

**2,997,119**

Filed Jan. 6, 1958

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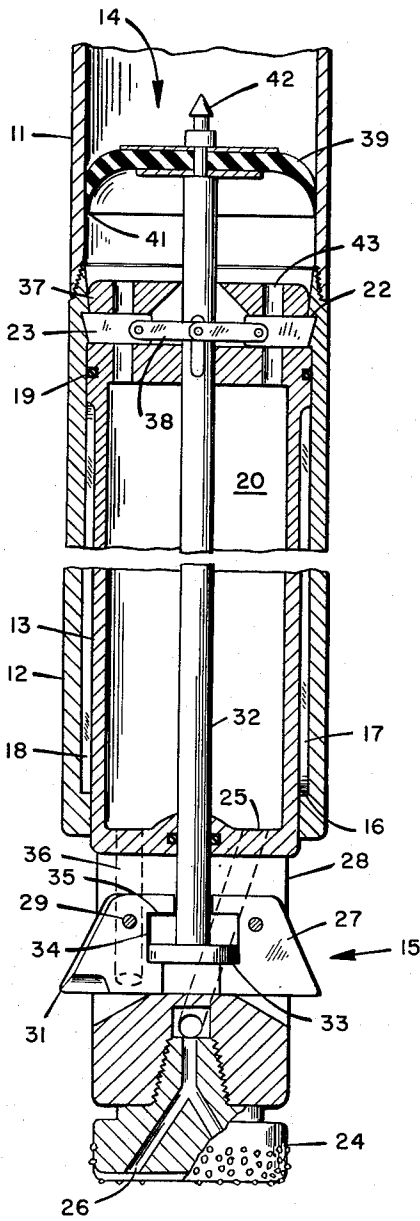


FIG. 1

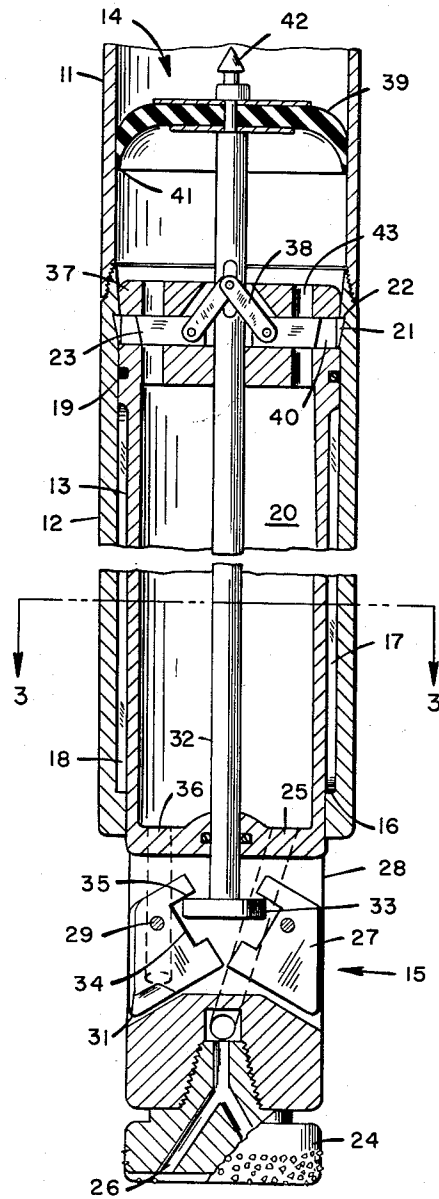


FIG. 2

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DRILL BIT ASSEMBLY

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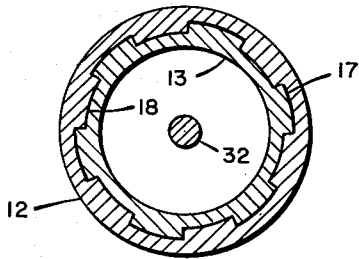


