Sept. 3, 1957 E. B. WILLIAMS, JR 2,805,043

JETTING DEVICE FOR ROTARY DRILLING APPARATUS

Original Filed Feb. 9, 1952 2 Sheets-Sheet 1.

Fig. 1.

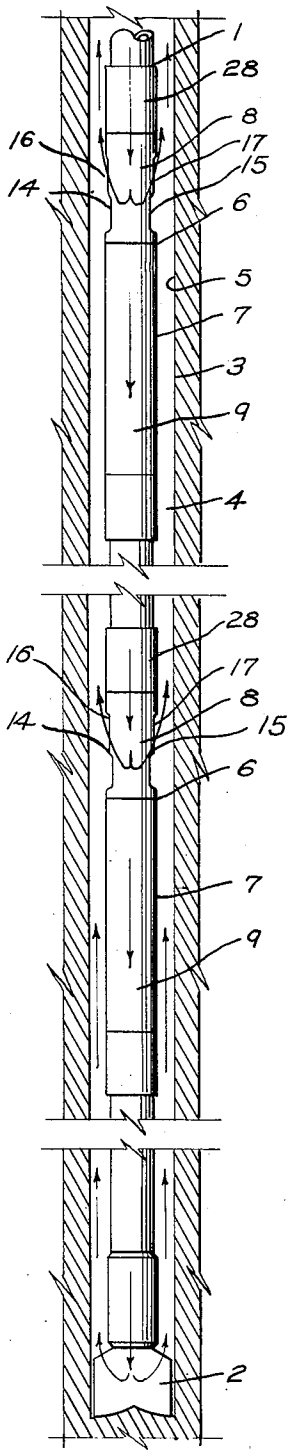


Fig. 3.

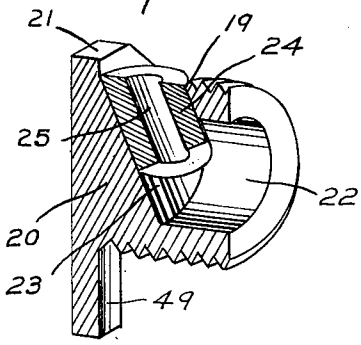
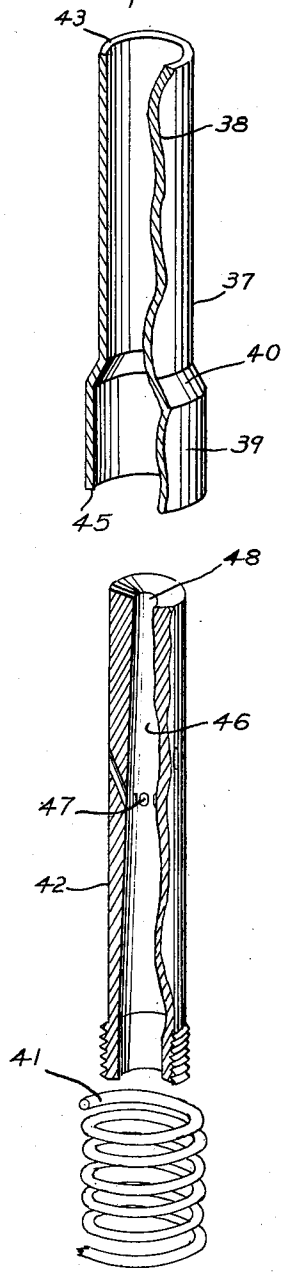


Fig. 2.



INVENTOR.
Edward B. Williams Jr.
BY
Paul E. Mullendore
ATTORNEY

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Original Filed Feb. 9, 1952 2 Sheets-Sheet 2

Fig. 4.

