May 2, 1961 J. M. CAMP ET AL 2,982,366

RETRACTABLE DRILL BIT

Filed July 30, 1956 2 Sheets-Sheet 1

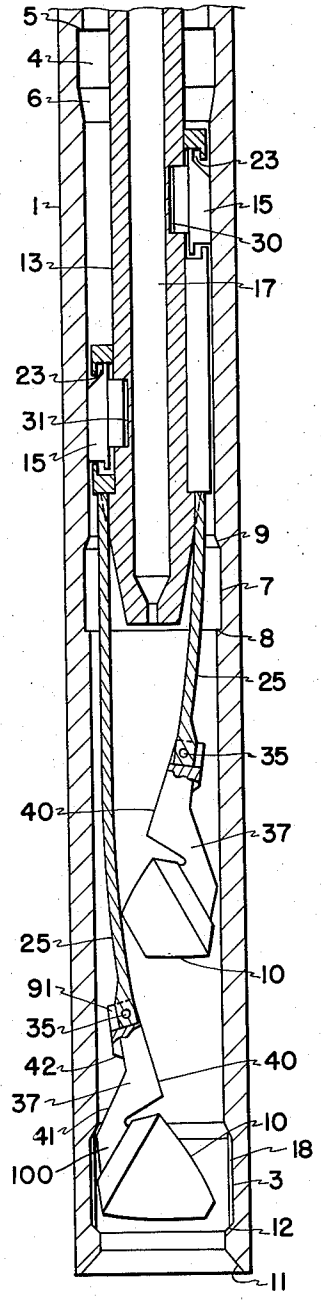


FIG. 1(A)

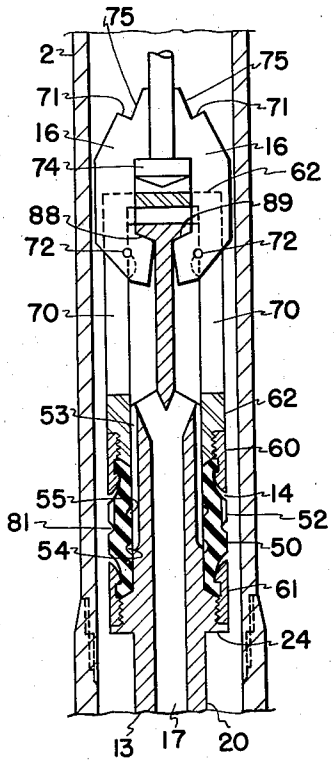


FIG. 1(B)

John M. Camp
Jackson M. Kellner Inventors

By W. O. Heilman Attorney

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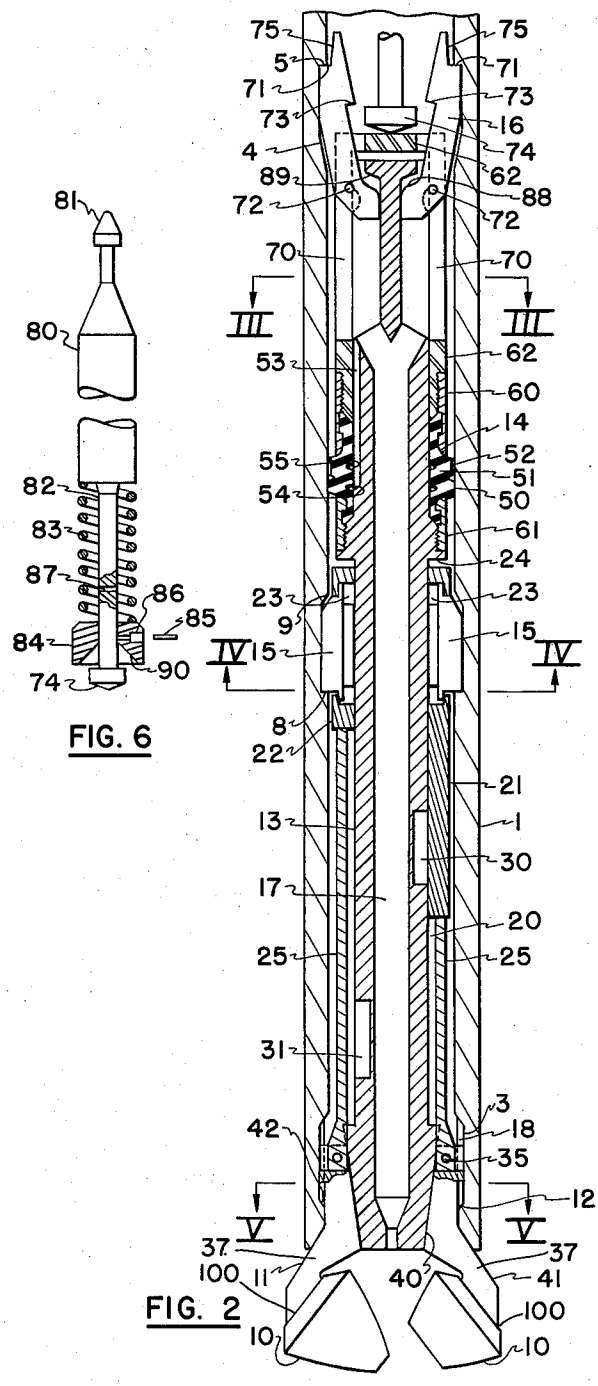


