

April 9, 1963

H. V. SEARS
DOWN-HOLE DRILL

3,084,673

Original Filed Feb. 8, 1961

2 Sheets-Sheet 1

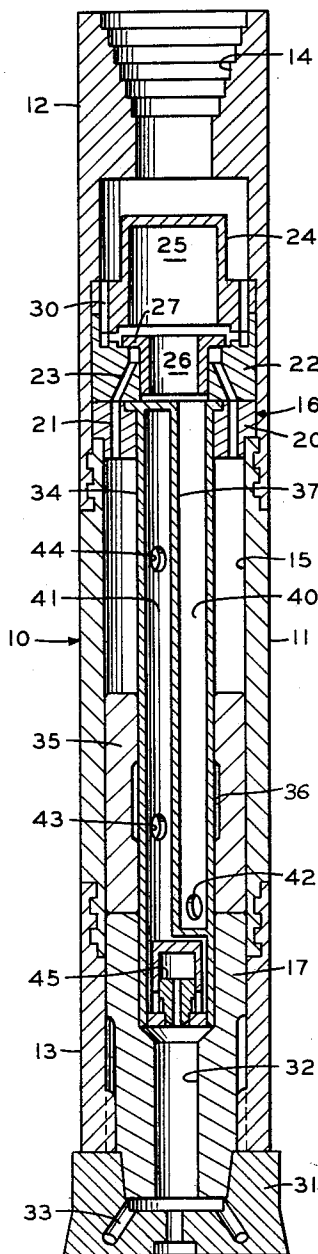


FIG. 1

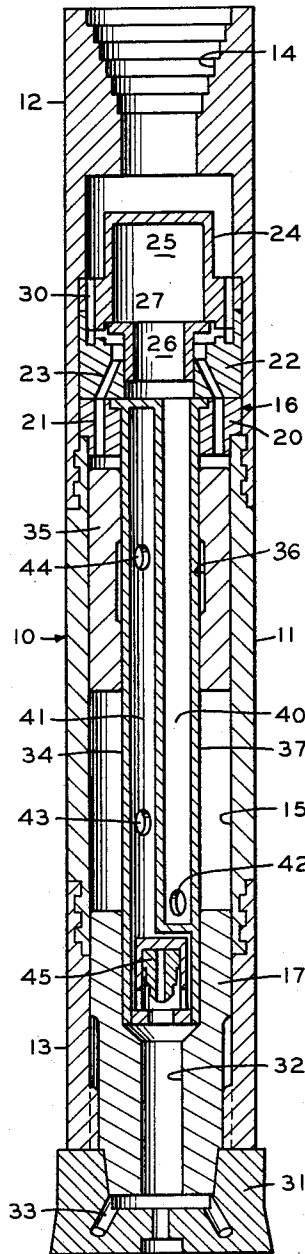


FIG. 2

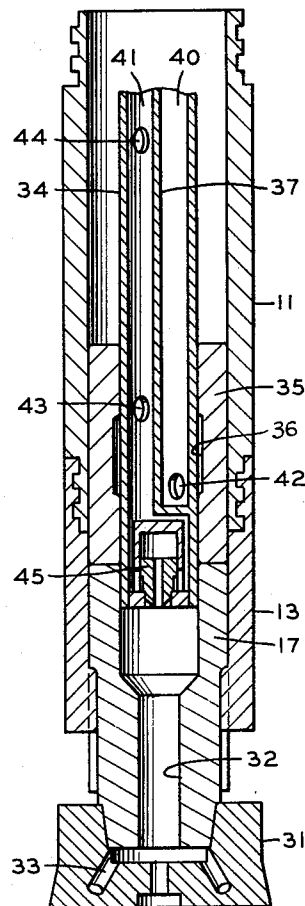


FIG. 3

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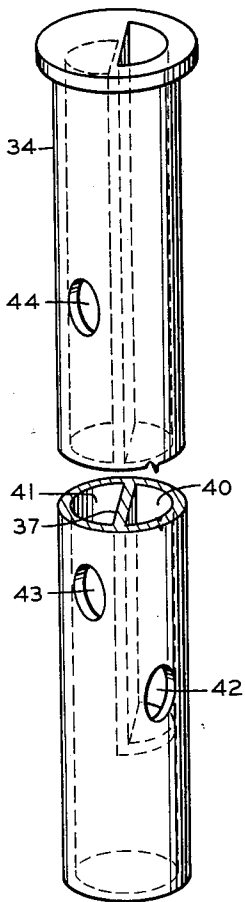