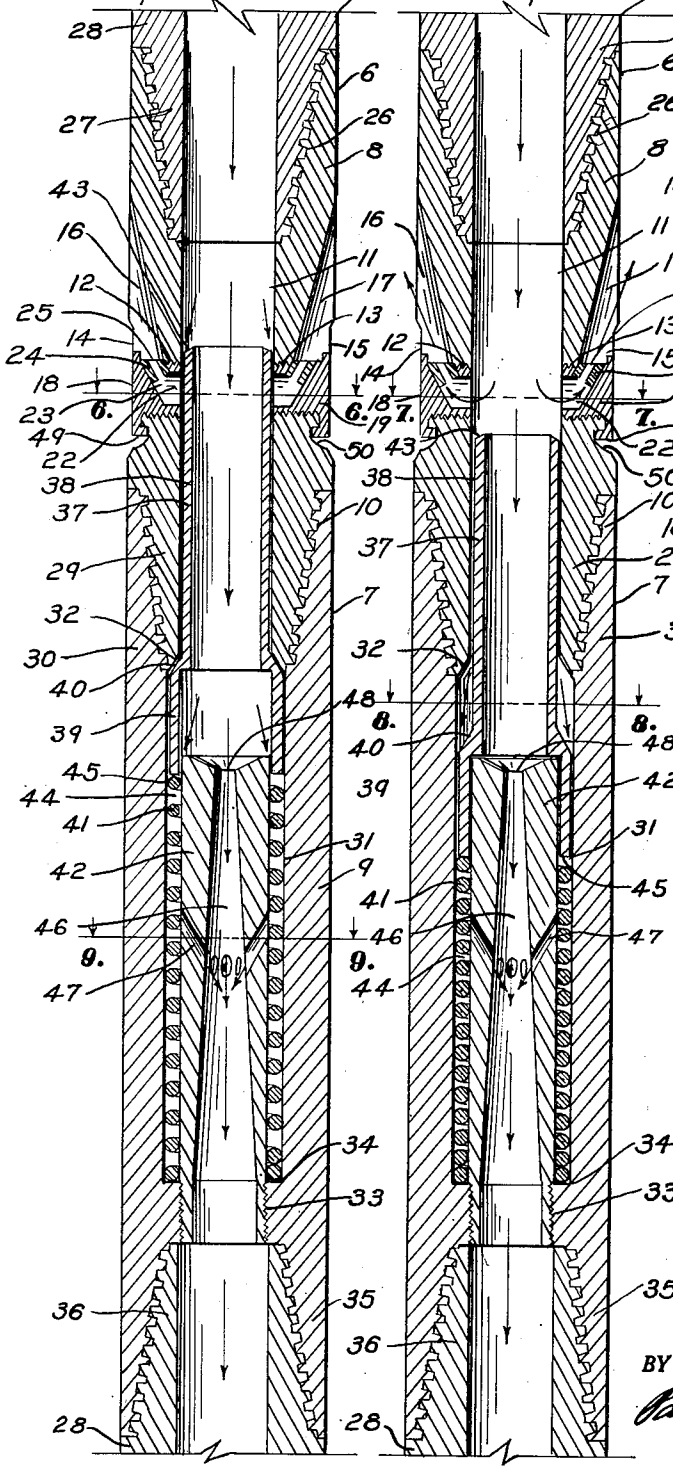


Fig. 5.

Fig. 6.

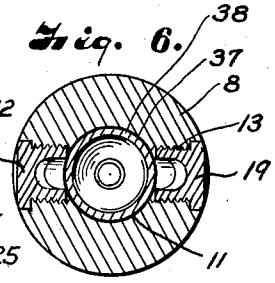


Fig. 7.

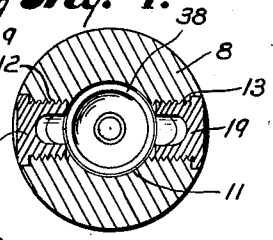


Fig. 8.

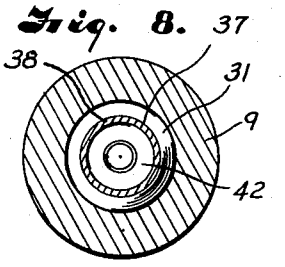
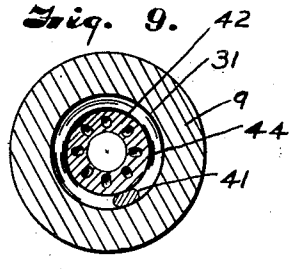


Fig. 9.



INVENTOR.
Edward B. Williams Jr.
BY
Paul E. Mullendore
ATTORNEY

United States Patent Office 2,805,043 Patented Sept. 3, 1957

2,805,043

JETTING DEVICE FOR ROTARY DRILLING APPARATUS

Edward B. Williams, Jr., Greenville, Tex.

Original application February 9, 1952, Serial No. 270,809, now Patent No. 2,765,146, dated October 2, 1956. Divided and this application July 12, 1956, Serial No. 597,511

4 Claims. (Cl. 255—24)

This invention relates to an apparatus for controlling pressure and flow volume of the drilling fluid within a bore hole while the drilling fluid is under flow through a string of drill pipe of a rotary well drilling mechanism, the present application being a division of my copending application on Jetting Device for Rotary Drilling Apparatus, Serial No. 270,809, filed February 9, 1952, now Patent No. 2,765,146, issued October 2, 1956.