FIG. 2

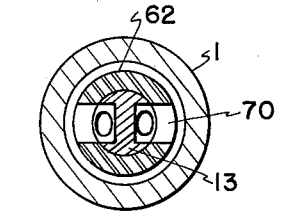


FIG. 3

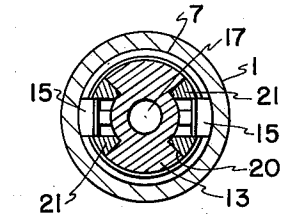


FIG. 4

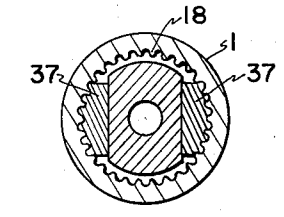


FIG. 5

FIG. 6

John M. Camp
Jackson M. Kellner Inventors

By W. O. Heibman Attorney

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2,982,366

RETRACTABLE DRILL BIT

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

Filed July 30, 1956, Ser. No. 600,910

4 Claims. (Cl. 175—259)

The present invention concerns an improved retractable drill for use in well drilling operations. More particularly, the invention concerns drilling apparatus including a retractable drill bit which is more rugged and dependable than retractable bits that have been employed or suggested to date.

It is a general object of the invention to provide a positive drive type retractable drill and drill bit which does not require orientation of its various component parts as the bit is assembled and expanded into a drilling position near the bottom of a bore hole. It is an additional object of the invention to provide an improved means for effecting a fluid-tight seal between tubular member portions of the apparatus, whose function it is to provide structural support for the cutting elements of the bit. The apparatus of the invention, it will be noted, is related to a retractable drill which is described and set forth in United States Patent application Serial No. 268,891, filed January 29, 1952 in the name of John M. Camp. This application has matured into Patent No. 2,764,388.

The apparatus of the invention includes a tubular drive sub which is attachable to the lower end of a string of well pipe. A tubular mandrel carrying a plurality of suspended cutter elements is adapted to fit within the drive sub and is lowered within the sub to a point near the bottom of a bore hole. Latching devices or equivalent means are slidably mounted in slides on the mandrel and are alternately engageable with recesses in the mandrel and in the drive sub. The slides support elongated straps or equivalent members which in turn extend below the drive sub and support individual cutter elements of the drill bit.

As the mandrel is originally assembled and lowered within a bore hole, the latching devices engage recesses in the mandrel in a manner such that the slides support the drill bit cutter elements in a vertically spaced, nested relationship. Then, as the mandrel enters and passes through the drive sub, the latching devices disengage from the mandrel, slide along the mandrel, and engage recesses within the sub. Simultaneously, the cutter elements protrude below the drive sub 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 drive sub, the center mandrel is free to move vertically downward an additional distance sufficient to bear against inner contact shoulders of the cutter support members and thereby force the cutter elements into locking engagement with the drive sub. Matching splines on the individual cutter elements and the drive sub provide a positive driving arrangement between the sub and the assembled bit. The splines, furthermore, are of a character such that the cutter elements require no particular orientation relative to the sub and therefore readily engage the sub without requiring pre-orientation.

