Oct. 2, 1956 E. B. WILLIAMS, JR 2,765,146

JETTING DEVICE FOR ROTARY DRILLING APPARATUS

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Fig. 1.

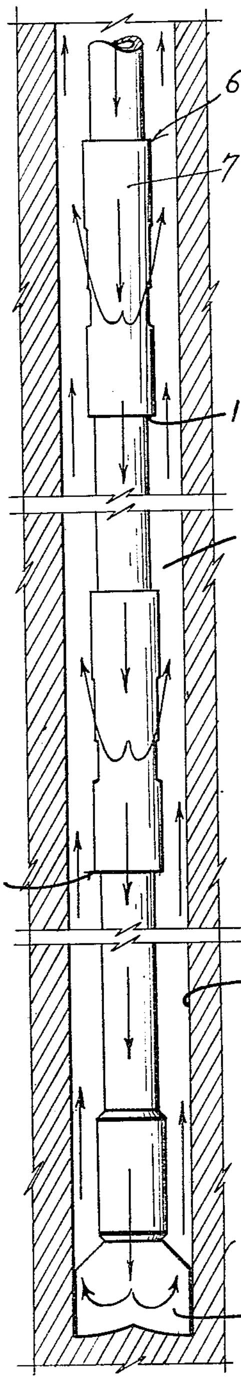

Fig. 2.

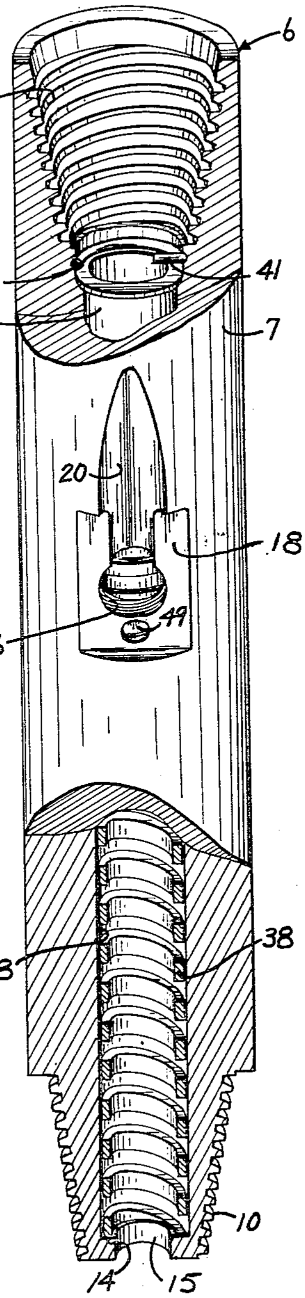

Fig. 3.

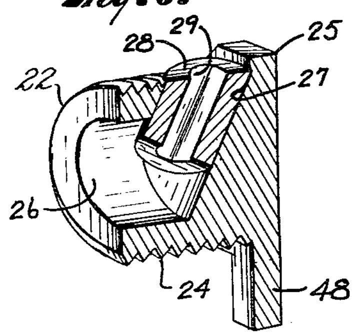

Fig. 4.

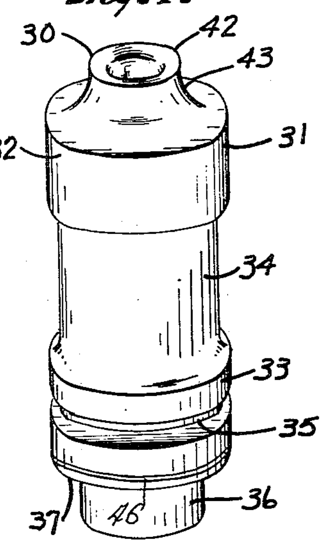

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Fig. 5.

