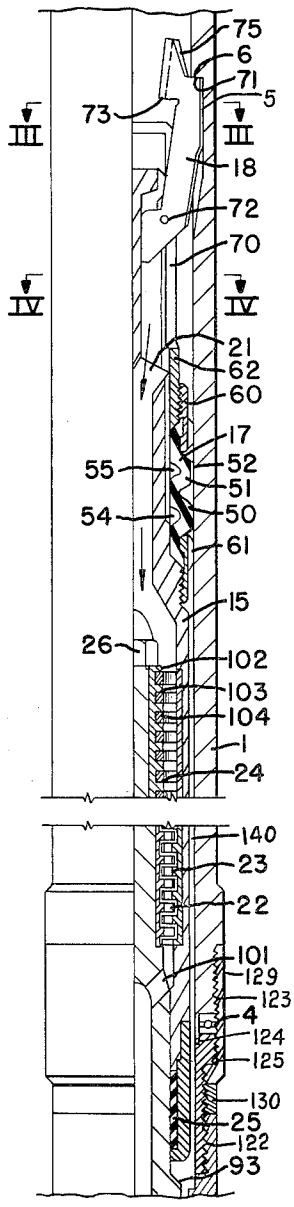


FIG.-1B

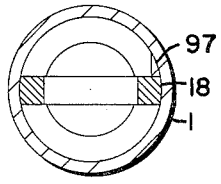


FIG.-3

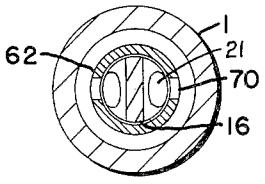


FIG.-4

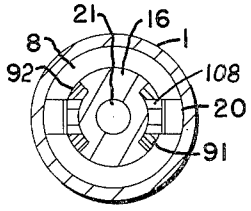


FIG.-5

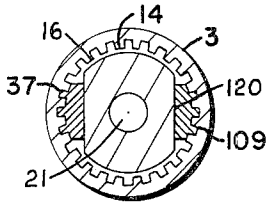


FIG.-6

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RETRACTABLE TURBINE DRILL

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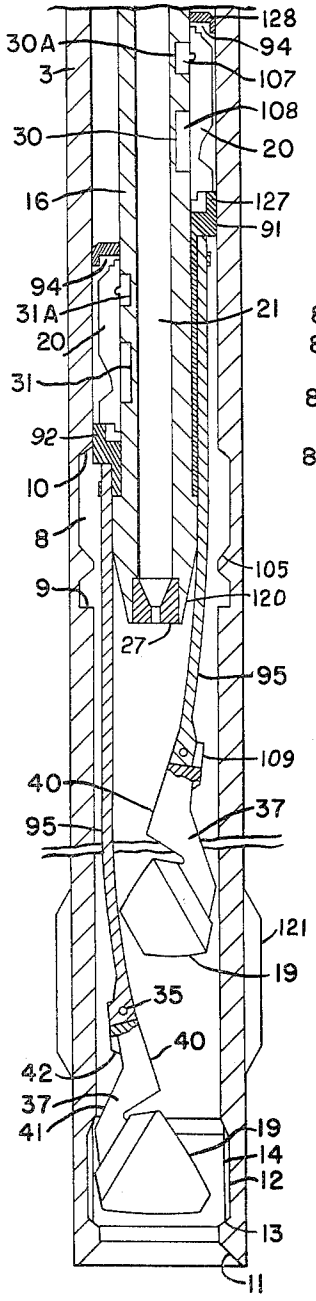