FIG. 3

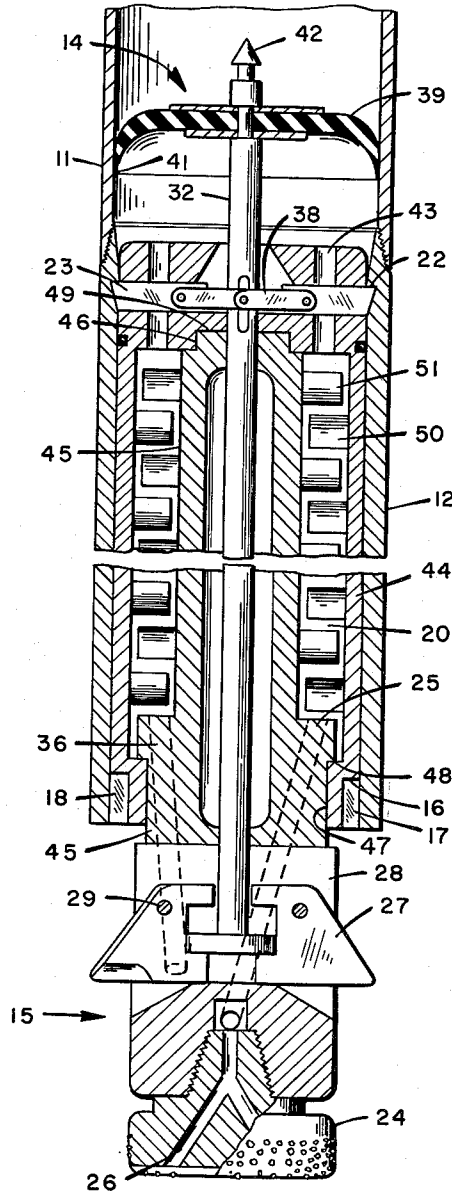


FIG. 4

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## DRILL BIT ASSEMBLY

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This invention relates to a drilling apparatus. More specifically, this invention is concerned with a retrievable drill bit, particularly a free drill bit which may be run into drilling position at the lower end of a drill string and changed without pulling the pipe or otherwise lowering a fishing string into a drilling well.

Retrievable bits which are changeable without pulling the drill pipe have been proposed and successfully used for a number of years. Typically, these retrievable bits are collapsed or folded to pass through the drill pipe. They are expanded after they emerge from the lower end of the drill pipe so that they will drill a hole larger than the outside diameter of the drill pipe. These retrievable bits are attached to and lowered through the drill pipe on a housing or body which is anchored in a special fitting or seating collar at the lower end of the drill pipe so that the bits may be rotated or reciprocated by movement of the drill pipe. By using such retrievable bits considerable "round-trip" time is saved during drilling since it is unnecessary to pull and run the drill pipe each time a bit is broken or becomes worn and must be changed. As practiced thus far, however, to change a retrievable bit, it has been necessary to lower a line with a fishing tool on the lower end into the drill pipe, latch onto the retrievable bit and lift it to the surface. At the surface, the bit itself or the bit assembly is either repaired or replaced and the bit assembly is again lowered on a running line through the drill pipe, the bit is expanded, the body is locked in the special seating collar on the lower end of the drill pipe, and the running line is then disconnected from the assembly and reeled in. Drilling with the new bit can then proceed. Bits can typically be changed within an hour or less by this method as compared to several hours where the drill pipe must all be pulled and rerun. The difference becomes more significant, of course, as the depth of a well increases. While the use of retrievable bits has thus permitted a considerable saving in round-trip time and has permitted the use of casing or other thin-walled and less expensive drill strings, it has been found that bits can be changed more rapidly and round-trip time can be further improved so that the drilling efficiency, i.e., the ratio of time when the bit is on bottom and drilling, may be substantially increased. Improvement in this ratio has been found particularly important in the case of turbine drilling where, due to its high speed of rotation, the drill bit is worn very rapidly making the round-trip time very significant in comparison to actual drilling time.

It is, therefore, an object of this invention to provide an improved retrievable drill bit. It is a more specific object of this invention to provide a retrievable drill bit assembly which will permit a substantial improvement in drilling efficiency. It is still a more specific object of this invention to provide an improved retrievable drill bit assembly which permits placing a bit on the lower end of a drill stem and removing a drill bit from that position by merely controlling the direction of circulation of the drilling fluid. A still more specific object of this invention is to provide a retrievable drill bit assembly including a drilling motor which can be readily removed from a drilling well by reverse circulation of the drilling fluid and can be reinserted or lowered into drilling position by direct circulation of the drilling fluid. Other ob-