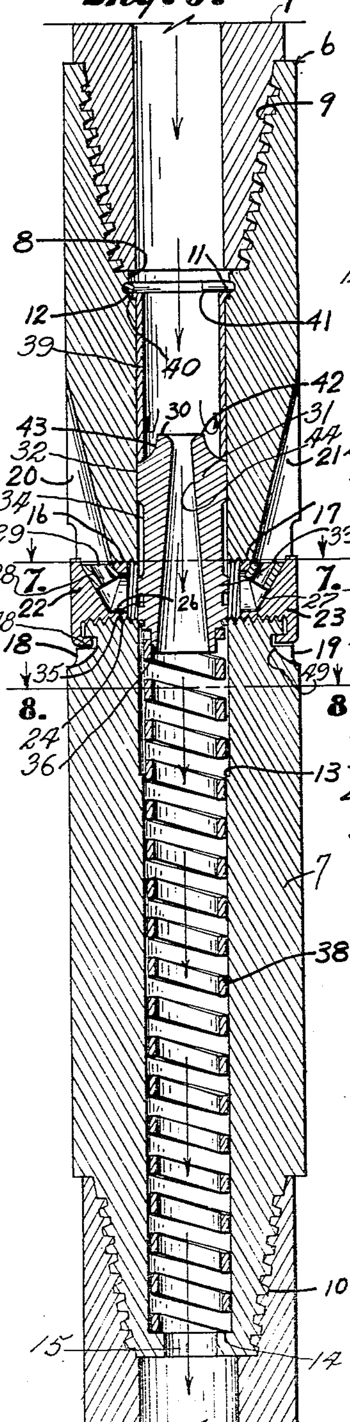

Fig. 6.

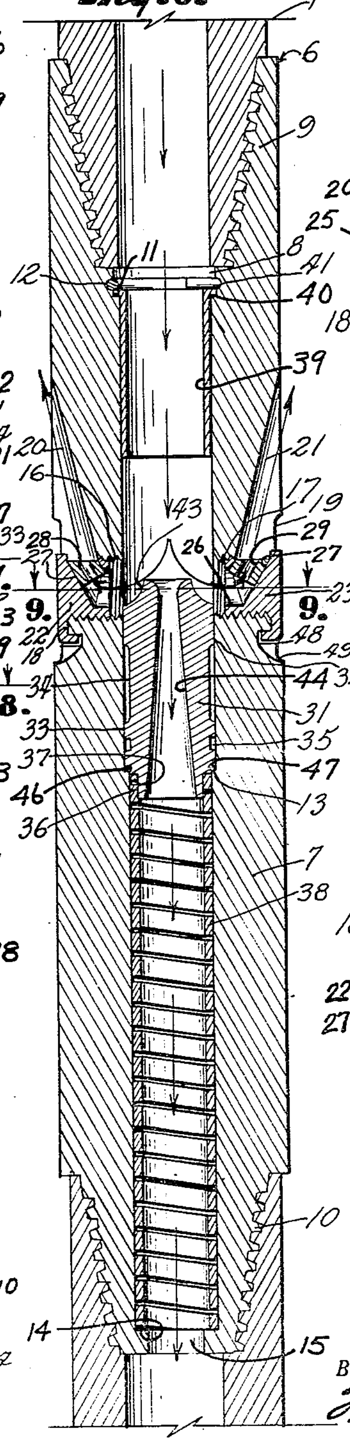

Fig. 7.

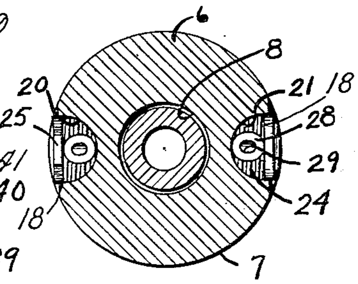

Fig. 8.

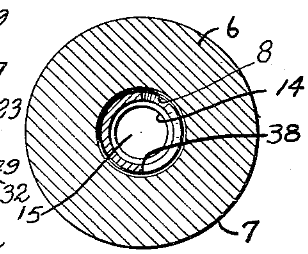

Fig. 9.

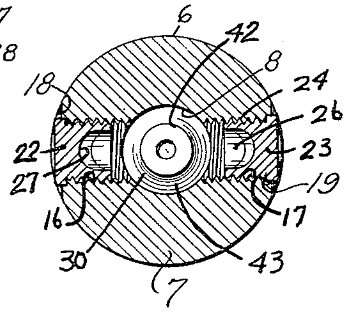

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Fig. 10.