FIG.-2A

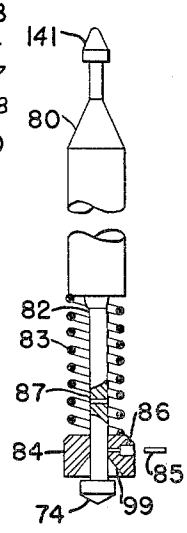


FIG.-7

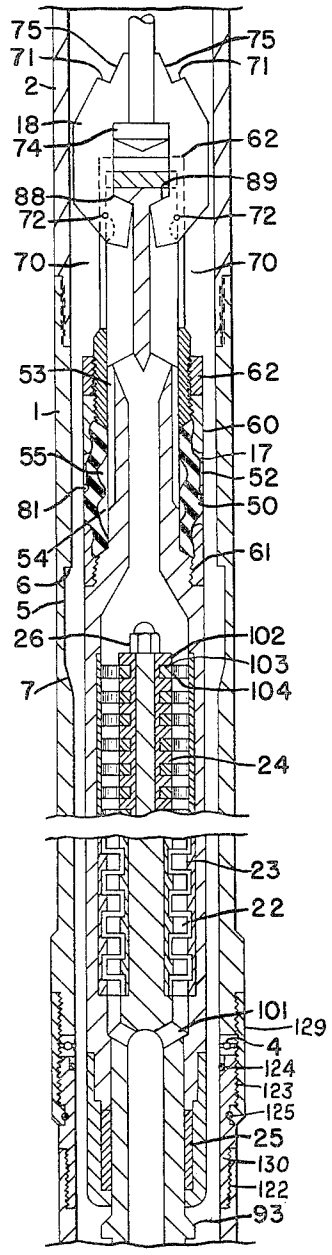


FIG.-2B

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United States Patent Office

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RETRACTABLE TURBINE DRILL

John E. Eckel and John M. Camp, Tulsa, Okla., assignors, by mesne assignments, to Jersey Production Research Company

Filed Oct. 11, 1957, Ser. No. 689,567
8 Claims. (Cl. 175—107)

The present invention concerns an improved retractable turbine drill for use in well-drilling operations. More particularly, the invention concerns a fluid-driven turbine incorporated within a rock drill bit in a manner such that the complete unit can be run through the drill pipe and expanded into drilling position or retracted therefrom by means of conventional wire line equipment.

The apparatus of the invention, it will be noted, is related to a retractable drill assembly which is described and set forth in U.S. patent application Serial No. 600,910, filed July 30, 1956, in the name of John M. Camp and Jackson M. Kellner.

The apparatus of the invention in a preferred embodiment includes a tubular sub which is attachable to the lower end of a string of well pipe and a drill collar which is supported from the sub by a swivel joint and bearing section. This swivel joint permits the sub to remain stationary or to be rotated slowly with the drill pipe while the lower section or drill collar is rotated at a higher speed by an elongated turbine adapted to fit within the sub and drill collar and to be lowered within the sub and drill collar to a point near the bottom of a borehole. A plurality of suspended cutters are carried by the turbine shaft. Latching devices or equivalent means are slidably mounted in slides in the turbine and are alternately engageable with recesses in the turbine and in the sub and drill collar. The slides support elongated straps or equivalent members which in turn extend below the drill collar and support individual cutter elements of the drill bit.

As the turbine is originally assembled and lowered within a well bore, the latching devices engage recesses in the turbine shaft in a manner such that the slides support the drill bit cutter elements in a vertically spaced, nested relationship. Then, as the turbine enters and passes through the sub and into the drill collar, the latching devices disengage from the turbine shaft, slide along the turbine shaft, and engage recesses within the drill collar. Simultaneously, the cutter elements protrude below the drill collar and assemble with one another in a manner to define an integral multi-cutter drill bit. Once the latching devices engage and lock within the sub and drill collar, the turbine is free to move vertically downward an additional distance sufficient to bear against inner contact shoulder of the cutter support members and thereby force the cutter elements into locking engagement with the drill collar. Matching splines on the individual cutter elements and the drill collar provide a positive driving element between the drill collar and the assembled bit. The splines are of a character such that the cutter elements require no particular orientation relative to the drill collar and therefore readily engage the drill collar without requiring preorientation. Drilling fluid enters the turbine from the drill pipe through entering ports and drives the shaft of the turbine, with the drilling fluid leaving the turbine through an exit port in the shaft near the cutter elements. The case of the turbine is engaged with the sub and is locked therein, with the shaft of the turbine being engaged and locked to the drill collar so that the rotation of the turbine shaft to which the cutter legs are affixed is transmitted to the drill collar which drives the cutter elements through spline sections at the same rate of speed as the rotation of the shaft. The drill pipe may

be stationary or it may be rotated independently at a slower rate.

An expansible sleeve packer of a type capable of very substantial longitudinal compressive movement is preferably provided on the case of the turbine and is activated subsequent to assembly of the particular cutter elements to provide a fluid-tight seal in the annulus between the turbine and the sub. Releasable engaging means are provided in the upper end of the turbine for positively engaging the sub when the bit cutters have been assembled and the packer has been set.

Having briefly outlined the major structural components and features of the present apparatus, attention is now directed to the drawing for a more complete and clearer understanding of the invention. The drawing illustrates an apparatus constituting a preferred embodiment of the invention which is contemplated to be the best mode for practicing the invention.

FIG. 1A and FIG. 1B illustrate the apparatus in partial vertical section as the apparatus appears with the particular cutter elements extended into drilling position. FIG. 1A illustrates a lower portion of the apparatus, and FIG. 1B an upper portion.

FIG. 2A and FIG. 2B illustrate the apparatus of the invention in vertical cross section as the apparatus appears with its cutter element in a retracted position for lowering within a borehole. FIG. 2A illustrates a lower portion of the apparatus and FIG. 2B an upper portion.