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jects of this invention will become apparent from the following description. In this description reference will be made to the accompanying drawings in which like reference numbers are applied to the same or similar parts and in which:

FIGURE 1 is a cross-sectional view of a retrievable bit and drill bit assembly locked in a drilling position at the lower end of a drill pipe;

FIGURE 2 is a cross-sectional view of the apparatus shown in FIGURE 1 in a condition to be displaced out of the drill pipe by reverse circulation of the drilling fluid;

FIGURE 3 is a cross-sectional view at the plane 3-3 of the apparatus shown in FIGURE 2; and,

FIGURE 4 is a cross-sectional view of an embodiment of the apparatus shown in FIGURES 1, 2, and 3, including a drilling motor for rotating the retrievable bit with reference to the drill pipe.

This invention may be described in brief as a free drill bit which permits retrievable drill bits to be changed without pulling the drill pipe by merely controlling the direction of circulation of the drilling fluid. More particularly, the invention involves lowering a free drill bit assembly, i.e., an assembly which is free like a free piston, through a drill pipe by direct circulation of the drilling fluid, locking the assembly in a special seating collar at the lower end of the drill pipe, expanding the drill bit so that it will drill a hole having a diameter larger than the external diameter of the drill pipe, and then drilling by continued direct circulation of the drilling fluid. It involves further reversing the direction of circulation of the drilling fluid so that it flows upwardly through the drill pipe to unlock the assembly from the special seating collar, to contract the drill bit and then to circulate the drill bit assembly to the surface so that the drill bit and/or assembly bit can be repaired or replaced and subsequently can be returned to drilling position. In a special adaptation of this free drill bit, means are provided in the drill bit assembly for rotating or reciprocating the drill bit with reference to the drill pipe so that, if desired, the drill bit may be actuated by the drilling fluid without rotating or reciprocating the drill pipe.

Referring now to FIGURE 1 for a more detailed description of the invention, the drill pipe 11 comprises preferably an internally flush pipe such as that subsequently used as casing after the well has been completed. The external diameter of this drill pipe is typically about one or two inches, or more, smaller than the diameter of the hole being drilled so that the pipe passes easily through the hole and may be rotated or reciprocated as necessary during drilling or during cementing of the pipe as a well casing. A special seating collar 12 is connected to the lower end of the drill pipe or to extra drill collars (not shown) disposed between the lower end of the casing 11 and the upper end of the special seating collar. This special seating collar is adapted to receive the body 13 of the retractable drill bit assembly 14, and to hold it in drilling position against rotation and/or axial movement in the seating collar so that, if desired, weight of the drill pipe can be applied to the expandable drill bit 15 which is connected to the lower end of the body. The seating collar 12 has a stop 16 at the lower end adapted to shoulder against the lower end of the body splines 17 and prevent the body 13 from passing through the seating collar 12. These splines on the collar also cooperate with the seating collar splines 18 as shown in FIGURE 3 to rotate the body of the drill bit assembly with the drill pipe or restrain rotation between the drill bit assembly and the seating collar so that the drill bit can be rotated. A fluid seal such as an O-ring packing 19 is placed above the body splines 17 to seal the annular space between the body and the in-

side of the seating collar so that drilling fluid flows through the body passage 20 rather than through the voids between the splines. The seating collar has an annular recess 21 which desirably has at least an upper shoulder 22 near its upper end to receive a lock or hold-down latch 23 which, with the stop 16, anchors the drill bit assembly and particularly the body 13 against axial movement in the seating collar and the drill pipe. Thus, when the drill bit assembly is locked in position in the seating collar the drill pipe may be raised to lift the drill bit off bottom or lowered to apply weight to the drill bit and the drill bit may be rotated in the same manner as if the drill bit were connected to the lower end of the drill pipe directly or indirectly by the use of intermediate drill collars.