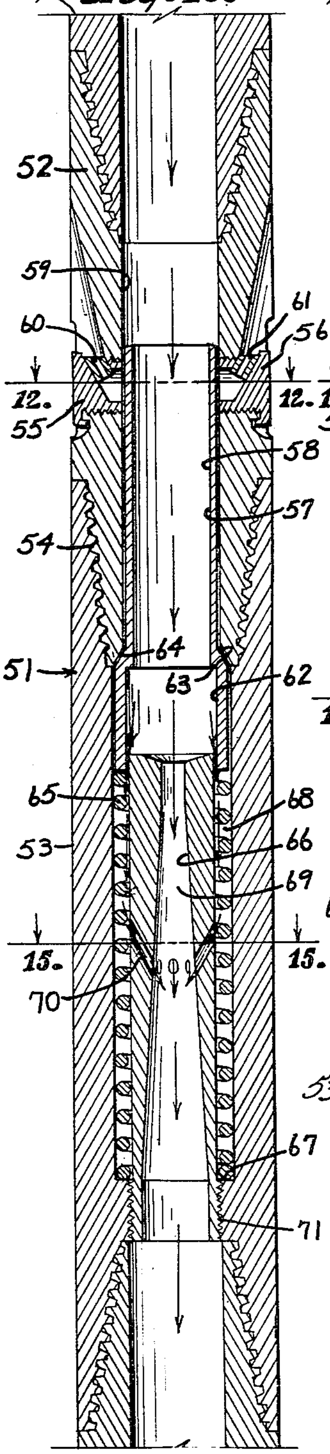


Fig. 11.

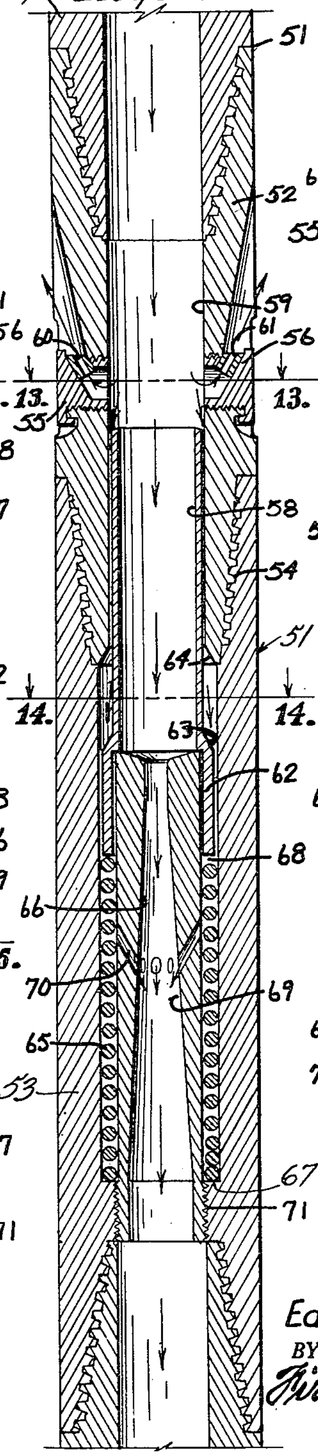


Fig. 12.

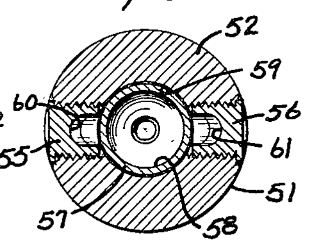


Fig. 13.

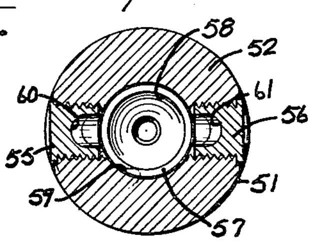


Fig. 14.

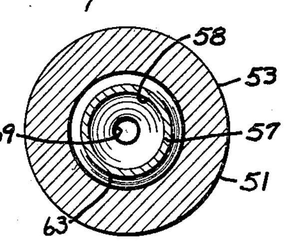
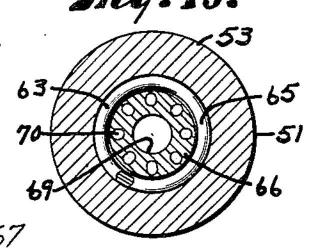


Fig. 15.