FIGURE 3 is a sectional view taken along lines III—III of FIG. 1B.

FIGURE 4 is a sectional view taken along the lines IV—IV of FIG. 1B.

FIGURE 5 is a sectional view taken along the line V—V of FIG. 1A.

FIGURE 6 is a sectional view taken along the line VI—VI of FIG. 1A.

FIGURE 7 is a partially sectioned view of a tool, shown on a reduced scale, for expanding or retracting the apparatus of FIGURES 1–6.

Referring to the figures, sub **1** is an elongated tubular member threaded at its upper end to engage drill pipe **2**. The actual junction of the sub with the drill pipe may be a threaded connection, as particularly shown in FIG. 2B, or it may be other equivalent devices. The sub preferably has an internal diameter substantially equivalent to that of the drill pipe in order to provide the sub with additional strength and ruggedness. A drill collar **3** is also an elongated tubular member and is connected to sub **1** by a swivel joint and bearing **4**, which permits the drill collar to be rotated while the sub is held stationary or turned at a slow rate. The raceways and bearings of swivel joint **4** are held in place by upper and lower interlocking ring members **129** and **130** which are threadedly connected to sub **1** and drill collar **3** at **123** and **122**, respectively. Preferably O-ring seal **125** is used to seal ring member **129** with ring member **130** and seal **124** seals lower ring member **130** with the lower end of sub **1** which extends below the raceway and bearings. Suitable seals for seals **124** and **125** are well known. The swivel joint **4** is designed such that both thrust and radial forces will be transmitted therethrough while permitting the drill collar to turn in relation to the sub. This is a very important feature as it reduces the thrust to which thrust bearing section **24** is subjected and results in less wear and longer life for thrust bearing section **24**.

Near the upper end interiorly of the sub **1** is a central circumferential groove **5** which possesses a downwardly facing shoulder **6**. The lower portion **7** of groove **5** is preferably tapered and inclined, as illustrated, for reasons that will be apparent later in this description.

A second peripheral groove **8** is provided in the drill

collar 3 intermediate its ends. This groove is provided with a lower, upward facing shoulder 9; an upper, downward facing, tapered shoulder 10; and a bevel 105 as illustrated. Bevel 105 prevents the cutters from hanging on square shoulder 9 as they are being lowered, and also aids in properly timing the engagement of the latching means. The lower end of drill collar 3 terminates in an inwardly tapered and downward facing shoulder 11, the angle of taper being selected in a manner to be considered later in this description.

Spaced slightly above shoulder 11 is a third groove 12 which extends around the inner periphery of drill collar 3. The upper and lower ends of this groove are preferably tapered as shown, the lower taper of shoulder 13 defining a surface whose purpose will be clear later in this description.

Disposed around the entire periphery of groove 12 are a plurality of longitudinally disposed and radially spaced splines 14. As will be apparent later, these splines coact with mating splines on each one of the cutter elements to effect a positive drive relationship between the drill collar and the cutter elements. The upper terminal ends of each spline are preferably tapered and rounded so that the splines on the cutter elements may freely engage the splines on the drill collar. Thus, sub 1 and drill collar 3 are connected longitudinally by swivel joint 4, forming essentially an elongated cylindrical member or chamber having a plurality of vertically spaced and internally disposed circumferential grooves and shoulders, the purpose of which is to coordinate and coact with various other parts of the apparatus to be considered next.

Fitting within sub 1 and drill collar 3 is an elongated turbine which includes case 15 and shaft 16. The turbine carries packer assembly 17 and upper latches 18 on case 15 and carries cutter elements 19 and lower latches 20 on shaft 16. A central passageway 21 extends vertically from the upper end of the case and serves as an entering port communicating with the interior of the drill pipe and the interior of the turbine drive means. The hydraulic turbine comprises shaft 16 upon which rotors 22 are mounted and case 15 upon which stators 23 are mounted. The turbine also has thrust bearing section 24 and radial bearing 25 and is provided with a diverting cap 26 which may be a nut, keeper ring, or the like. Thrust bearing section 24 includes a series of substantially thrust receiving ring members 104 fixed to the inner wall of the outer case 15 and disposed in face to face relation and spaced longitudinally of said series; a corresponding series of spaced ring elements 102 fixed to the shaft in longitudinally spaced relation thereof and in alternate overlapping spaced relation to said thrust receiving ring; and an annular resilient cushioning means or bearing 103 disposed between adjoining portions of the respective thrust receiving rings and thrust ring elements. Other type bearing section which transmits the thrust between shaft 16 and case 15 may be used. Drilling mud or other fluids from the interior of the drill string passes through entering port or passageway 21 and passes through the fluid turbine, thus giving rotary motion to shaft 16; and the fluid then passes out exit passage means including port 101 to the cutter element of the bit and a passageway or fluid nozzle 27 which is provided for better directing the drilling mud or other fluid at high velocities against the bit. The direction of fluid flow is indicated by the arrows. Stabilizers 121 are attached or made an integral part of drill collar 3 to stabilize the drilling and are an aid in drilling a straight hole. It is, of course, understood that turbines other than the type shown may be utilized but must be capable of passing through the drill pipe employed and be adaptable to the retractable latching and engaging means described herein.