Any of a wide variety of expansible drill bits 15 may be attached to the body 13. As an example of a preferred type of drill bit, a pilot bit 24, smaller in diameter than the inside diameter of the drill pipe and seating collar, may be attached to the lower end of the body. A drilling fluid passage 25 through the lower end of the body and in fluid communication with the body passage 20 permits drilling fluid to circulate through the pilot bit jets 26 in the usual manner. An expandable reamer having blades 27 in a transverse slot 28 is placed on the body above the pilot bit. These blades rotate about anchor pins 29 so that the cutting edges 31 of the blades may be expanded to ream the pilot bit hole to a diameter greater than the external diameter of the drill pipe 11, including any collars or protectors thereon. The reamer blades are expanded to cutting position as shown in FIGURE 1 by lowering a control rod 32 which has a head 33 at the lower end. This head may be raised and lowered in slots 34 of the reamer blades respectively to contract and expand the reamer blades. When the control rod is raised and the head 33 is thus raised in these slots the head strikes shoulders 35 at the upper end of the slots 34 to rotate the reamer blades or permit them to be rotated into a contracted position having a maximum dimension diametrically less than the inside diameter of the drill pipe, the seating collar and the stop 16 thereon. This position of the control rod with the reamer blades contracted is shown in FIGURE 2 while the expanded position is shown in FIGURE 1. Another fluid passage 36 through the lower end of the body terminates in the wall of the transverse slot 28 near the cutting edges 31 of the reamer blades to supply drilling fluid to the reamer.

The control rod 32 which thus acts to expand and contract the drill bit or a reamer placed above a pilot bit also desirably actuates the hold-down latches 23 at the same time the drill bit is expanded to anchor or lock the drill bit assembly in the seating collar. These hold-down latches are mounted for lateral movement in transverse slots 40 within the upper head 37 of the body 13 and in an expanded position extend beyond the body to seat in the annular recess 21 and transmit weight from the drill pipe via the shoulder 22 to the drill bit assembly. These hold-down latches are connected by links 38 to the control rod 32 so that when the control rod is in its lower position as shown in FIGURE 1 both the drill bit and the hold-down latches are in their expanded positions and so that when the control rod is in its upper position both the drill bit and the hold-down latches are in their contracted position as shown in FIGURE 2. A packer 39 preferably a unidirectional packer such as an inverted swap cup, which permits fluid to pass it in only one direction, is attached to the upper end of the control rod above the body. The diameter of this packer in an unstressed state is desirably at least as great as the inside diameter of the drill pipe 11 so that it will normally form a fluid seal with the drill pipe. The sealing edges, lips 41, extend downward as shown in the drawings so that direct circulation fluid flow, i.e., downward flow, through or by the packer is permitted and reverse circulation fluid flow, i.e., upward flow through or by the packer, is prevented.

That is, this packer serves not only as a fluid seal to prevent fluid flow past the drill bit assembly upwardly but it also provides a unidirectional valve, i.e., a check valve which allows fluid flow downwardly through the drill bit assembly. It will be apparent that other types of packers and unidirectional valves can be substituted. A fishing neck 42 may be connected to the upper end of the control rod 32 above the packer 39 so that in an emergency a fishing tool can be lowered through the drill pipe, latched onto the drill bit assembly, and the drill bit assembly can be retrieved from the drill pipe and the well without pulling the drill pipe.

In operation, the drill bit assembly in a contracted position as shown in FIGURE 2 is lowered into drilling position at the lower end of the drill pipe by first filling the well with drilling fluid and then merely dropping the drill bit assembly in the drill pipe. The weight of the assembly acting on packer 39 will cause the drilling fluid to be circulated in the direction of direct circulation. Additional drilling fluid can be pumped into the drill pipe above the drill bit assembly to facilitate displacement of the assembly through the drill pipe. Since the weight of the body and drill bit is applied to the packer 39 through the control rod 32, the control rod will be in the upper position as it is circulated into position. The hold-down latches 23 and reamer blades 27 are therefore held in a contracted position as shown in FIGURE 2 so that the drill bit assembly passes freely through the drill pipe with the drilling fluid. When the assembly reaches the bottom of the drill pipe the lower end of the body splines 17 first interlock with the seating collar splines 18 and then strike the stop 16. The body and drill bit are thus stopped but continued direct circulation of the drilling fluid carries the packer 39 further downward forcing the control rod to move down in the body and lock the body and drill bit in drilling position, i.e., forcing the hold-down latches 23 and the reamer blades 27 to an expanded position. After reaching this lower or drilling position as shown in FIGURE 1, the control rod and packer cannot move down further and therefore the drilling fluid passes downwardly around or through valved ports in the packer, through the fluid ports 43 in the head 37 and, thence, downwardly through the body passage 20 and fluid passages 25 and 26 to the drill bit. It is then circulated by continued direct circulation back to the surface through the annular space surrounding the drill pipe. The expanded drill bit may then be rotated by rotating the drill pipe and drilling may proceed by continued direct circulation of the drilling fluid.