An expansible sleeve packer of a type capable of very substantial longitudinal compressive movement is provided on the mandrel and is actuated subsequent to assembly

of the bit cutter elements to provide a fluid-tight seal in the annulus between the mandrel and the sub. Releasable interengaging means are provided at the upper end of the mandrel 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.

Figure 1 illustrates the apparatus of the invention in vertical cross-section, as the apparatus appears with its cutter elements in a retracted position for lowering within a bore hole. Figure 1(*a*) illustrates a lower portion of the apparatus and Figure 1(*b*) an upper portion.

Figure 2 illustrates the apparatus of Figure 1, again in cross-section, as the apparatus appears with the bit cutter elements expanded into drilling position.

Figure 3 is a section-view taken along the line III—III of Figure 2.

Figure 4 is a section-view taken along the line IV—IV of Figure 2.

Figure 5 is a section-view taken along the line V—V of Figure 2.

Figure 6 is a partially sectioned view of a tool for expanding or retracting the apparatus of Figures 1–5.

Referring to the figures, drive or drill 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 Figure 1(*b*), or it may be a welded joint, a bolted section or other equivalent device. The drill sub preferably has an internal diameter substantially equal to that of the drill pipe, and its outer diameter may be somewhat larger than the drill pipe in order to provide the sub with additional strength and ruggedness. The sub, it will be recognized, may be considered as a particular type of drill collar modified in the manner shown to meet the requirements of the invention.

Near the upper end and interiorly of drill sub **1** is a circumferential groove **4**, which possesses a downwardly facing shoulder **5**. The lower portion of the groove **6** is preferably tapered or inclined as illustrated for reasons that will be apparent later in this description.

A second peripheral groove **7** is provided in a drill sub **1** at a point intermediate its ends. This groove is provided with a lower upward facing shoulder **8** and an upper downward facing tapered shoulder **9** as illustrated. The lower end of drill sub **1** 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 **3** which extends around the inner periphery of drill sub **1**. The upper and lower ends of this groove are preferably tapered as shown, the lower taper or shoulder **12** defining a surface whose purpose will be clear later in this description.

Disposed around the entire periphery of groove **3** are a plurality of longitudinally disposed and radially spaced splines **18**. 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 sub 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 sub.

Thus, drill sub **1** is essentially an elongated cylindrical member having a plurality of vertically spaced and inter-

nally 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 drill sub **1** is tubular mandrel **13** which carries cutter elements **100**, packer assembly **14**, lower latches **15**, and upper latches **16**. A central passageway **17** extends vertically throughout the mandrel and provides means for transmitting drilling mud or other fluids from the interior of the drill string to the cutter elements of the bit. The lower end of this passageway preferably terminates in the form of a jet for better directing the drilling mud or other fluid at high velocity against the bit.

The outer surface of the lower end of the mandrel **13** is preferably tapered somewhat to resemble a frusto-conical wedge. This structural feature enables the mandrel to apply a wedging action against the cutter elements **100** when the cutter elements are expanded into a drilling position and engaged with the lower end of the drive sub. The cutters **10** of the cutter elements, as illustrated, are preferably cone-type cutters.

Disposed above the lower tapered portion of the mandrel and extending upwardly along the length of the sub, are elongated grooves or slots **20** which provide vertical runways for movement of slides **21** and **22**. These elongated grooves do not extend the entire length of mandrel **13** but instead terminate below the packer assembly **14** at the shoulders **24**.

The upper end of each slide is recessed internally with a cavity **23**. Disposed within each cavity a latching dog **15**, each dog being normally urged radially outward by means of springs or other equivalent resilient devices not shown. The dogs, it will be noted, are provided with shoulders at each vertical end which engage retaining shoulders on the slides, thereby retaining the dogs positively within the slides. The dogs themselves are preferably tapered on their outer and upper ends so as to enable them to disengage readily from sub **1**, when such disengagement is desired.

Secured to the lower ends of the slides are elongated straps or equivalent supporting members **25** which are attached or secured to shanks **37** of cutter elements **100**.

Each slide **21** and its attached strap lies within a elongated groove or slot **20** formed within the wall surface of mandrel **13**. Thus, each slide and its attached strap is able to move in a vertical or longitudinal slidable manner relative to the mandrel.