FIG. 4

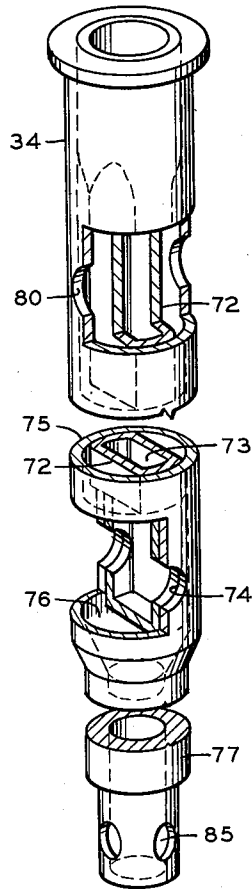


FIG. 5

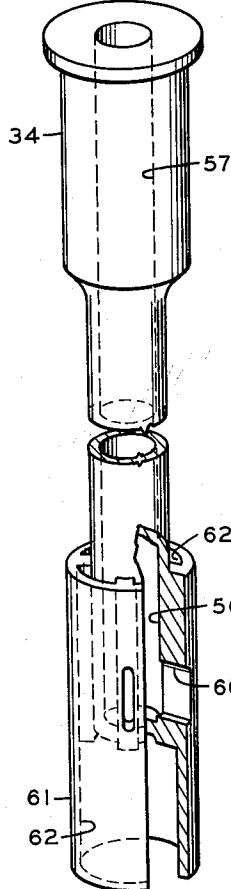


FIG. 6

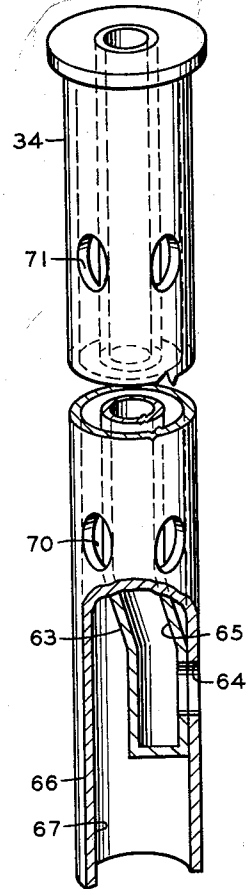


FIG. 7

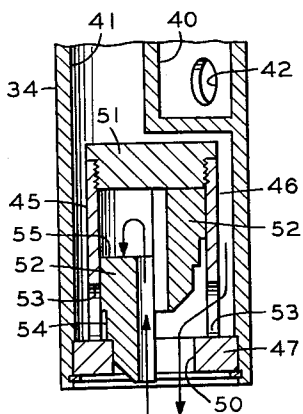


FIG. 8

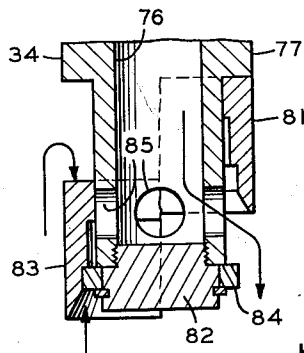


FIG. 9

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3,084,673

DOWN-HOLE DRILL

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Continuation of application Ser. No. 87,879, Feb. 8, 1961. This application Apr. 16, 1962, Ser. No. 190,845
19 Claims. (Cl. 121—28)

This invention relates generally to improvements in a down-hole drill and more particularly to improvements in a pressure fluid-operated drill of the percussion type adapted to enter the hole being drilled so that the percussive forces of the drill are transmitted directly to the drill bit.

It is a major objective of the present invention to provide an advantageous system for directing and controlling the flow of pressure fluid through the drill so that the hammer operates more efficiently and so that all of the exhaust air is discharged at the bit for more efficient operation.

An important object is achieved by providing a centrally located tube of circular cross section along which the hammer reciprocates in a chamber provided in the drill housing, the tube serving to convey high pressure hammer-return air through a first passage to the chamber near the bottom of the hammer as well as to convey all exhaust air centrally through a separate second passage communicating with the chamber above the place of communication of the first passage with the chamber, out through the bit tappet and bit for discharge to the atmosphere.

The central tube eliminates the necessity for double cylinders that provide a duct between them for conducting high pressure hammer-return air around the inner cylinder to the bottom end of the air cylinder, as is required in heretofore conventional drills of this type.

Another important object is realized in that the central tube enables the construction of smaller diameter drills capable of drilling smaller diameter holes than that possible with drills having the double casing mentioned above.

Still another important objective is realized in that the central air tube eliminates the necessity for a small diameter section on the bottom of the hammer and a mating reduced diameter sleeve which provide an air tight compression chamber for reducing the shock of hammer impact on the forward threaded connection between the cylinder housing and the bit-retaining device when the bit is not in contact with the rock at the bottom of the hole.

Other important advantages are realized in that the central air tube thereby allows the hammer striking face to occupy the entire area between the central air tube and the cylinder housing. Moreover, because the hammer is of symmetrical construction, the hammer can be turned end for end when one striking face begins to wear out so as to secure twice the normal use from this part.

Yet another important object is achieved in that the large impact face areas of the hammer and bit tappet allow a greater working volume of air to be used to operate the drill at higher speed and heavier impacts, thereby resulting in faster drilling rates.

Another important objective is to provide a drill in which the entire volume of air used in producing useful work is utilized in sweeping drill cuttings from the bottom of the hole out to the surface. This results in a greater efficiency of operation than when high pressure air must be by-passed to the bit around the work cycle, without doing any useful work, in order to sweep the drill cuttings adequately from the bottom of the hole. Moreover, because the entire volume of air is exhausted into centrally located ports in the center tube high in the

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machine, and thence through the bit tappet and bit, the cooling effect of expanding air will prevent overheating of the tappet and bit from impact of the hammer.