When the bit is worn or when it is otherwise desired to remove or replace the drill bit, reverse circulation of the drilling fluid is commenced by injecting fluids from the mud pumps at the surface down through the annular space surrounding the drill pipe, and the drill bit and thence upwardly through the pilot bit jets 26, the fluid passages 25 and 36, the body passage 20, and the fluid ports 43 in the head 37 of the body and thence upwardly against the unidirectional packer 39. The force of this circulating fluid against the lower side of the unidirectional packer forces the packer and the control rod up with reference to the body. This upward movement of the control rod withdraws the hold-down latches 23 from the annular recess 21, contracts the drill bit, and permits the drill bit assembly to be lifted through the drill pipe to the surface with the drilling fluid as reverse circulation of the drilling fluid is continued. At the surface the assembly can be retrieved by attaching a hoist to the fishing neck 42 as it appears above the open end of the drill pipe. Similarly, in the case of an emergency where displacement of the assembly to the surface by reverse circulation of the drilling fluid is not possible, a fishing tool may be lowered into the drill pipe, latched onto the fishing neck 42, and the assembly may be unlocked or disconnected from the seating collar 12 by reeling in the fishing line. The first action in either case is to retract

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the hold-down latches and contract the drill bit and then to lift the complete assembly through the drill pipe.

Referring to FIGURE 4, a preferred embodiment of the free drill bit will now be described in detail. In this embodiment, as in the previous embodiment, a special seating collar 12 is connected either directly or indirectly or by intermediate drill collars to the lower end of the drill pipe 11. The drill bit assembly 14 which includes the packer, the body, and the retractable drill bit 15 is generally the same as that described above. In this case, however, the body is divided into two parts: an outer stator 44 and a rotor 45. The stator is fixed against rotation in the seating collar by the use of splines in the same manner as in the embodiment described above, the stator having external splines 17 and the seating collar having complementary internal splines 18, which, together, prevent the stator from rotating in the seating collar. The rotor is also preferably fixed against axial movement, particularly downwardly, in the seating collar by use of the stop 16 and the hold-down latches 23. The drill bit is connected to rotor 45 which is concentrically mounted in the stator 44 with an upper bearing 46 and a lower bearing 47. A lower thrust bearing 48 supports the rotor and the drill bit when the drill bit is rotated off bottom. An upper thrust bearing 49 transmits the weight of the drill pipe or in the absence of hold-down latches 23 the weight of the stator and any other attached weight to the rotor and via the rotor to the drill bit. As is well known in this art, these thrust bearings, particularly the upper one, are important elements in the proper performance of turbine drills. Wood or rubber thrust bearings which have been found superior to metallic thrust bearings are therefore preferred. Stator blades 50 are fixed at the outer ends to the stator 44. These stator blades cooperate with the rotor blades 51 which are fixed at the inner ends to the rotor 45 so that high velocity drilling fluids in direct circulation through the packer 39, the fluid port 43, and the body passage 20 turn the rotor in the stator. The drill bit, being fixed to the rotor, is also turned by the turbine, i.e., by the fluid jets issuing from the stator blades and impinging on the rotor blades. Drilling fluids discharging from the turbine pass to the drill bit through the fluid passages 25 and 36 washing the cuttings off of the cutting surface, lubricating and cooling the bit, etc., as is well known in this art. The drilling fluid is then returned through the annular space surrounding the drill pipe to the surface.

The operation of the embodiment of this invention shown in FIGURE 4 is substantially the same as the operation of the other embodiment as previously described. The drill bit assembly 14 is lowered by direct circulation of the drilling fluid into and locked in position in the seating collar 12 in the same manner as above described. After the drill bit assembly has been locked in position by displacement of the control rod downward, however, further direct circulation of the drilling fluid through the turbine turns the rotor 45 and rotates the drill bit with reference to the drill pipe. By this means it can be seen that the drill bit can be rotated without rotating the drill pipe if desired, or in some cases, the drill pipe may be rotated slowly as the drill bit is rotated more rapidly by the turbine. Typically, when the drill bit is driven by the turbine, it rotates at several hundred revolutions per minute whereas the drill pipe, if rotated at all, may be rotated at only 1-10 revolutions per minute for the purpose of maintaining a straight hole or for other purposes. Typically, however, in this embodiment the drill pipe is not rotated, instead it is held at the surface against counter-rotation and is lowered into the hole as the drill bit progresses into the formation. When the drill bit becomes worn or for some other reason it becomes desirable to remove the drill bit from the hole, the entire drill bit assembly including the packer, the turbine, i.e., the body, and the drill bit is first unlocked by reverse circulation of the drilling fluid against the lower side of the packer 39 to