Vertically spaced recesses **30** and **31** are positioned along the mandrel **13**, each recess being in alignment with one of the slots **20**. It is the purpose of these recesses to contain the lower latching dogs **15**, as the tool is lowered in the hole, to prevent any movement of the cutters **10**, the strap **25**, and the slides **21** with relation to the mandrel **13** before all of these parts reach the proper position within the drive sub. It will be apparent that vertical spacing of the recesses **30** and **31** 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 expanded or drilling position.

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 space 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 mandrel. Furthermore, the number of splines **18** in the lower portion of the drill 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 **18** in the drill sub and the matching splines associated with each cutter element is readily and cleanly made when this condition is observed. If this condition is not met, the cutter elements will have a different angular spacing in an expanded condition than they possess in a retracted condition; and the mandrel will be generally unable to force the cutter elements into complete and smooth engagement with the drill sub. In addition, it is necessary that even spacing of the cutter elements be observed in order to take full advantage of the space available at the bottom of a borehole. It follows that the number of teeth or splines on the drill sub must be an even multiple of the number of cutters; otherwise, such even spacing is impossible.

Each cutter element **100** is attached to its respective strap **25** 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 anglar configuration to coordinate these members with the mandrel and the drill sub. Specifically, each shank is provided with an inner shoulder **40** which is tapered to coincide with the lower tapered end of the mandrel. A lower outer shoulder **41** is provided to coincide with the shoulder **11** at the bottom end of sub **1**; and an upper outer shoulder **42** is provided to coincide with and bear against the lower taper or shoulder **12** of the sub.

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 **14** is mounted on mandrel **13** at a point vertically above shoulder **24**. As illustrated, the packing element should 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 the mandrel **13**. 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 **14**, it will be observed that lower pleat **50** actually contacts and provides a sealing surface against the inner wall of sub **1**, whereas the upper pleat **51** does not contact the sub completely around its periphery. Thus, pleat **51** may be made smaller in diameter than pleat **50**; or alternative-

ly a slot 52 may be cut through pleat 51. Furthermore, it will be observed that a longitudinal groove or passageway 53 is provided along the length of mandrel 13, 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 mandrel. It is then impossible for liquid to be entrapped in any of the cavities that are formed between the pleats of the packer assembly 14 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 14 is held against the outer wall surface of mandrel 13 by virtue of upper retaining ring 60 and lower retaining ring 61. Lower ring 61 is secured directly to mandrel 13, while upper ring 60 is attached to sleeve 62 which is vertically moveable relative to the mandrel. Thus, a vertical force or thrust downward against sleeve 62 drives this member plus upper retaining ring 60 vertically downward relative to the mandrel and thereby compresses the pleats 50 and 51. Pleat 50 seals against sub 1, and both pleats—i.e. pleats 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 is should be noted that sleeve 62 extends up beyond mandrel 13 and is provided with two ports 70 through which upper dogs 16 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 16 are provided with outer upward facing shoulders 71 adapted to engage shoulder 5 on drill 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 mandrel 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 16 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 6 and includes sinker bar 80, upper spearhead 81, stem 82, spring 83, retracting sleeve 84, lower spearhead 74 and pin 85. Sleeve 84 is slideably moveable on stem 82 and is normally urged downward from sinker bar 80 by means of spring 83. The tool is illustrated in Figure 6 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 the drill by the tool is actually accomplished when the inner shoulders 88 on the dogs 16 engage the shoulders 89 near the top of the mandrel.

When the tool in Figure 6 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 at its lower end to enable the sleeve to retract dogs 16 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 bore hole in order to carry out a drilling operation.

Referring to Figure 1, the apparatus is there illustrated in the condition required to enable it to be lowered within a bore hole. The spearhead 74 of the lowering tool illustrated in Figure 6 is in engagement with the shoulders 73 of the retractable upper dogs 16, and the entire bit assembly is suspended from the spearhead. The dogs 16 are maintained in a retracted condition by contact with the inner surface of the drill pipe; and, since packing assembly 14 is under no compressive loading, it also is in a retracted position. Cone cutters 10 of the bit are in a retracted, vertically nested condition, the slides 15 being locked or in engagement with the recesses 30 and 31 in mandrel 13.