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United States Patent Office

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JETTING DEVICE FOR ROTARY DRILLING APPARATUS

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

Application February 9, 1952, Serial No. 270,809

1 Claim. (Cl. 255—24)

This invention relates to apparatus for controlling pressure and flow volume of the drilling fluid within a bore hole while the drilling fluid is under flow through the string of drill pipe and bit of a rotary well drilling mechanism, the present application being a continuation in part of my copending application on "Automatic Valve," Serial No. 678,909, filed June 24, 1946, now abandoned.

Return circulation of drilling fluid, between the string of drill pipe and the open 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 from 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 or in fact the entire production may be shut off. Another difficulty is that where oil is used in cleaning out a completed bore hole, the high pressures which are required result in a similar loss in the clean-out oil and a longer clean-out 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 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 at intervals in the string of drill pipe for discharging jets of drilling fluid into the fluid column within the bore hole to give upward lift thereto and reduce the hydrostatic pressures below the points of jetting action.

Other objects of the invention are to provide jetting devices operable automatically responsive to flow of drilling fluid through the drill bit; to provide jetting devices that are 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.

Other objects of the invention are to provide jetting devices of simple structure and free of parts that could interfere with drilling operations; to provide jet orifices with erosion resisting inserts; and to provide a simple seal about the jet control sleeve valves whereby the sleeve valves are readily responsive to pressure differential on the respective ends thereof.

In accomplishing these and other objects of the invention hereinafter pointed out, I have provided improved structure, the preferred forms of which are 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 string of drill pipe and which is supplied with a drilling fluid under sufficient 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

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jetting devices in accordance with the present invention, circulation of the drilling fluid being shown by the arrows.

Fig. 2 is an enlarged perspective view of the body portion of one of the jetting devices with portions being broken away to better illustrate the construction.

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

Fig. 4 is a perspective view of the pressure responsive sleeve valve shown in Figs. 5 and 6.

Fig. 5 is a vertical section through the assembled jetting device, showing the pressure responsive sleeve valve in position for shutting off flow through the jet nozzles.

Fig. 6 is a similar view but showing the pressure responsive sleeve valve in position to establish discharge of drilling fluid through the jet nozzles.

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. 6.

Fig. 10 is a vertical section through a modified form of the invention showing a pressure responsive sleeve valve in position for closing the jet nozzles.

Fig. 11 is a view similar to Fig. 10 but showing the pressure responsive sleeve valve in retracted position for discharge of drilling fluid through the jet nozzles.

Fig. 12 is a horizontal section on the line **12—12** of Fig. 10.

Fig. 13 is a horizontal section on the line **13—13** of Fig. 11.

Fig. 14 is a horizontal section on the line **14—14** of Fig. 11.

Fig. 15 is a horizontal section on the line **15—15** of Fig. 10.

Referring more in detail to the drawings:

1 designates a rotary drilling string made up by a plurality of drill pipe sections coupled together by tool joints, as in conventional practice. Connected to the lowermost section is a drill bit **2** for drilling a bore hole **3** in the earth's formation as when prospecting for naturel petroleum fluids. The drill pipe is rotated from above ground, and a drilling fluid is pumped into the upper end of the string of drill pipe for flow through the bit **2** to cool the bit and wash the cuttings to the top of the bore hole, the drilling fluid moving upwardly in the annular space **4**. 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 the drilling fluid and increases the time required in washing the cuttings from the bore hole. The loss of fluid also results in reduced velocity flow 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 the 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 fluid loss 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. Consequently, it is difficult to maintain a clean hole and a longer circulation is required to clean out the hole upon completion of the well.

All of the above difficulties are eliminated by providing the drililng 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 flow in the drill pipe to the fluid stream in the annular space **4** between the drilling string and the well casing or between the drilling string and the wall of the open hole 3 so as to increase the upward upflow velocity and reduce the hydrostatic pressure below the respective devices.

Each jetting device 6 comprises a cylindrical body 7 of slightly larger outer diameter than the outer diameter of the string of drill pipe and which has an axial bore 8 to connect the bores of the string of drill pipe sections to which the device connects. One end of the cylindrical body has an internally threaded box 9 and the other end is provided with a standard pin 10 that make up the respective tool joint connections of the string of drill pipe sections as best shown in Fig. 2. Formed in the bore 8 at the base of the box 9 is an annular shoulder 11 encircled thereabove by an annular groove 12 for a purpose later described. The bore 8 has a slight reduction in diameter about midway of its length to provide an annular shoulder 13, and the lower end of the bore has a shoulder 14 encircling an outlet opening 15.