The outer surface of the lower end of turbine shaft 16 is preferably tapered somewhat to resemble a frustoconical wedge. Tapered surface 120 of shaft 16 is clearly shown in FIG. 6. The structural feature enables the

shaft to apply a wedging action against the cutter elements 19, and the cutter elements are extended downwardly and outwardly into a drilling position and engage with the lower end of the drill collar. The cutter elements, as illustrated, are preferably cone-type cutters.

Disposed above the lower tapered portion of shaft 16 and extending upwardly along the length of the drill collar are elongated grooves or slots 90 which provide vertical runways for movement of slides 91 and 92. The elongated grooves do not extend the entire length of shaft 16 but instead terminate below the radial bearing 25 between the shaft and the case of the turbine at the shoulders 93. The lower end of grooves 90 terminate at shoulder 126.

The upper end of each slide is recessed internally with a cavity 94. Disposed within each cavity is a latching dog 20, each dog being normally urged radially outward by means of springs or other equivalent devices not shown. The dogs, it will be noted, are provided with lugs 107 and 108. The dogs are also provided with shoulders at each vertical end which engage retaining shoulders, thereby retaining the dogs within the slides. Each dog 20 has a lower square shoulder 127 which is essentially normal to the axis of turbine shaft 16. The upper shoulder 128 is tapered to match tapered shoulder 10 of groove 8.

Secured to the lower end of the slides 91 and 92 are elongated straps or equivalent supporting members 95 which are attached or secured to shanks 37 of cutter elements 19.

Each slide 91 and 92 and its attached strap lie within an elongated groove or slot 90 formed within the wall surface of turbine shaft 16. Thus, each slide and its attached strap are able to move in a vertical or longitudinal slidable manner relative to the turbine shaft. Slides 91 and 92 have different longitudinal lengths. This permits dogs 20 to be engaged and disengaged at different times. It also permits cutters 19 to be spaced longitudinally when suspended as shown in FIG. 2A.

A set of recesses 30 and 30A are positioned along the shaft 16 and in alignment with one of the slots 90. Recesses 30 and 30A are vertically spaced so as to simultaneously receive lugs 108 and 107, respectively, as the tool is lowered into the hole to prevent any movement of a cutter 19, the strap 95, and a slide 91 with relation to the shaft 16 before all of these parts reach the proper position within the sub and drill collar. A second set of recesses 31 and 31A are spaced vertically from the first set of recesses 30 and 30A and perform the same function in relation to a second strap and cutter. It will be apparent that vertical spacing of the first set of recesses 30 and 30A and the second set 31 and 31A is required in the illustrated apparatus in order that the vertically spaced cutters in a retracted position may be placed in the same horizontal plane in their extended or drilling position. It should be noted that one lug 108 could be utilized instead of lugs 107 and 108; and, likewise, one recess 30 could be used instead of both recesses 30 and 30A. However, it has been found that the arrangement as shown in the preferred embodiment illustrated herein gives far better timing of the various latching mechanisms and is to be preferred.

At this point it will be noted that the apparatus in the drawing is shown to possess two cutter elements. An apparatus with two cutters has been chosen to illustrate and describe the invention, since description of such an apparatus is relatively straight forward and readily understood. It should be pointed out, however, that an apparatus employing three cones is actually preferred for the purposes of the invention. In the latter instance the cutters are spaced 120° apart rather than the 180° shown in the present drawing.

It should also be noted at this point that it is essential for the cutters and their associated straps and slides to be distributed in an equally spaced manner around the periphery of the center shaft of the turbine. Furthermore, the number of splines 14 in the lower portion of the sub 1

should be evenly divisible by the number of cutter elements in the bit portion of the apparatus. For example, 60 splines would be suitable for use with bits containing two to six cutters. It has been ascertained that engagement of the splines 14 in the drill sub and the matching splines associated with each cutter element is readily and cleanly made when this condition is observed.

Each conical cutter 19 is attached to its respective strap 95 by means of a pivot pin 35. The pins provide the cutters with a degree of movement necessary for them to be expanded and retracted as desired.