Return circulation of drilling fluid between the string of drill pipe and the open bore hole often requires such high pump pressures that the drilling fluid flows into the formation and it is difficult to maintain sufficient upflow to keep a clean hole. Also, where the drilling fluid loss occurs within a possible producing formation, the formation fluids are driven back into the bore hole and the cuttings that are carried by the lost drilling fluid plug up the formation to such an extent that the ultimate production of the finished well is greatly reduced, and in fact the entire production may be shut off. Another difficulty is that where oil is used for cleaning out a completed bore hole, the high pressures which are required result in a similar loss of the cleanout oil and a longer cleanout time is required.

It is the object of the present invention to overcome these difficulties by transferring energy of the drilling fluid stream within the string of drill pipe to the fluid stream moving upwardly in the space between the string of drill pipe and the wall of the bore hole, thereby increasing the upward flow velocity and reducing pressure on the formation through which the hole is drilled.

A further object is to effect such transfer of energy by jetting devices adapted to be inserted in the string of drill pipe for discharging jets of drilling fluid into the fluid column within the bore hole to give an upward lift thereto and reduce the hydrostatic pressures below the points of jetting action.

Other objects of the invention are to provide a jetting device operable automatically responsive to flow of drilling fluid through the drill bit, to provide a jetting device that is readily connected between the tool joints of the string of drill pipe sections, and to provide the jetting devices with nozzles and an arrangement thereof to prevent the jets from eroding the wall of the bore hole.

Another object of the invention is to provide a jetting device of simple structure and free of parts that could interfere with drilling operations.

In accomplishing these and other objects of the invention hereinafter pointed out, I have provided improved structure which is illustrated in the accompanying drawings wherein:

Fig. 1 is a vertical section through a bore hole being drilled into an earth formation by a drill bit rotated through a spring of drill pipe and which is supplied with the drilling fluid under pressure to carry the cuttings to the top of the bore hole, the string of drill pipe being provided at intervals along the length thereof with jetting devices in accordance with the present invention, circulation of the drilling fluid being shown by arrows.

Fig. 2 is a perspective view of the jet control members shown in disassembled spaced relation.

Fig. 3 is a perspective view of one of the jet nozzles.

Fig. 4 is a vertical section through one of the jetting devices and showing the pressure responsive sleeve valve in position for closing the jet nozzles.

Fig. 5 is a similar view but showing the pressure responsive sleeve valve in retracted position for discharge of drilling fluid through the jet nozzles.

Fig. 6 is a horizontal section on the line 6—6 of Fig. 4.

Fig. 7 is a horizontal section on the line 7—7 of Fig. 5.

Fig. 8 is a horizontal section on the line 8—8 of Fig. 5.

Fig. 9 is a horizontal section on the line 9—9 of Fig. 4.

Referring more in detail to the drawings:

1 designates a rotary drilling string made up of a plurality of drill pipe sections coupled together by tool joints as in conventional practice. A drill bit 2 is connected to the lowermost section of the drilling string for drilling a bore hole 3 in the earth formation, as when prospecting for natural petroleum fluids. The string of drill pipe is rotated from above ground and a drilling fluid is pumped into the upper end thereof for discharge through the bit 2 to cool the bit and wash cuttings to the top of the bore hole 3, the drilling fluid moving upwardly in the annular space 4 between the drilling string 1 and wall 5 of the bore hole. The pressure on the drilling fluid must be sufficient to lift the fluid to the top of the bore hole. At times, and particularly when the drilling is near completion, the pressure of the fluid may exceed the pressure within the formation, with the result that the drilling fluid flows into and through the formation to push backward the formation fluids. This results in loss of drilling fluid and increases the time required in washing the cuttings from the bore hole. The loss of fluid also results in reduced velocity, so that it may not be sufficient to lift the cuttings. Consequently, the cuttings tend to accumulate in the bore hole, to further interfere with circulation. Another very serious effect is that the cuttings are carried into the formation to block the return flow of the fluids into the bore hole. Thus the finished well may fail to produce, or at least the production may be below the expected amount. Even when loss of fluid is not a factor, the flow volume through the bit may not be sufficient at times to maintain the desired upward velocity to carry the cuttings to the top of the bore hole. Consequently, it is difficult to maintain a clean hole and a longer circulation is required to clean out the bore hole upon completion of the well.