Other important advantages and functional results are obtained because the drill design permits installation of a check valve at the bottom of the drill adapted to close the central air passage automatically when the air is turned off the machine. The check valve makes it possible to drill in rock formation containing mud and water because its specific location and operation prevents entry of mud and rock cuttings into any part of the machine through air passages when the air is turned off.

Another important object is achieved by the use of a single unported cylindrical housing to contain the automatic valve parts, the hammer and the bit tappet. Because the interior wear is concentrated in this one housing part which is also subjected principally to erosion on the outside by drill cuttings as they are blown out of the hole, replacement of a worn cylindrical housing will renew the strength and worn outside diameter of the machine as well as renew the internal fits of the working parts.

By construction the interconnection of the bit tappet with the lower end of the machine, the bit tappet is allowed to drop down from normal operating position when the bit is not in contact with the rock, thereby allowing the hammer to drop down to where an internal groove on the hammer spans both pressure and exhaust ports in the central tube so that the debris is blown from the hole with full pressure and volume of air.

An important object is to provide a down-hole drill that is simple and durable in construction, economical to manufacture, efficient in operation, and which is fully automatic.

The foregoing and numerous other objects and advantages of the invention will more clearly appear from the following detailed description of a preferred embodiment, and several modifications thereof, particularly when considered in connection with the accompanying drawings, in which:

FIG. 1 is a longitudinal cross sectional view of the down-hole drill, illustrating the bit tappet and hammer in its initial position prior to its return stroke;

FIG. 2 is a longitudinal cross sectional view similar to FIG. 1, but illustrating the hammer at the end of its return stroke and at the beginning of its power stroke;

FIG. 3 is a fragmentary longitudinal cross sectional view similar to FIG. 1, but illustrating the bit and bit tappet fully extended so that said hammer is in full blowing position;

FIG. 4 is a fragmentary perspective view of the center tube utilized in FIG. 1;

FIG. 5 is a fragmentary perspective view, partially in cross section, of a modification of the center tube;

FIG. 6 is a fragmentary perspective view, partly cut-away and in cross section, of a modification of the center tube;

FIG. 7 is a fragmentary perspective view, partially cut-away and in cross section, of another modification of the center tube;

FIG. 8 is an enlarged cross sectional view of the check valve utilized in FIG. 1 and capable of use with the center tubes illustrated in FIGS. 4, 6 and 7; and

FIG. 9 is a cross sectional view of a modified check valve capable of use with the center tube shown in FIG. 5.

Referring now by characters of reference to the drawings, and first to FIGS. 1 and 2, it is seen that the drill unit includes a cylindrical tubular housing generally indicated at 10. An intermediate housing portion 11 is threadedly connected at its upper end to a top housing portion 12, and is threadedly connected at its lower end to a bottom housing portion 13 constituting a chuck. The top housing portion 12 is adapted to be connected

by internal fastening means 14 to a source of fluid under pressure.

The intermediate housing portion 11 provides a chamber 15 defined at its top end by valve means 16 and at its bottom end by bit tappet 19 constituting a bit-supporting means.

The valve means 16 includes a first plate 20 seating on a shoulder provided by the top rim of intermediate housing portion 11. Formed in first plate 20 are a plurality of valve passages 21 communicating with the top end of chamber 15. A second plate 22 seats on top of the first plate 20 and is provided with a plurality of valve passages 23 that are aligned and communicate with valve passages 21 formed in first plate 20.

Disposed between the top of second plate 22 and a shoulder formed on the top housing portion 12 is a closure cap 24, the cap 24 providing an internal compartment 25.

A tubular valve member 26 is reciprocally mounted within the second plate 22, the interior of valve member 26 communicating with the compartment 25 of closure cap 24. The valve member 26 includes a peripheral flange 27 that seats on second plate 22 in its lowered position to close the valve passages 23, and opens the cap compartment 25 to a plurality of valve passages 30 formed in the closure cap 24 communicating with the source of pressure fluid. In its uppermost position, the flange 27 of valve member 26 closes the cap compartment 25 by sealingly engaging the cap 24, yet opening the valve passages 30 to the aligned valve passages 23 and 21.

The bit tappet 17 is reciprocally mounted within the lower housing portion 13. Specifically, the bit tappet 17 is splined to the lower housing portion 13 so that it is drivingly rotated by the cylindrical housing 10, and is reciprocally movable within limits.

Attached to the lower end of bit tappet 17 is a suitable drill bit 31. The drill bit 31 engages the bottom end of housing 10 to determine the fully retracted position of bit tappet 17. The head of the bit tappet 17 engages the spline on the lower housing portion 13 to determine its fully extended position as is shown in FIG. 3.

The bit tappet 17 is provided with an internal bore 32 that communicates at its bottom end with passages 33 formed in drill bit 31. For reasons which will later appear, the tappet bore 32 and the bit passages 33 are hereinafter designated a discharge passage.