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raise the control rod 32 and then the assembly is raised through the drill pipe with the drilling fluid by continued reverse circulation of the drilling fluid until the assembly reaches the surface. At the surface the drill bit and turbine, or either, may be repaired and the assembly, or a similar repaired assembly, is lowered back into the well through the drill pipe so that drilling may proceed with only a very short period of time elapsed when the bit is not on the hole bottom and drilling. While in the preferred embodiment the turbine stator is fixed against axial movement in the seating collar 12 as above described, it will be apparent that upper and lower stops are not altogether necessary and that in some cases it will be necessary only to provide means such as splines to prevent rotation between the stator 44 and the seating collar 12 so that the drill bit assembly is allowed to float axially in the lower end of the drill pipe and apply to the drill bit only the weight of the assembly plus any differential pressure of the drilling fluid across the turbine.

It will also be apparent that various other modifications in the construction and operation of this free drill bit apparatus can be employed without departing from the spirit of this invention. For example, whereas, in one embodiment, a free turbine drill has been employed for rotating a drill bit, it will be apparent that in some cases other types of drills such as churn or percussion drills can be substituted so that retrievable percussion drilling assemblies can be coupled to the lower end of the drill pipe for percussion drilling rather than rotary drilling. The invention should, therefore, be construed to be limited only by the scope of claims and not by any description of the specific apparatus which is merely exemplary.

I claim:

1. A drilling apparatus including a drill pipe, a seating collar at the lower end of said drill pipe, and a retrievable drill bit assembly, said assembly including a body, an expansible bit connected to the lower end of said body, means to lock said body in said seating collar, said last-named means including a recess in said seating collar and at least one hold-down latch movable transversely of said body, a control rod extending through said body, a uni-directional packer attached to the upper end of said control rod, linkage means connecting said control rod to said at least one hold-down latch, said linkage means retracting said at least one hold-down latch when said packer is raised relative to said body, and said control rod serving to expand said expansible drill bit when said control rod is lowered in said body and to contract said expansible drill bit when said control rod is raised in said body.

2. A drilling apparatus according to claim 1 wherein said body includes a fluid turbine having a stator and a rotor, said rotor being mounted to rotate within said stator and being hollow to accommodate passage of said control rod to actuate said expansible bit, ducts in said body to conduct fluids from inside said drill pipe to said turbine to turn said rotor, ducts in said body to allow flow of fluids from said turbine, spline means to couple said stator to said seating collar and prevent rotation of said stator in said seating collar, and means connecting said expansible drill bit to said rotor whereby said expansible drill bit may be rotated with reference to said drill pipe by direct circulation of drilling fluid through said drill pipe and whereby said assembly may be raised through said drill pipe by reverse circulation of said drilling fluid through said drill pipe.

3. A drilling apparatus including a drill pipe, a seating collar attached to the lower end of said drill pipe, an annular recess in said seating collar, a longitudinal spline on the inner wall of said seating collar, a stop in said seating collar, a body supported on said stop and adapted to seat in said seating collar, said body including a body spline on the outer surface adapted to cooperate with said longitudinal splines to couple said body in said seating collar and prevent rotation of said body in said seating

collar, a packing element mounted on said body to form a fluid seal between said body and said collar, a hold-down latch in said body, said latch being adapted to move transversely in said body and capable of being extended beyond the periphery of said body for cooperation with said annular recess to anchor said body in said seating collar, an expansible bit connected to the lower end of said body, a control rod extending through said body, means connecting said control rod to said hold-down latch, said control rod serving to expand said hold-down latch into said annular recess and to expand said expansible bit when said control rod moves to its bottom position and to contract said hold-down latch and said expansible bit when said control rod moves to its upper position, and a packer attached to said control rod, said packer being adapted to transmit fluid downwardly but to prevent fluid movement upwardly thereby, whereby said drill bit and said body may be lowered into said drill pipe with said drilling fluid and coupled to said seating collar for movement with said drill pipe and whereby when said drilling fluid is reverse circulated through said drill pipe, said control rod is lifted to said upper position and said body is released from said seating collar and raised by said drilling fluid through said drill pipe.