All of the above difficulties are eliminated by providing the drilling string with one or more jetting devices 6 that are constructed in accordance with the present invention and which are inserted between certain of the string of drill pipe sections to transfer energy of the fluid in the drill pipe to the fluid stream in the annular space 4 between the drilling string and the well casing (not shown) or between the drilling string and the wall of the open hole, so as to increase the upward flow velocity and reduce the hydrostatic pressure below the respective devices.

Each jetting device 6 comprises a cylindrical body member 7 of slightly larger outer diameter than the outer diameter of the drill pipe and which is composed of an upper section 8 and a lower section 9 that are connected together by a threaded joint 10 to permit assembly of the working parts in the body member 7, as later described. The upper section 8 of the body member 7 has an axial bore 11, and extending through the wall of the body section 8 are radial bores 12 and 13 opening outwardly through flattened face sides 14 and 15. Intersecting the outer ends of the radial bores 12 and 13 are upwardly and outwardly diverging grooves 16 and 17 to clear

fluid jets when they are discharged upwardly into the annular space 4, as later described. The radial bores 12 and 13 are provided with internal threads for mounting jetting nozzles 18 and 19.

The jetting nozzles are best illustrated in Fig. 3 and are shown as having externally threaded body portions 20 having polygonal shaped heads 21 by which they may be turned into the internally threaded bores 12 and 13. The inner sides of the body portions 20 have inlets or recesses 22 that connect the bore 11 with the upwardly and outwardly directed passages 23 carrying wear resistant inserts 24. The inserts have ports 25 of suitable size to provide discharge of drilling fluid upwardly and outwardly through the grooves 16 and 17, as shown by the arrows in Fig. 5. The upper end of the upper section of the body has an internally threaded box 26 to accommodate the exteriorly threaded pin 27 on the tool joint 28. The lower end of the upper section 8 has an externally threaded pin 29 engaging in the internally threaded box 30 of the lower section 9 to form the threaded joint 10. The lower section 9 has a bore 31 of larger diameter than the bore 11 of the upper section to form an annular stop or shoulder 32 at the end of the pin 29. The lower end of the bore 31 terminates in a smaller internally threaded opening 33 to provide an annular shoulder 34. The lower end of the lower section forms a box 35 to connect with the pin 36 of the tool joint 28.

In order to automatically control flow of drilling fluid through the jet nozzles, the bore 11 and the upper end of the bore 31 of the lower section 9 slideably contains a valve member 37. The valve member 37 is of the sleeve type in that it has a sleeve portion 38 freely slideable in the bore 11 of the upper body section 8 to restrict flow through the orifices of the jet nozzles 18 and 19. The sleeve type valve 37 includes a larger skirt portion 39 that forms an annular shoulder 40 with the sleeve portion 38 to engage the annular seat or stop shoulder 32 when the upper end of the sleeve member is in closing relation with the jet nozzles. The valve 37 is normally retained in closed position, with the shoulder 40 engaging the stop 32, by means of a coil spring 41 which encircles a venturi member 42. The lower end of the spring 41 seats upon the annular shoulder 34 which encircles the threaded opening 33 of the lower section 9. The valve 37 effectively restricts flow through the jet nozzles 18 and 19, but when dsplaced downwardly as later described it fits loosely within the bore 31 so that a portion of the drilling fluid may move downwardly to act on the shoulder 40 for supplementing the force of the drilling fluid that acts on the upper annular end face 43 of the sleeve portion 38. This flow of fluid is indicated by the arrows in Fig. 5.

The skirt portion 39 of the valve 37 is movable in an annular space 44 surrounding the venturi member 42 and the bottom end face 45 is subject to a lower pressure that is effected responsive to flow of drilling fluid through a venturi shaped bore or flow passage 46 of the venturi member 42 by way of downwardly converging ports 47. The ports 47 are formed in the wall of the venturi member 42, as best shown in Figs. 4, 5 and 9, to terminate at the venturi bore 46 substantially midway the length thereof.