The shanks 37 are provided with an angular configuration to coordinate these members with the shaft and the drill sub. Specifically, each shank is provided with an inner shoulder 40 which is tapered to coincide with the lower tapered surface 120 of shaft 16. The mating of tapered surfaces 120 with shoulder 40 is shown particularly in FIG. 6. A lower outer shoulder 41 is provided to coincide with the shoulder 11 at the bottom end of drill collar 3; and an upper outer shoulder 42 is provided to coincide with and bear against the lower taper or shoulder 13 of the drill collar.

The lower outer shoulder 41 of each shank should form an angle with the vertical of between about 35° and 45°, since it has been found that angles in this range provide a unique advantageous distribution of thrust and space for the expansion and retraction of the cutter elements. Most conventional cone-type bits have pin angles of about 39°; and it has been observed that when using such cutters, the angle with the vertical of the shoulders 41 should likewise be about 39° for best overall results.

Insofar as the angular disposition of the upper outer shoulders 42 are concerned, it is preferred that these shoulders form an angle of at least about 30° from the vertical and preferably at least about 45°. An angle of 90° should not be exceeded.

A packing element 17 is mounted on turbine case 15 at a point vertically above shoulder 93. This packing element is used to seal or "pack-off" annulus 140 between case 15 and sub 1. As illustrated, the packing element should preferably be a sleeve-type element which resembles a bellows in structure and which is capable of radial expansion in response to longitudinal compression. It is necessary and desirable that the packer element be of a character to set under relatively low loads and that it further be characterized by substantial longitudinal compression.

The packer element should be constructed of an elastic, deformable material—preferably natural or synthetic rubber—and it should be pleated as indicated to resemble a bellows. It has been found that very substantial longitudinal movement is attainable with the bellows construction and such movement is necessary in order that the latching dogs may properly coordinate and engage the sub 1 and collar 3 in relation with the turbine. Conventional rubber sleeve packers have been tried in this application, but they have been found to require setting loads which are impractical and undesirable in the practice of this invention. On the other hand, the bellows- or accordion-shaped packer illustrated in the drawing has been found to combine all of the features that are necessary to insure proper and dependable operation of the apparatus.

Referring more particularly to packer assembly 17, it wil be observed that lower bellows element 50 actually contacts and provides a sealing surface against the inner wall of sub 1, whereas the upper bellows element 51 does not contact the sub completely around its periphery. Thus, bellows element 51 may be made smaller in diameter than element 50; or alternatively a slot 52 may be cut through element 51. Furthermore, it will be observed that a longitudinal groove or passageway 53 is provided along the length of turbine case 15, the purpose of this groove or slot being to vent the inner cavity portions 54 and 55 of the bellows to the interior passageway of the turbine. It is then impossible for liquid to be entrapped in any of the cavities that are formed between the pleats

of the packer assembly 17 when this assembly is expanded into contact with the sub. Any liquid so entrapped has been found to impair the ability of the packer to compress under light loading, and the venting passageways are therefore vital to the successful operation of the packer.

Packer assembly 17 is held against the outer wall surface of the sub 1 by virtue of upper retaining ring 60 and lower retaining ring 61. Lower ring 61 is secured directly to the turbine case 15, while upper ring 60 is attached to sleeve 62 which is vertically movable relative to the turbine. Thus, a vertical force or thrust downward against sleeve 62 drives this member plus upper retaining ring 60 vertically downward relative to the turbine and thereby compresses the bellows elements 50 and 51. Element 50 seals against sub 1, and both elements—i.e., elements 50 and 51—contract longitudinally a distance sufficient to enable the sets of latching dogs to engage the proper grooves at the proper instant.

At this point it should be noted that sleeve 62 extends up beyond the turbine case 15 and is provided with two ports 70 through which upper dogs 18 are able to pivot. Both dogs are pivoted about pivot pins 72 which in turn are mounted in sleeve 62. The upper ends of dogs 18 are provided with outer upward facing shoulders 71 adapted to engage shoulder 6 on sub 1; and they are also provided with inner downward facing shoulders 73 which are adapted to engage the spearhead 74 of a tool for raising or lowering the turbine and its associated parts. The dogs are normally urged outwardly as by means of a suitable spring or other resilient element not illustrated.

The upper end of each upper dog 18 is provided with a tapered section 75. The purpose of this tapered section is to enable a suitable tool to urge the dogs radially inward, when it is desired to retract the drill and raise it from within the drive sub. An example of a suitable tool is shown in FIGURE 7 and includes sinker bar 80, upper spearhead 141, stem 82, spring 83, retracting sleeve 84, lower spearhead 74 and pin 85. Sleeve 84 is slideably movable on stem 82 and is normally urged downward from sinker bar 80 by means of spring 83. The tool is illustrated in FIGURE 7 with the spring in its expanded position; and it is in this condition that the spring is employed to retract the drill assembly. The pin 85 is not inserted in the tool in this instance. Lifting of drill by the tool is actually accomplished when the inner shoulders 88 on the dogs 18 engage the shoulders 89 near the top of the turbine.