The cylindrical body 7 is provided on opposite diametrical sides thereof at a point spaced above the shoulder 13 with lateral bores 16 and 17 opening outwardly through flattened faces 18 and 19. Intersecting the bores 16 and 17 are upwardly and outwardly diverging grooves 20 and 21 to clear fluid jets when they are discharged upwardly into the annular space 4 as later described.

The bores 16 and 17 are provided with internal threads for mounting jetting plugs 22 and 23. The jetting plugs are best illustrated in Fig. 3 and are shown as having externally threaded body portions 24 having polygonal shaped heads 25 by which they may be turned into the internally threaded bores 16 and 17. The inner sides of the plugs have cylindrical recesses 26 that connect the bore 8 with upwardly and outwardly directed passages 27 carrying wear-resistant inserts 28 having ports 29 of suitable size to provide discharge of drilling fluid upwardly and outwardly through the grooves 20 and 21 as shown by the arrows in Fig. 6.

In order to automatically control flow of drilling fluid through the jets, the bore 8 contains a pressure responsive valve 30 having a substantially cylindrical body 31 provided with spaced apart annular bearing portions 32 and 33 at the respective ends thereof. The bearing portions of the sleeve valve 30 are of a diameter to slide within the bore 8. The midportion 34 of the sleeve valve 30 is of reduced diameter as best shown in Fig. 4. The bearing portion 33 at the base of the sleeve valve 30 is provided with an annular fluid groove 35 which fills with liquid to form a liquid seal about the circumference of the sleeve valve 30.

Extending from the lower end of the pressure responsive sleeve valve 30 is a reduced portion 36 for forming an annular seat 37 that engages the upper end of a coil spring 38. The coil spring 38 is contained within the lower portion of the bore 8 and has its lower end seated upon the shoulder 14 as best shown in Figs. 5 and 6.

The spring thus normally retains the pressure responsive sleeve valve 30 in valving relation with the bores 16 and 17 as shown in Fig. 5 with the upper end of the sleeve valve 30 in stopped engagement with a sleeve 39 that is inserted in the upper end of the bore and which has a flange 40 seated on the upper shoulder 11. The sleeve is retained in seated position on the shoulder by means of an expansion ring 41 that is engaged in the groove 12. The upper end of the pressure responsive sleeve valve 30 has a reduced portion 42 that curves downwardly and outwardly as indicated at 43 to join with the portion 32 of the pressure responsive sleeve valve 30 and form a guiding surface whereby the downwardly flowing drilling fluid is directed outwardly through the jet plugs when the piston is in uncovering relation with the bores 16 and 17 as shown in Fig. 6.

The pressure responsive sleeve valve 30 is provided with a downwardly and outwardly tapering bore to provide a substantially venturi passageway 44 through which a portion of the drilling fluid is passed downwardly through the string of drill pipe to supply lower jets and the drill bit with drilling fluid.

The downward movement of the pressure responsive sleeve valve 30 under force of the drilling fluid is limited by contact of the base portion of the sleeve valve 30 with the internal shoulder 13 and to further seal about the sleeve valve 30 the skirt portion of the sleeve valve 30 may be provided with an annular groove 46 to contain an O ring 47 which forms a seal with the annular shoulder when the sleeve valve 30 is in depressed position as best shown in Fig. 6.

In order that the jet plugs may be locked in position, the head portions thereof may be provided with tongues 48 which after the plugs are in position, are bent inwardly to engage in recesses 49 as best shown in Figs. 5 and 6.

In assembling the jetting device, the spring is inserted into the upper end of the bore 8, followed by the sleeve valve 30. The sleeve 39 is then inserted in the upper end of the bore and retained by the locking ring 41. The jet plugs 22 and 23 having the proper size jet orifices are turned into the internally threaded bores 16 and 17 so that they may be locked in position by bending the tongues 48 into the recesses 49 as shown in Fig. 5.