Upon being lowered within drill sub 1, the mandrel and its associated parts coact with the sub in the following sequence. First, the lower one of the two latching dogs 15 reaches groove 7 and pops out into the groove from recess 31. Since dog 15 is clear of mandrel 13 when it engages groove 7, mandrel 13 is free to move vertically downward relative to the lower dog.

Simultaneously with the entry of the lower dog 15 into groove 7, lower cutter 10 expands into a drilling position immediately below the lower end of the drive sub. 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 12, respectively, of the drive sub. Similarly, splines 91 of the cutter shanks engage the matching splines 18 of the sub.

Subsequent to engagement of the lower of the two cutter elements 100 with drive sub 1, mandrel 13 continues vertically downward with its remaining lower dog and cutter element—i.e. the upper of the dogs 15 and the upper of the cutter elements 100. When the remaining dog reaches groove 7, it—like the first dog—pops into the groove and disengages itself from the mandrel. Simultaneously, its cutter expands into a drilling position radially opposite the first cutter. Then, mandrel 13, being free of both locking dogs, slides down relative to both cutters until its lower conical wedging surface bears against the inner shoulders 40 of shanks 37. This action on the part of the mandrel serves to wedge the shank portions and their attached cutters firmly in drilling position. The spline segments 90 on each shank are now in engagement with the spline 18 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 mandrel which is sufficient to wedge the cutters and their attached shanks into a drilling position. As illustrated in Figure 6, 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 sub 1, expansion of the packer assembly 14 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 mandrel in combination with lower retaining ring 61, longitudinal compression of the bellows results. This compression in turn causes the individual 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 drive sub and the well pipe above the sub. Similarly, any liquid entrapped in the outer peripheral cavity 81 defined by the two pleats is free to vent upwardly in the annular space between the upper retaining ring 60 and the sleeve 62 into the drive sub passageway.

Longitudinal contraction and radial expansion of the packer results in pleat 50 forming a peripheral seal between the mandrel portion of the overall assembly and the inner wall surface of the drive 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 16 are forced outwardly until they come laterally opposite the upper groove 4 in drive sub 1. Since the spearhead 74 is now bearing directly against sleeve 62 it follows that dogs 16 are free to expand and ride along the inner surface of sub 1 until they reach groove 4. At this time they expand further and enter groove 4.

The drill is now in condition for drilling, and spearhead 74 may be raised vertically from the apparatus and removed from the bore hole. Actual drilling is obtained by lowering the drive sub and the attached well pipe above the sub until the cutters reach the bottom of the bore hole. Rotation of the bit, the drive sub and the well pipe is obtained by use of conventional surface rotary equipment; and loading of the bit is likewise controlled by means of conventional surface apparatus. Downward thrusts on the well pipe are transmitted through dogs 16 to sleeve 62 and thence through the bellows packer and the mandrel to maintain the cutter shanks 37 in a locked relationship in the drive sub. Simultaneously, downward thrusts on the well pipe are transmitted through the shoulders 11 on the drive sub to shoulder 41 on the cutter shanks to apply drilling loads to the cutters.

When a drilling operation has been interrupted and it is desired to remove the drill from a bore hole, the following sequence of operations is employed. First, the well pipe and drive sub 1 are removed or lifted from the bottom of the hole, and rotation of the equipment is ceased. The tool illustrated in Figure 6 with pin 85 removed is lowered through the well pipe. When the spearhead 74 of the tool reaches the upper latches 16, the inner conical surface 90 of the tool forces the latches radially inward from the groove 4 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 mandrel 13 with the result that cutter elements 100 are retracted from their drilling position and lifted within the drive sub 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 then follows.

Simultaneously with the retraction of the cutters, upward pull of the mandrel 13 causes the slides 21 and 22 to be sequentially engaged and lifted relative to the drive sub. As the slides move upward in their slots 21, they force dogs 15 to be retracted from the groove 7 and to enter the recesses 31 and 30. At this point the drill is in a fully retracted position and may be lifted to the surface of the earth.