When the tool in FIGURE 7 is to be used to lower the drill into a bore hole, spring 83 is compressed, and pin 85 is inserted in the holes 86 and 87 to hold the spring in its compressed position. Sleeve 84 is provided with a conical recess 99 at its lower end to enable the sleeve to retract dogs 18 by bearing down upon shoulders 75. Upper spearhead 81 is attachable to a wire line or equivalent means for raising and lowering the retracting tool.

Having described the various structural components of the apparatus in the drawing, attention is now directed toward a consideration of the manner in which the apparatus functions. For this purpose, it will be assumed that the apparatus is first to be lowered within a borehole in order to carry out a drilling operation.

Referring to FIGURE 2, the apparatus is there illustrated in the condition required to enable it to be lowered within a borehole. The spearhead 74 of the lowering tool illustrated in FIGURE 7 is in engagement with the shoulders 73 of the retractable upper dogs 18, and the entire bit assembly is suspended from the spearhead. The dogs 18 are maintained in a retracted condition; and, since packing assembly 17 is under no compressive loading, it also is in a retracted position. Cone cutters 19 of the bit are in a retracted, vertically nested condition, the slides 91 and 92 being locked or in engagement with the recesses 30 and 30A and 31 and 31A in turbine shaft 15. Lugs 107 and 108 of latching dog 20 fit, respectively, into recesses 30A and 30 during lowering operation and aid

in reducing the wobbling of the unit as it is being lowered into position.

Upon being lowered within sub 1 and drill collar 2, the turbine and its associated parts coact with the sub in the following sequence. First, the lower one of the two latching dogs 20 reaches groove 8 and pops out into the groove from recesses 31 and 31A. Since dog 20 is clear of turbine shaft 16 when it engages groove 8, turbine shaft 16 is free to move vertically downward relative to the lower dog.

Simultaneously with the entry of the lower dog 20 into groove 8, lower cutter 19 expands into a drilling position immediately below the lower end of the drill collar. In other words, the lower outer shoulder 41 and the upper outer shoulder 42 of the shank attached to the lower cutter engage shoulder 11 and shoulder 13, respectively, of the drill collar. Similarly, splines 109 of the cutter shanks engage the matching splines 14 of the drill collar.

Subsequent to engagement of the lower of the two cones or cutters 19 with drill collar 3, turbine shaft 16 continues vertically downward with its remaining lower dog and cutter, i.e., the upper of the dogs 20 and the upper of the cutters 19. When the remaining dog reaches groove 8, it—like the first dog—pops into the groove and disengages itself from the turbine shaft. Simultaneously, its cutter expands into a drilling position radially opposite the first cutter. Then, the turbine, being free of both locking dogs, slides down relative to both cutters until the lower conical wedging surface of the turbine shaft bears against the inner shoulders 40 of shanks 37. This action on the part of the turbine serves to wedge the shank portions and their attached cutters firmly in drilling position. The spline segments 109 on each shank are now in engagement with the spline 14 of the drive sub.

At this point it is well to note that it will be generally necessary to employ sinker bars or other weighted devices for applying a load on the turbine which is sufficient to wedge the cutters and their attached shanks into a drilling position. As illustrated in FIGURE 7, such sinker bars or other weights may be incorporated directly as components of the tool which is used to raise and lower the drill.

Once the cutters have been wedged into drilling position at the bottom of drill collar 3, expansion of the packer assembly 17 is the next step in the operating sequence. Briefly, the aforementioned sinker bar or other weight exerts a downward thrust through spearhead 74 and the upper end of sleeve 62 which is sufficient to drive the sleeve vertically downward against retaining ring 60 and the bellows packer. Since the lower end of the bellows packer is supported directly from the turbine in combination with lower retaining ring 61, longitudinal compression of the bellows results. This compression in turn causes the individual bellows elements or pleats 50 and 51 to contract vertically and to expand radially. Any liquid entrapped within the inner peripheral cavities 54 and 55 is vented through slot 53 into the interior passageway within the turbine and the well pipe above the sub. Similarly, any liquid entrapped in the outer peripheral cavity 81 defined by the two bellows elements is free to vent upwardly in the annular space between the upper retaining ring 60 and the sleeve 62.

Longitudinal contraction and radial expansion of the packer results in bellows element 50 forming a peripheral seal between the turbine case portion of the overall assembly and the inner wall surface of the sub. The degree of compression and the degree of sealing may be readily controlled by the amount of force which is applied by means of the sinker bar or other weight.