Extending longitudinally in chamber 15 is a center tube 34 (FIG. 1), the upper end of which is secured by the first valve plate 20 of the valve means, and the lower end of which is slidably mounted within the bore 32 of bit tappet 17.

A hammer 35 is provided with a longitudinal bore adapted to receive the center tube 34 in substantial sealing relation, the hammer 35 being reciprocal in chamber 15 between the valve means 16 and bit tappet 17. For reasons which will later appear, the hammer 35 is provided with an internal groove 36 that spaces an intermediate portion of the hammer 35 from the center tube 34.

The center tube 34 is provided with an internal partition 37 that divides the tube 34 into two separate passages 40 and 41. As is best seen in FIGS. 1 and 4, the first passage 40 communicates with the interior of valve member 26 at the upper end of center tube 34 and communicates with the bottom of chamber 15 through first tube port 42. When the bit tappet 17 is fully raised as is shown in FIG. 1, the tube port 42 communicates with the chamber 15 below hammer 35.

The center tube 34 is provided with a second and a third tube ports 43 and 44 above the first tube port 42, these tube ports 43 and 44 communicate the second passage 41 with the chamber 15. The second passage 41 also communicates with the tappet bore 32 through the lower end of center tube 34.

A check valve 45 (FIG. 1) is secured to the lower end of center tube 34 and is located within the second pas-

sage 41, the check valve 45 being adapted to assure flow through the second passage 41 only in one direction. The details of construction of check valve 45 are clearly shown in FIG. 8.

From FIG. 8 it is seen that the check valve 45 includes a cylindrical casing 46 that seats on an internal ring 47 fixed to the bottom end of tube 34. The ring 47 is provided with a center opening 50 communicating the lower end of casing 46 with the tappet bore 32. The top of casing 46 is closed by plug 51. Reciprocally mounted within casing 46 is a tubular check valve member 52 shown in a lowered and in a raised position in FIG. 8. The interior of tubular check valve 52 communicates with the opening 50 at the bottom of the center tube. The casing 46 is provided with a plurality of valve ports 53 that are adapted to be opened and closed by reciprocating check valve member 52.

The check valve member 52 is provided with a pressure surface 54 that communicates with the second passage 41 through the valve ports 53. Furthermore, the check valve member 52 is provided with a pressure surface 55 that communicates with the bottom opening 50 through the interior of check valve member 52.

When fluid pressure is exerted through the second passage 41, such pressure raises the check valve member 52 to open the valve ports 53, and thereby places the second passage 41 in direct communication with the tappet bore 32. On the other hand, when fluid pressure is turned off, the pressure differential on pressure surfaces 54 and 55 causes the check valve member 52 to drop and close the valve ports 53. The pressure existing at the bottom of the machine in the drill hole, acts on pressure surface 55 through the tubular check valve member 52 to maintain the check valve member in its closed position until the fluid pressure is subsequently turned on.

It will be assumed that the initial starting position of the component elements of the drill are shown in FIG. 1. When fluid pressure is turned on through the top of the cylindrical housing 10, the fluid is directed through valve passages 30 into the cap compartment 25 and thence through the tubular valve member 26 into the first passage 40. This fluid pressure is directed from the first passage 40 through the first tube port 42 against the lower face of hammer 35, thereby lifting the hammer 35 for a return stroke.

As the hammer 35 is raised in this return stroke, fluid in the chamber 15 above the hammer 35 is moved through third tube port 44 into the second passage 41, and consequently fed through the bit discharge passage. The hammer will first clear the second tube port 43, thereby placing the tube ports 42 and 43 in direct communication. The high pressure fluid will then flow directly from the first passage 40, through tube port 42, into second tube port 43 and thence into the second passage 41 where it is directed out the bottom of the machine through bit discharge passage. The momentum of hammer 35 will then carry it past the third tube port 44 so as to close such tube port 44. The air in the upper part of chamber 15 is then compressed by hammer 35 and acts through valve passages 21 and 23 to raise the valve member 26 to the position illustrated in FIG. 2.

The machine is now conditioned for a power stroke. The pressure fluid is directed from valve passages 30 into the aligned valve passages 23 and 21 and is then directed into the top of chamber 15 above hammer 35. This high pressure drives the hammer 35 downwardly with force. As the hammer moves downwardly, the fluid below the hammer is moved through the second tube port 43, into the second passage 41 and out the bottom of the machine. The hammer 35 will first clear the third tube port 44. The high pressure fluid will then be directed from the upper portion of the chamber through the third tube port 44 directly into the second passage 41 and then directed through the bit 31. The hammer 35 continues in its power stroke to strike the

bit tappet 17 so as to extend the bit 31 from housing 10.

When the second tube port 43 is closed by the hammer 35 as the hammer descends, the fluid below the hammer in the chamber 15 is compressed through the first tube port 42 and into the first passage 40. This increase in fluid pressure in the first passage 40 acts on valve member 26 to lower the valve member 26 to its initial position shown in FIG. 1. After the bit tappet 17 and the drill bit 31 have been extended upon impact by the hammer 35, the weight of the unit will cause the cylindrical housing 10 to move downwardly so that the bit tappet is again fully retracted. The mechanism is now conditioned for another cycle of operation.