The drilling fluid flows through the sleeve valve 37 and enters the restricted end 48 of the flow passage 46 of the venturi member so that the drilling fluid, on passing through the venturi shaped bore, produces a lower pressure at the lower ends of the ports 47 and induces flow exteriorly of the venturi member through the ports 47, as shown by the arrows in Fig. 5, to maintain a low pressure on the lower end face 45 of the skirt portion 39 of the valve 37. The higher pressure above the valve 37, acting on the annular upper end thereof, is then effective to move the valve downwardly against action of the spring 41 which is supplemented by the pressure that acts on the shoulder 40 as soon as the fluid begins to pass around the exterior side of the control member, as shown by the arrows in Fig. 5. The sleeve valve 37 is therefore moved downwardly for uncovering the inlets to the jet nozzles.

In assembling a jetting device constructed as described, the venturi member 42 is screwed into the internally threaded opening 33 at the lower end of the lower section 9. The coil spring 41 is then inserted in the annular space 44 surrounding the venturi member 42. The jet nozzles 18 and 19 are screwed into the internally threaded bores 12 and 13 of the upper section 8 and secured so that the orifices thereof discharge through the grooves 16 and 17. The nozzles are locked in this position by bending tongues 49 thereon inwardly into recesses 50 that are provided in the section 8.

The sleeve valve 37 is then inserted with the sleeve portion 38 thereof entering the lower end of the bore 11, with the annular shoulder 40 engaging the annular stop 32. The pin 36 of the upper section 8 is then screwed into the box 35 of the lower section 9 to complete the assembly of the device.

The device thus assembled is inserted in a desired position between the sections of one of the tool joints which couples adjacent pipe sections of the drilling string, as shown in Fig. 1. One or more of the jetting devices may be used as desired.

The pressure fluid is pumped into the upper end of the drilling string 1 and passes through the bores 46 of the venturi members 42 of the jetting devices 6 and is discharged through the bit 2 into the bottom of the bore hole 3. Upon rotation of the drilling string 1, the bit chips away the formation and the cuttings are carried upwardly of the bore hole 3 by the flow of drilling fluid. However, in case it becomes necessary to increase the velocity of the flow, the pressure of the drilling fluid which is admitted to the drilling string is increased so as to effect operation of the sleeve valve 37 against action of the spring 41. As the increased flow enters the restricted end 48 of the venturi member 42, the pressure is momentarily increased, but as the flow expands the pressure becomes less within the larger end of the venturi shaped bore. This effects a flow of the higher pressure fluid above the valve to be effective on the lower end 45 of the sleeve portion 38, as shown by the arrows, to act upon the shoulder 40 and pass downwardly through the annular space 44 for discharge at substantially high velocity through the ports 47, whereby the higher pressure acting on the sleeve valve above the venturi member 42 holds the spring 41 in compression and the sleeve valve in open position whereby a portion of the drilling fluid is discharged at high velocity through the jet nozzles and upwardly within the bore hole to educe a higher velocity flow of drilling fluid upwardly from the drill bit to carry the cuttings up into the high velocity flow jets. The jets thereby assist in lifting the cuttings to the top of the bore hole.

It is obvious that the jetting device 6 forms a coupling member having ends connecting adjacent sections of drill pipe to provide a through bore forming a continuation of the bore of the string of drill pipe, and that the jet nozzles provide a side discharge passage having the inlet thereof in connection with the through bore 11, and the outlet thereof is directed upwardly for discharging a jet of drilling fluid directly within the bore hole exteriorly of the string of drill pipe. It is also obvious that the control means for the nozzles includes the sleeve valve which has a part in covering relation with the inlet to the passageway of the jet nozzle in one axial position thereof, and which uncovers the inlet in another axial position thereof. It is also obvious that the venturi passage of the venturi member establishes a pressure differential to effect movement of the sleeve valve upon an increase in pressure of the drilling fluid admitted to the upper end of the drilling string.

When the jet nozzles are effective, the pressure of the drilling fluid on the formation is reduced to an extent that the formation is kept free of stoppage by cuttings. The effect may be accomplished by dividing the circulation of the fluid stream between any number of places in the bore hole depending upon the number and placement of the jetting devices.

The drilling fluid discharged through the jet nozzles at substantially high velocity creates an upward lift on the column of the drilling fluid and thereby assists in promoting the upward flow and removal of the cuttings so as to maintain a clean bore hole.

It is obvious that when oil is used to clean out fluid, as when finishing the well, the cleanout time is greatly reduced because of the increased velocity maintained incidental to operation of the jetting devices.