Concurrently with the setting of the packer, upper dogs 18 are forced outwardly until they come laterally opposite the upper groove 5 in sub 1. Since the spearhead 74 is now bearing directly against sleeve 62 it follows that dogs 18 are free to expand and ride along the inner surface of sub 1 until they reach groove 5. At this time they expand further and enter groove 5. Torque opposing lug 97 is provided to resist rotary movement of the turbine case 15 in relation to the sub and drill pipe.

The drill is now in condition and position for drilling, and spearhead 74 may be raised vertically from the apparatus and removed from the borehole. Actual drilling is obtained by lowering the sub and drill collar and the attached well pipe until the cutters reach the bottom of the borehole. Rotation of the bit is obtained by passing the drilling fluid through the hydraulic turbine which effects the rotation of shaft 16. The rotation of shaft 16 is transmitted to the cutter shanks by the lower wedging surface of the shaft contacting the shoulder 40 on the cutter shanks. The engagement of the spline segments 109 on the cutter shanks with the splines 14 of the drill collar 3 transmit rotation to the drill collar 3. Downward thrusts on the well pipe are transmitted from sub 1 through swivel joint 4 to drill collar 3 and thence directly from drill collar 3 to the shoulder 41 of cutter 19. A part of the downward thrust on the well pipe is transmitted through dogs 18 to sleeve 62 and thence through the bellows packers and case 15 through thrust bearing section 24 to shaft 16 to maintain the cutter shanks 19 in a locked relationship in the drill collar. The drill pipe and sub may be held stationary by surface equipment while the cutters and drill collar are rotated by shaft 16.

When a drilling operation has been interrupted and it is desired to remove the drill from the borehole, the following sequence of operations is employed. First, the well pipe is removed or lifted a sufficient distance to lift the cutters off the bottom of the hole, and the injection of fluid through the drill pipe is ceased thus stopping the rotation of the turbine shaft. The tool illustrated in FIGURE 7 with pin 85 removed is lowered through the well pipe. When the spearhead 74 of the tool reaches the upper latches 18, the inner conical surface 99 of the tool forces the latches radially inward from the groove 5 so that they disengage from the sub 1 and in turn engage the spearhead. An upward pull on the tool then causes upward movement of sleeve 62 with a resultant longitudinal expansion and radial contraction of the packer.

Upward pull of the tool also lifts the turbine shaft 16 with the result that cutter elements 19 are retracted from their drilling position and lifted within the drill collar in a sequence which is substantially the reverse of the sequence by which they were expanded into the drilling position. Thus, the right-hand cutter in FIGURE 2 is the first of the cutters to be retracted and withdrawn, and the left-hand cutter than follows.

When turbine shaft 16 is withdrawn, shoulder 126 contacts slip 91 first. At this point grooves 30 and 30A in shaft 16 are substantially opposite dog 20 held by slip 91. Upward force of shaft 16 is transmitted to dog 20 through slip 91 which is forced against square shoulder 127 of dog 20. Upper shoulder 128 of dog 20 is tapered to match shoulder 10 of groove 8. The upward force against dogs 20 pushes the tapered shoulder 128 of dog 20 against tapered shoulder 10 of groove 8, thus forcing dog 20 out of groove 8 and into recesses 30 and 30A.

Simultaneously with the retraction of the cutters, upward pull of the turbine shaft 16 causes the slides 91 and 92 to be sequentially engaged and lifted relative to the drill collar. The slots 90 move upward and their slides 91 and 92 remain stationary until dogs 20 are retracted from the groove 8 and enter the recesses 31 and 31A and 30 and 30A. At this point the drill is in a fully retracted position and may be lifted to the surface of the earth.

The use of the retractable turbine as disclosed herein may also be utilized or adapted for use with other retractable bits such as, for example, the one described in U.S. Patent 2,330,083, issued to B. W. Sewell, assignor to Standard Oil Development Company or the retract-

able bit of Reed Roller Bit Company of Houston, Texas, described in their Catalog 37, pages 1480–1481.

It will be apparent that the drills of this invention are preferably operated by means of wire-line apparatus. It will further be apparent that the apparatus may be constructed from the usual materials such as steel, rubber, and the like that are conventionally used in drilling equipment. Furthermore, it will be recognized that conventional drilling techniques such as the use of drilling mud or other drilling fluids may be employed as desired to aid the drilling process.