If, for any reason, the bit tappet 17 and attached drill bit 31 fall free as a result of there being an absence of supporting formation, the hammer 35 will drop to the position illustrated in FIG. 3 on top of the bit tappet 17. In this position, the internal groove 36 of hammer 35 places the first tube port 42 in direct communication with the second tube port 43. Consequently there is a continuous blowing action of pressure fluid from the first passage 40, into the second passage 41 and out the bottom of the machine through the tappet bore 32 and bit ports 33. The machine is subsequently conditioned automatically for cycling operation when the bit 31 engages the bottom of the drill hole and the bit tappet 17 is fully retracted as is shown in FIG. 1.

Of course, it will be readily apparent that the center tube 34 can be of different constructions to provide the same results. For example, the tube 34 in FIG. 6 includes an inner tubular portion 56 that provides a first passage 57 communicating the valve means 16 with a first tube port 60 that corresponds to the first tube port 42 previously described with respect to FIGS. 1 and 4. An outer tube portion 61 is spaced from the inner tube portion 56 to provide a separate second passage 62. It will be seen from FIG. 6 that an intermediate length of the inner tubular portion 56 is reduced so that the second passage communicates with chamber 15 as determined by the reciprocating action of hammer 35. The second passage 62 places the chamber 15 in direct communication with the open bottom end of the outer tubular portion 61.

A check valve of the type fully disclosed in FIG. 8 can be attached to the bottom of this center tube 34 (FIG. 6) in the same manner as was utilized with respect to the center tube 34 (FIG. 4).

Briefly described, fluid pressure is introduced initially through the first passage 57 and out the first tube port 60 below the hammer 35, thereby acting to raise the hammer for its return stroke. As the hammer 35 is raised, the fluid in chamber 15 above the hammer flows between the hammer and the tube into the second passage 62. First, the hammer 35 will clear the top of outer tubular portion 61 so as to place the first tube port 60 in direct communication with the second passage 62 through the reduced intermediate tube length. Upon continued movement upwardly of hammer 35, the hammer 35 engages the enlarged upper portion of the tube 34 to close off the second passage 62 with the chamber 15 above the hammer, thereby conditioning the valve means 16 for a power stroke as previously described.

As the hammer 35 is moved downwardly in a power stroke, the fluid in chamber 15 below the hammer moves along the reduced intermediate tube portion and into the second passage 62. The hammer 35 will first clear the reduced tube portion so that the high pressure fluid above the hammer flows between the hammer and reduced tube portion and thence flows into the second passage 62. Continued movement of hammer 35 in its power stroke closes off the reduced tubular portion with the chamber 15 below the hammer so that the fluid is compressed through the first tube port 60 and in the first passage 57 to actuate the valve means 16, and thereby condition the machine for another return stroke.

Another center tube construction is illustrated in FIG. 7.

In this modification, the center tube 34 includes an inner tubular portion 63 that is open at the top to communicate with the tubular valve member 26 and is open through a first tube port 64 to the lower end of chamber 15 below hammer 35. Again, it will be noted that the first tube port 64 corresponds to the first tube port 42 previously described in the center tube of FIG. 4. The inner tubular portion 63 provides a first passage 65.

An outer tubular portion 66 is spaced from inner tubular portion 63 to provide a separate second passage 67 that is open at the bottom of center tube 34. The outer tubular portion 66 is provided with a second tube port 70 communicating the second passage 67 with the chamber 15 above the first tube port 64. A third tube port communicates the second passage 67 with the chamber 15 above the second tube port 70. It will be noted that the second and third tube ports 70 and 71 correspond respectively to the second and third tube ports 43 and 44 previously described with respect to the center tube in FIGS. 1 and 4.

The operation and functional advantages of the center tube 34 illustrated in FIG. 7 is the same as that previously described with respect to the center tube 34 of FIG. 4.

Again, the check valve 45 shown in FIG. 8 may be advantageously utilized and mounted in the bottom end of the center tube 34 illustrated in FIG. 7.

Still another center tube construction is shown in FIG. 5. In the embodiment of FIG. 5, the center tube 34 includes an inner tubular portion 72 having flattened sides. The inner tubular portion 72 provides a first passage 73 that communicates at its top end with the tubular valve member 26, and which communicates with the lower end of chamber 15 through a first tube port 74 as will be explained later.

An outer tubular portion 75 surrounds the inner tubular portion 72 and is spaced from the flat sides to provide a second passage 76. The outer tubular portion 75 is provided with a reduced section 77 below the first tube port 74. The outer tubular portion 75 is provided with a second tube port 80 that communicated the second passage 76 with the upper end of chamber 15 above the first tube port 74.