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. In a retractable drill of the type described including a tubular drive sub attachable at its upper end to the lower end of a string of well pipe and a tubular mandrel longitudinally movable within the well pipe and the drive sub, the mandrel carrying a plurality of cutter elements suspended therefrom in a vertically spaced relation when the drill is in a retracted condition, the cutter elements being assembled immediately below the drive sub and wedged between the mandrel and the sub when in a drilling position, the improvement which comprises a plurality of longitudinally disposed splines equally spaced and extending around the lower inner periphery of the drive sub, at least one longitudinal spline on an exterior portion of each cutter element, the splines on the drive sub being sufficient in number and an even multiple of the number of cutter elements so as to enable the cutter elements to be assembled in a drilling position without pre-orientation, a longitudinally compressible, radially expansible, laterally pleated sleeve packer around and supported at its lower end from the outer wall surface of the mandrel; means to vent the cavities defined by the pleats of the packer, said packer upon longitudinal compression within the drive sub being adapted to seal the annulus between the drive sub and the mandrel.

2. In a retractable drill of the type described including a tubular drive sub attachable to the lower end of a string of well pipe, and a tubular mandrel adapted to move longitudinally within the well pipe and the sub, the mandrel carrying a plurality of cutter elements, a packer assembly and retractable latching means when the drill is in a retracted condition, the mandrel and its associated parts being cooperable with the drill sub to assemble the cutter elements below the drive sub and to lock the cutter elements in their assembled condition, the improvement which comprises a plurality of longitudinally disposed, equally spaced splines extending around the inner periphery of the sub and spaced from the lower end thereof, at least one spline on the exterior upper surface of each cutter element adapted to engage the splines on the sub, the number of splines on said sub being sufficient in number and an even multiple of the number of cutter elements so as to enable the cutter elements to be assembled in a drilling position without pre-orientation, a lower exterior portion of each cutter element defining a tapered surface forming an angle of about 35° to 45° with the vertical when the cutter element is in an expanded position, the lower end of said drive sub having a downward-facing tapered surface adapted to engage with the tapered surfaces of the cutter elements when in their expanded position, said packer assembly comprising a longitudinally compressible, radially expansible, laterally pleated sleeve packer and including means to vent the cavities defined by the pleats of the packer.

3. In a retractable drill of the type described including a tubular drive sub and a cutter element-carrying tubular mandrel longitudinally movable within the drive sub, the cutter elements in a retracted condition being suspended in a vertical array from the mandrel and in a drilling condition being wedged between the lower ends of the mandrel and the sub, and an expansible packer assembly on the mandrel operable to effect an annular seal between the mandrel and the sub, the improvement which comprises longitudinally disposed splines recessed within and equally spaced around the interior surface of the drive sub at a point spaced from the lower end of the sub, a downward-facing peripheral shoulder inclined at an angle of about 35° to 45° with the vertical on the internal surface of the sub below the splines, each cutter element including an upward-facing external shoulder adapted to seat against the peripheral shoulder of the sub, longitudinally disposed splines on each cutter element above the shoulder portions thereof to engage the splines on the sub, said packer assembly comprising a laterally pleated, longitudinally compressible sleeve packer, and means to vent the cavities defined by the pleats thereof, the splines on said sub being sufficient in number and an even multiple of the number of cutter elements so as to enable the cutter elements to be assembled within their drilling position without pre-orientation.

4. In a retractable drill of the type described including a tubular drive sub attachable at its upper end to

the lower end of a string of well pipe and a tubular mandrel longitudinally movable within the well pipe and the drive sub, the mandrel carrying a plurality of cutter elements suspended therefrom in a vertically spaced relation when the drill is in a retracted condition, the cutter elements being assembled immediately below the drive sub and wedged between the mandrel and the sub when in a drilling position, the improvement which comprises a plurality of longitudinally disposed splines equally spaced and extending around the lower inner periphery of the drive sub, at least one longitudinal spline on an exterior portion of each cutter element, the splines on the drive sub being sufficient in number and an even multiple of the number of cutter elements so as to enable the cutter elements to be assembled in a drilling position without pre-orientation, a longitudinally compressible, radially expansible sleeve packer surrounding and supported at its lower end by the outer wall surface of the mandrel, said packer upon longitudinal compression within the drive sub being adapted to seal the annulus between the drive sub and the mandrel.

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