What is claimed is:

1. A retractable turbine drill bit assembly comprising in combination a tubular sub attachable to the lower end of a string of well pipe, a drill collar having spline segments extending around its lower end and being longitudinally supported below said tubular sub, a swivel joint connecting said sub and said collar, an elongated turbine within said sub and said collar and provided with at least one entering port communicating with said drill pipe and with at least one exit port terminating at the lower end of said turbine, said turbine having a case and a shaft, a plurality of cutters having spline segments on the exterior thereof, retractable latching means securing the case of said turbine to said sub, a strap connected to each said cutter, a second retractable latching means secured to each said cutter by each said strap, said second latching means being of a character to selectively secure said strap to said turbine shaft or to said drill collar in accordance with the relatively longitudinal position of said shaft with respect to said collar, said straps being of the proper length such that when said latching means is secured to said collar said cutters extend beyond the lower end of said collar, said shaft and said cutters including means for wedging said shaft against the cutters firmly into drilling position with said spline segments on the exterior of each cutter into said spline segments extending around the lower end of said collar.

2. A retractable turbine drill bit assembly comprising a tubular sub attachable to the lower end of a drill pipe, a drill collar having internal splines and an internal groove and being supported longitudinally below said sub, a thrust and radial bearing swivel joint supporting said collar from said sub, a turbine including a turbine case and a turbine shaft with said turbine being adapted to fit within said sub and said collar, a plurality of cutters having spline means matable with said splines in said collar and being supported from slides slidably mounted on said shaft in a longitudinally movable relation, releasable latching means engaging grooves in said collar for placing said cutters in same horizontal plane in their drilling position as said turbine is lowered in relation to said drill collar, said shaft being movable additionally against said cutters after said cutters are positioned in same horizontal plane to wedgingly engage said spline means of said cutters with said mating splines on said drill collar, at least one entering port communicating between the interior of said case and said drill pipe, at least one exit passage means communicating between the interior of said case and the exterior thereof adjacent said cutters, retractable latching means for lockingly supporting said case from said sub, whereby said turbine assembly may be lowered into and removed from said sub and drill collar without pulling said drill pipe and when drilling fluid from said drill pipe passes through said entering port into the turbine case the shaft of said turbine is thereby driven which in turn rotates said drill collar and said bits while said drill pipe is substantially stationary.

3. An apparatus as defined in claim 2 in which the cutters are conical cutters and three in number.

4. A retractable turbine drill bit assembly comprising an elongated turbine having a shaft and an outer case with said shaft having inwardly tapered shoulders at its lower end, slides confined in slots on the external periphery of said case of said turbine in a longitudinally movable relation, straps slidably mounted on said slides, a plurality of cutters having shanks with internally facing tapered surfaces and mating the tapered shoulders of said shaft and being suspended from said straps, said cutters being equally spaced about the periphery of said shaft in a vertically spaced relation, said cutters in an upper position depending from said turbine in a vertically spaced relation, said cutters in a lower position being on substantially the same lateral plane and below said turbine, an arcual spline segment on an exterior surface of each cutter, a tubular sub attachable to the lower end of a drill pipe, a drill collar rotatably supported longitudinally below said sub, said turbine being adapted to be lowered within said sub and said drill collar, an upper set of retractable latching means mounted on the case of said turbine and engageable with a recess on said on said sub, a lower set of retractable latching means mounted on the shaft of said turbine and engageable with a recess on said drill collar, a plurality of splines extending circumferentially around the lower end of said drill collar and being engageable with said arcual spline segments, said slides being mounted in said slots with said slots terminating in a manner such that said slides will have proper vertical movement for proper positioning of said cutters, said lower latching means being disposed in said slides which hold said cutters in a predetermined position in relation to said turbine and with said slides being beld in a predetermined position relative to said drill collar by the expansion of said lower latching means into said lower recesses as said lower latching means reach the same elevation as said lower recesses, said turbine being adapted to move downwardly relative to said cutters when said cutters are in their lower position and to urge said spline segments into engagement with said splines, and an annulus packer adapted to seal the annulus between said case and said sub.

5. An apparatus as defined in claim 4 in which said annulus packer is a packer having lateral pleats mounted on said turbine case vertically intermediate said sub and said lower latching means and means to longitudinally compress and thereby radially expand said packer into peripheral engagement with said drive sub and fluid passageway means to vent the interior portion of the pleats in said packer.

6. An apparatus as defined in claim 5 in which the number of splines on said drive sub is evenly divisible by the number of cutters.

7. An apparatus as defined in claim 5 in which the packer is constructed of an elastic deformable material.

8. In a retractable turbine drill bit assembly including a retractable drill bit comprising in combination a tubular sub attachable to the lower end of a string of well pipe, a drill collar longitudinally supported below said tubular sub, a swivel joint connecting said sub and said drill collar, an elongated turbine within said sub and said collar, said turbine including an outer case and a shaft, retractable latching means for lockingly attaching the retractable drill bit to said shaft and the drill bit in a fixed position against the lower end of said collar whereby said turbine and said drill bit may be lowered within and removed from said drill string without removal of said drill pipe and said drill bit is rotatable by said shaft.

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