4. A drilling apparatus according to claim 3 wherein said body includes a turbine having a rotor and a stator and wherein said body spline is on said stator for cooperation with said longitudinal spline to couple said stator to said seating collar and prevent rotation of said stator in said seating collar, said rotor being mounted to rotate within said stator and being hollow to accommodate passage of said control rod to actuate said expansible bit, ducts in said body to conduct fluids from inside said drill pipe to said turbine to turn said rotor, ducts in said body to allow flow of fluids from said turbine, and means connecting said expansible drill bit to said rotor whereby said expansible drill bit may be rotated with reference to said drill pipe when said body is coupled to said seating collar.

5. A drilling apparatus according to claim 3 wherein said body includes a stator having a series of stator blades fixed thereto and a rotor having a series of rotor blades fixed thereto for cooperation with said series of stator blades to turn said rotor in said stator and wherein said body spline is on said stator for cooperation with said longitudinal spline to couple said stator to said seating collar, said rotor being mounted to rotate within said stator and being hollow to accommodate passage of said control rod to actuate said expansible bit, ducts in said body to conduct fluids from inside said drill pipe to said turbine to turn said rotor, ducts in said body to allow flow of fluids from said turbine, and means to connect said rotor coaxially to said expansible drill bit, whereby said expansible drill bit may be turned relative to said stator and said drill pipe by fluid circulated downwardly through said packer and said series of stator blades and said series of rotor blades.

6. A turbine drilling apparatus including an internally flush drill pipe, a seating collar connected to the lower end of said drill pipe, a turbine stator adapted to pass through said drill pipe, a control rod movable axially in said stator, a recess in said seating collar, a hold-down latch on said stator adapted to expand into said recess, linkage means connecting said hold-down latch to said control rod for expanding and contracting said hold-down latch, stator

blades on said stator, a turbine rotor axially mounted in said stator, rotor blades on said rotor adapted to cooperate with said stator blades to turn said rotor when fluid is injected into said stator, an expansible bit coaxially connected at the lower end to said rotor, a unidirectional packer attached to the top of said control rod, said packer being adapted to form a fluid seal with said drill pipe when fluid is circulated upwardly through said drill pipe and to permit fluid to bypass said unidirectional packer when fluid is circulated downwardly through said drill pipe, whereby said stator may be lowered into said drill pipe and said seating collar by direct circulation of said drilling fluid in said drill pipe and whereby said rotor may be turned by continued direct circulation of said drilling fluid when said stator is restrained by said latch, and whereby said stator, said rotor and said bit may be retrieved from said drill pipe by reverse circulation of said drilling fluid through said drill pipe, and whereby said stator may be anchored in said seating collar and the weight of said drill pipe may be applied to said bit.

7. A turbine drilling apparatus according to claim 6 including means connecting said control rod to said bit for expanding said bit to a diameter greater than said drill pipe whereby said drill pipe may be lowered through the hole produced by said bit.

8. An expansible drill bit for attachment to the lower end of a drill pipe including an elongated cylindrical body smaller than said drill pipe, a transverse slot through the axis of said body, a pilot bit smaller than said drill pipe connected coaxially to the lower end of said body, reamer blades pivotably mounted in said transverse slot to expand radially from the periphery of said body, fluid passages extending longitudinally through said elongated body to said pilot bit and to said reamer blades, control rod means extending through said body, means on said control rod for locking said body to said drill pipe, means on said control rod for pivoting said reamer blades to an expanded position having a maximum diameter greater than the diameter of said drill pipe and to a contracted position having a maximum diameter not substantially greater than the diameter of said pilot bit, and a unidirectional packer attached to the upper end of said control rod adapted to pass fluid in direct circulation down through said drill pipe but to form a fluid seal with said drill pipe and lift said control rod, unlock said expansible reamer and raise said expansible bit through said drill pipe when said fluid is reverse circulated up through said drill pipe.

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