A check valve 81, the details of which are illustrated in FIG. 9, is attached to the bottom of center tube 34 illustrated in FIG. 5. From FIG. 9 it is seen that the lower end of the center tube 34 of FIG. 5 is closed by a plug 82. Reciprocally mounted about the end of the tube 34 is a check valve member 83 that is movable between limits as determined by abutment with the reduced tube portion 77 and by abutment with a ring 84 attached to closure plug 82. Upon reciprocation, the check valve member 83 is adapted to open or close a plurality of check valve ports 85 formed in the lower end of the center tube. The second passage 76 communicates with the tappet bore 32 through the check valve port 85 when the check valve member 81 is raised upon exertion of fluid pressure through the second passage 76.

When the bit tappet 17 is fully retracted within housing 10 and the hammer 35 seats on the top of the bit tappet 17, the internal groove 36 of hammer 35 bridges the first tube port 74 and the reduced tube portion 77 so that pressure fluid is directed into the first passage 73, out through the first tube port 74, and subsequently along the internal hammer groove 36 and down the reduced tubular portion 75 to the bottom face of hammer 35. The hammer is then raised in a return stroke.

As the hammer 35 is raised in its return stroke, the fluid in the upper end of the chamber is moved through the second tube port 80 into the second passage 76. The existence of fluid pressure in the second passage 76 raises the check valve member 83 to open the check valve ports 85, thereby placing the second passage 76 in direct communication with the discharge passage so that the fluid is ejected through the drill bit 31.

In this return stroke of hammer 35, the internal ham-

mer groove 36 first bridges the first tube port 74 and second tube port 80 to place the first and second passages 73 and 76 in direct communication so that high pressure fluid flows directly out the bottom of the machine. Then, the hammer 35 closes the second tube port 80 and compresses the fluid at the top of the chamber so as to condition the valve member 26 for a power stroke as previously described.

During the power stroke, the fluid under pressure throws the hammer downwardly. As the hammer moves downwardly, the fluid at the bottom end of the chamber 15 flows upwardly along the reduced tubular portion 77 and along the internal hammer groove 36, into the second tube port 80, and consequently is moved through the second passage 76 and out through the drill bit. Then, upon continued movement of the hammer in the power stroke, the hammer 35 opens the second tube port 80 so that the high pressure fluid is moved directly therethrough into the second passage 76. The hammer then strikes the bit tappet 17 and extends the drill bit 31.

In this embodiment of FIG. 5, when the bit tappet 17 and drill bit 31 drop free upon the absence of any supporting formation below the drill bit, the hammer 35 will fall sufficiently with the bit tappet 17 so that the first tube port 74 is opened above the hammer 35. This action places the first tube port 74 in direct communication with the superjacent second tube port 80 so that there is a continuous flow or blowing of fluid under high pressure through the first and second passages and consequently out the bottom of the machine.

Although the invention has been described by making detailed reference to a single preferred embodiment and several modifications of a part thereof, such detail is to be understood in an instructive, rather than in any restrictive sense, many variants being possible within the scope of the claims hereunto appended.

This application is a continuation of my application Serial No. 87,879 filed February 8, 1961, now abandoned.

I claim as my invention:

1. A down-hole drill, comprising a housing adapted for connection at one end to a source of fluid pressure, an annular hammer reciprocally mounted within said housing, valve means adjacent said one end of the housing, a bit-supporting means reciprocally mounted at the other end of the housing, a tube supported within said housing and extending through the hammer bore, the tube having one end in pressure fluid transmitting communication with said bit-supporting means, port means in said valve for directing pressure fluid alternately to one end of the hammer and into the other end of said tube, hammer controlled port means adjacent said one end of the tube for directing pressure fluid to the other end of the hammer and further valve means for selectively directing pressure fluid from said tube to said bit-supporting means.

2. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and a second passage communicating with said chamber above the place of communication of said first passage with said chamber, said hammer opening and closing said second passage upon reciprocation, said hammer opening said second passage below the hammer when the hammer is partly raised and closing said second passage above the hammer when the hammer approaches its fully raised

position in said chamber, the bit-supporting means and the bit being provided with a discharge passage communicating with said second passage, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage.

3. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means including a reciprocal valve member supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and a separate second passage communicating with said chamber above the place of communication of said first passage with said chamber, said hammer opening and closing said second passage relative to said chamber upon reciprocation, the bit-supporting means and said bit being provided with a discharge passage communicating with said second passage, said valve member in one position directing fluid pressure through said first passage to lift the hammer for a return stroke, said second passage being open above said hammer as the hammer is initially lifted but said hammer maintaining said second passage closed below said hammer, said hammer opening the second passage below the hammer during the return stroke and said hammer closing the second passage above the hammer as the hammer approaches the end of its return stroke, the valve member disposed in another position to direct pressure fluid to the chamber above said hammer to lower the hammer in a power stroke, said second passage being open below said hammer as the hammer is initially lowered in said power stroke but said hammer closing said second passage above said hammer, said hammer opening said second passage above said hammer during the power stroke and closing the second passage below the hammer as the hammer approaches the end of its power stroke.

4. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber with said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top of said chamber, said valve means including a reciprocal valve member supported at the top of said chamber, said valve member being tubular, and a closure cap overlying the top of said tubular valve member, a bit-supporting means reciprocally mounted at the bottom of said chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the interior of said tubular valve member with said chamber below said hammer, and a second passage communicating with the chamber above the place of communication of the first passage with said chamber, the bit-supporting means and bit being provided with a discharge passage communicating with said second passage, the valve member in one position directing fluid pressure through the valve member and into said first passage, and in another position directing fluid pressure around the valve member and into the chamber above said hammer.

5. The combination and arrangement of elements as recited above in claim 4, but further characterized in that said hammer opens and closes said second passage upon reciprocation, said hammer opening said second passage below the hammer when the hammer is partly raised and

closing said second passage above the hammer when the hammer approaches its fully raised position in said chamber to actuate said valve member.

6. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including an inner tubular portion defining a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and said tube and inner tubular portion defining a separate second passage communicating with said chamber above the place of communication of said first passage with said chamber, said hammer opening and closing said second passage upon reciprocation, the bit-supporting means and the bit being provided with a discharge passage communicating with said second passage, the valve means being adapted selectively to direct pressure fluid through said first passage to lift the hammer in a return stroke, or to direct pressure fluid to the chamber above said hammer to lower the hammer in a power stroke, said hammer opening said second passage below the hammer and subsequently closing the second passage above the hammer during the return stroke, and said hammer opening the second passage above the hammer and subsequently closing the second passage below the hammer during the power stroke.

7. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer, and a second passage communicating with the chamber above the place of communication of the first passage with said chamber, and a check valve disposed in said second passage at the bottom end of said tube, said check valve being adapted to close said second passage automatically when the fluid pressure is turned off so as to preclude entry of mud and cuttings into said second passage and chamber, the bit-supporting means and the bit being provided with a discharge passage communicating with said second passage through said check valve, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage.

8. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means including a reciprocal valve member supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and a second passage communicating

with the chamber above the place of communication of said first passage with said chamber, said hammer opening and closing said second passage upon reciprocation, the valve member disposed in one position to direct pressure fluid through said first passage to lift the hammer in a return stroke, said hammer closing said second passage above the hammer during the return stroke, and the valve means in said other position directing fluid pressure to the chamber above the hammer to lower the hammer in a power stroke, said hammer opening the said second passage during the power stroke, the bit-supporting means and bit being provided with a discharge passage communicating with the second passage at the bottom of said tube.

9. The combination and arrangement of elements as recited above in claim 8, but further characterized by the provision of a check valve in the said second passage at the bottom end of said tube, said check valve being adapted to close said second passage automatically when fluid pressure is turned off so as to preclude entry of mud and cuttings into said second passage and chamber.

10. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means including a reciprocal valve member supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in a substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and a separate second passage communicating with said chamber above the place of communication of said first passage with said chamber, said hammer opening and closing said second passage upon reciprocation, said hammer opening said second passage below the hammer when the hammer is partly raised and closing said second passage above the hammer when the hammer approaches its fully raised position in said chamber, and a check valve disposed in said second passage at the bottom end of said tube, said check valve being adapted to close said second passage automatically when fluid pressure is turned off, said bit-supporting means and bit being provided with a discharge passage communicating with said second passage through said check valve, said valve member being disposed in one position to direct pressure fluid to the chamber above said hammer and in another position to direct pressure fluid through said first passage.

11. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said hammer having an internal groove about said tube, said tube including a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and a separate second passage communicating with said chamber above the place of communication of said first passage with said chamber, the bit-supporting means and the bit being provided with a discharge passage communicating with said second passage at the bottom of said tube, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage, said first and second passages being

placed in direct communication by said internal hammer groove as the hammer is lowered when the bit-supporting means and attached bit drop freely, whereby to cause a continuous blowing through the tube passages and said discharge passage.

12. The combination and arrangement of elements as recited above in claim 11, but further characterized by the provision of a check valve in said second passage at the bottom end of said tube, said check valve being adapted to close said second passage automatically when fluid pressure is turned off so as to preclude entry of foreign material into said second passage and chamber.

13. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said hammer having an internal groove about said tube, said tube including a first passage communicating the valve means with said chamber below said hammer when the bit-supporting means is raised, and a separate second passage communicating with said chamber above the place of communication of said first passage with said chamber, said hammer opening said second passage below the hammer when the hammer is partly raised and closing said second passage above the hammer when the hammer approaches its fully raised position in said chamber, the bit-supporting means and bit being provided with a discharge passage communicating with said second passage at the bottom end of said tube, the valve means being adapted to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage, said first and second passages being placed in direct communication by said internal hammer groove as the hammer is lowered when the bit-supporting means and attached bit drop freely, whereby to cause a continuous blowing through the tube passages and said discharge passage.

14. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including an inner tubular portion open at the top to provide a first passage communicating with the valve means, said tube being provided with a first port communicating the first passage with said chamber below said hammer when the bit-supporting means is raised, the tube and said inner tubular portion being spaced to provide a separate second passage communicating with said chamber above said first port, said hammer opening and closing said second passage upon reciprocation, said hammer opening said second passage below the hammer when the hammer is partly raised and closing said second passage above the hammer when the hammer approaches its fully raised position in said chamber, the bit-supporting means and the bit being provided with a discharge passage communicating with said second passage at the bottom of said tube, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage.

15. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pres-

sure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a partition providing a first passage communicating with the valve means, said tube being provided with a first port communicating the first passage with said chamber below said hammer when the bit-supporting means is raised, said partition providing a separate second passage, the tube being provided with a second port communicating with said chamber above the said first port, and being provided with a third port communicating with said chamber above the said second port, said hammer opening and closing said second and third ports upon reciprocation, said hammer opening said second port below the hammer when the hammer is partly raised in the return stroke to exhaust pressure fluid through the second passage, and said hammer closing said third port above the hammer when the hammer approaches the top of its return stroke, the bit-supporting means and bit being provided with a discharge passage communicating with said second passage at the bottom end of said tube, valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage.

16. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber with said housing, a reciprocal hammer with said chamber, said hammer having an axial bore therethrough, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means said tube including means providing a first passage communicating with the valve means, said tube being provided with a first port communicating the first passage with said chamber below said hammer when the bit-supporting means is raised, said tube means providing a second separate passage, the tube being provided with a second port communicating with said chamber above said first port and being provided with a third port communicating with said chamber above said second port, said hammer opening and closing said second and third ports upon reciprocation during a return stroke and a power stroke, the bit-supporting means and bit being provided with a discharge passage communicating with said second passage at the bottom of said tube, the valve means being adapted selectively to direct pressure fluid through said first passage and through said first port to raise said hammer for a return stroke, said hammer opening said second port during the return stroke to exhaust pressure fluid through said second passage and out said bit, and said hammer subsequently closing said third port during said return stroke so as to actuate said valve means for a power stroke, said valve means being adapted to direct pressure fluid to the chamber above said hammer to lower the hammer in a power stroke, said hammer opening said third port during the power stroke to exhaust pressure fluid through said second passage and out said bit, and subsequently closing said second port as the hammer approaches the end of its power stroke to force pressure fluid through said first port and first passage so as to actuate said valve means for another return stroke of said hammer.

17. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within

said chamber, said hammer having an axial bore there-through, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, the tube including a first passage communicating the valve means with said chamber below said hammer, and a separate second passage communicating with the chamber above the place of communication of the first passage with said chamber, a check valve means carried by the lower end of said tube including a valve port communicating with said second passage, a reciprocal check valve member movable to open or close said valve port, said check valve member having one surface subjected to fluid pressure from said second passage through said valve port and adapted to move the check valve member toward a port-open position upon application of fluid pressure, the bit-supporting means and bit being provided with a discharge passage communicating with said second passage through said valve port, said check valve member having another surface subjected to external pressure through said discharge passage tending to move the check valve member toward a port-closed position when the fluid pressure is terminated, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage.

18. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer within said chamber, said hammer having an axial bore there-through, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer, and a second separate passage communicating with the chamber above the place of communication of the first passage with said chamber, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid to said first passage, a check valve means carried by the lower end of said tube including a tubular casing within the lower tube end, said casing having a valve port communicating the second passage with the said lower tube end, and a tubular check valve member reciprocally mounted in said casing and adapted to open or close said valve port, said check valve

member placing the casing interior above the valve member in communication with the lower tube end, said check valve member having one surface subjected to fluid pressure from said second passage through said valve port and adapted to move the check valve member toward a port-open position upon application of fluid pressure, the bit-supporting means and bit being provided with a discharge passage communicating with said second passage through said open lower tube end and said check valve port, said check valve member having another surface subjected to external pressure through the open lower tube end and discharge passage tending to move the check valve member toward a port-closed position when the fluid pressure is terminated.

19. In a down-hole drill, a tubular housing adapted for connection at its top end to a source of fluid pressure, a chamber within said housing, a reciprocal hammer with said chamber, said hammer having an axial bore there-through, valve means supported at the top end of said chamber, a bit-supporting means reciprocally mounted at the bottom end of the chamber, a drill bit attached to said bit-supporting means, a tube supported at its top end by said valve means and extending through the hammer bore in substantial sealing relation, the tube having its bottom end received in said bit-supporting means, said tube including a first passage communicating the valve means with said chamber below said hammer, and a separate second passage communicating with the chamber above the place of communication of the first passage with said chamber, the valve means being adapted selectively to direct pressure fluid to the chamber above said hammer or to direct pressure fluid through said first passage, a check valve means carried by the lower end of said tube including a closure cap attached to the lower end of said tube, the lower end of said tube being provided with a valve port above said closure cap communicating with said second passage, and a tubular check valve member reciprocally mounted on the lower end of said tube and adapted to open or close said valve port, means on said closure cap holding said check valve member on said lower tube end, said check valve member having one surface subjected to fluid pressure from said second passage through said check valve port and adapted to move the check valve port toward a port-open position upon application of fluid pressure, said bit-supporting means and bit being provided with a discharge passage communicating with said second passage through said check valve port, said check valve member having another surface subjected to external pressure through said bit discharge passage tending to move the check valve member toward a port-closed position when the fluid pressure is terminated.

No references cited.