What I claim and desire to secure by Letters Patent is:

1. The combination with a rotary string of drill pipe for supplying drilling fluid for flow through a drill bit connected with the lower end of the string of drill pipe to cool the drill bit and wash the cuttings produced by the drill bit to the top of the bore hole, of means in said string of drill pipe for controlling pressure and flow volume of drilling fluid within the bore hole while maintaining said flow from the string of drill pipe through the drill bit, said means including a body member having ends for connection into the string of drill pipe above the drill bit and having a through bore forming a continuation of the bore of the string of drill pipe and having a side discharge passage with an inlet thereof in connection with said through bore and having a substantially upwardly directed outlet for discharging a jet of the drilling fluid upwardly within the bore hole exteriorly of the string of drill pipe, control means slideable axially in said bore of the body member and having a part in covering relation with said inlet in one axial position of said control means and in uncovering relation with said inlet in another axial position of said control means, venturi means in said bore providing a flow passage for the drilling fluid to the drill bit, said flow passage having upper and lower ends with the lower end of larger diameter than the upper end for creating a lower pressure of the drilling fluid at the larger end of said flow passage, said covering part of the control means having an upper end subject to pressure of the drilling fluid above said smaller end of the flow passage and a lower end subject to the pressure of the drilling fluid at said larger end of the flow passage to effect movement of said covering part from said covering position to said uncovering position when the pressure of the drilling fluid is increased, and means acting on said lower end of said covering part of the control means for normally retaining said covering part in covering relation with said inlet of the said discharge passage, said control means being yieldable under movement of said covering part responsive to said increase of the pressure of the drilling fluid above said flow passage to effect discharge of a jet of drilling fluid directly into the bore hole by way of the side discharge passage while the flow of drilling fluid is maintained through said flow passage to the drill bit.

2. The combination as described in claim 1 wherein said control means includes a sleeve valve slideable coaxially within the bore of the body member and having the part in covering relation with said inlet in one axial position of the sleeve valve and in uncovering relation with said inlet in another axial position of said sleeve

valve, and said venturi means comprises a member fixed coaxially within the bore of the body member below the sleeve valve and having said flow passage of larger diameter at the lower end for creating a said lower pressure at the larger end of said flow passage, said sleeve valve having an upper end subject to said pressure of the drilling fluid above said fixed member and a lower end subject to pressure of the drilling fluid effected within the flow passage of said fixed member to effect movement of said sleeve valve to move the covering part thereof from covering relation with the inlet to the side discharge passage, and wherein the yieldable means acts upon the lower end of the sleeve valve.

3. A jetting device for connection in a rotary string of drill pipe which supplies drilling fluid for flow through a drill bit on the lower end of the string of drill pipe to cool the drill bit and wash cuttings produced by the drill bit to the top of the bore hole, said jetting device including a body member having ends for connection into the string of drill pipe at a point above the drill bit and having a through bore forming a continuation of the bore of the string of drill pipe and having a radial opening in a side thereof intersecting an upwardly and outwardly sloping groove, a jet plug in said radial opening and having an inlet in connection with said bore of the body member, a jet nozzle carried by the jet plug in connection with said inlet and having discharge in said groove, control means slideable axially in said bore of the body member and having a part in covering relation with said inlet of the jet plug in one axial position of said control means and in uncovering relation with said inlet in another axial position of said control means, venturi means in said bore having a flow passage for the drilling fluid to the drill bit, said flow passage having upper and lower ends with the lower end of a larger diameter than the upper end for creating a lower pressure of the drilling fluid at the larger end of the venturi passage, said covering part of the control means having an upper end subject to pressure of the drilling fluid above said smaller end of the flow passage and a lower end subject to the pressure of the drilling fluid at said larger end of the flow passage to effect movement of said covering part from said covering position to said uncovering position when the pressure of the drilling fluid is increased, and means acting on the lower end of said covering part of the control means for normally retaining said covering part in covered relation with said inlet in the jet plug, said means being yieldable under movement of said covering part responsive to said increase of the pressure of the drilling fluid above the said flow passage to effect discharge of a jet of drilling fluid directly into the bore hole by way of the jet nozzle while the flow of drilling fluid is maintained through said flow passage to said drill bit.

4. The combination described in claim 1 wherein said control means fits loosely within the through bore and has an annular shoulder engaging an internal shoulder in the through bore when the control means is in said one axial position and to be acted upon by the drilling fluid passing around the venturi means and said venturi means has ports below the control means and connected with the flow passage in said venturi means for passing drilling fluid which passes around the control means and through which said lower end of the control means is subjected to the drilling fluid at the larger end of the flow passage.

No references cited.