One or more of the jetting devices 6 thus assembled is inserted in the drilling string at a point above the drill bit 2 and at the desired elevations at which the drilling fluid is to be jetted into the fluid of the bore hole 3, the connections being made by turning the pins 10 of the jetting devices into the box of a lower drill pipe section of the string of drill pipe and threading the pin of the next upper drill pipe section of the string of drill pipe into the box 9 of the jetting device as shown in Fig. 5. When the string of drill pipe is lowered into the well and rotated to effect drilling of the bore hole, drilling fluid is circulated downwardly through the string of drill pipe 1 and through the venturi openings 44 of the pressure responsive sleeve valves 30 to the bottom of the string of drill pipe for supplying the bit 2 and providing an upward circulation of the drilling fluid to carry the cuttings to the top of the bore hole.

The pressure responsive sleeve valves 30 restrict the flow of fluid and cooperate with the venturi-shaped bores therein to cause a pressure differential between the respective ends of the sleeve valves, but until the pressure differential overcomes the action of the springs 38, the sleeve valves 30 remain in seated position as shown in Fig. 5 and none of the drilling fluid is discharged through the jet nozzles. However, upon increase in pressure of the drilling fluid, the increased pressure acting on the upper end of the pressure responsive sleeve valves and the reduced pressure therebelow caused by increased velocity incidental to the venturi-shaped bores 44 cause the pressure responsive sleeve valves to be forced downwardly against action of the springs to uncover the jet ports whereby streams of the drilling fluid are directed upwardly and outwardly at substantially high velocity to assist in the elevation of the drilling fluid moving upwardly within the bore hole and to reduce the pressure acting on the formation at a point below the jets.

In practice the pressure responsive sleeve valves operate successively, that is, the sleeve valve 30 of the lowermost jetting device functions first and as fluid pressure increases, the next jetting device toward the upper end of the drill pipe is similarly opened and so on until all of the jetting devices are in operation. When a plurality of jetting devices are used, a stage action may be accomplished by having progressively larger orifices in the lower pressure responsive sleeve valves.

In case the drill bit 2 becomes plugged, the flow stops through the lowermost pressure responsive sleeve valve and fluid pressure is equalized thereon so that the spring 38 lifts the sleeve valve 30 and shuts off circulation at that jetting device. This action continues throughout the jetting devices toward the upper end of the drilling string until all of the jets are closed.

When the jets are in operation, the pressure of the drilling fluid on the formation is reduced to such an extent that the formation is kept free from stoppage by the cuttings.

It is also obvious that the effect is accomplished by dividing the circulation of the fluid stream between any number of points in the drilling stream depending upon the number of jetting devices used and after a predetermined amount of circulation has been started through the drill bit.

The drilling fluid discharged through the jets at substantially high velocity creates an upward lift on the column of 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 also obvious that when oil is used as the clean-out fluid as when finishing the well, the clean-out time is greatly reduced because of the increased velocity maintained incidental to operation of the jetting devices.

The hydrostatic pressure at one or more depths may be controlled through the application of additional jetting devices **6** or removal of certain of the jetting devices as the conditions may require.

In the form of the invention illustrated in Figs. 10 to 15, inclusive, the body **51** of the jetting device is composed of two sections **52** and **53** that are connected together by a threaded joint **54** to permit assembly of parts. The jet plugs **55** and **56** correspond with the jet plugs of the device previously described.

The control member **57** is of the sleeve type in that it has a sleeve portion **58** that is slidable in a bore **59** of the body section **52** to close flow through the jet orifices **60** and **61**. The sleeve type control member **57** includes a larger skirt portion **62** that forms a shoulder **63** with the sleeve portion **58** and which engages an annular seat **64** of the body section **52**. The sleeve type control member **57** is retained with the shoulder **63** thereof in engagement with the seat **64** by means of a coil spring **65** which encircles a venturi member **66** and has its lower end seating against a shoulder **67** of the lower body section **53**. The control member **57**, like the sleeve valve **30**, effectively closes the jets **60** and **61** but when displaced downwardly, as later described, it fits loosely within the bore **59** so that a portion of the drilling fluid may move downwardly to act on the shoulder **63** for supplementing the force of the drilling fluid that acts on the upper end of the sleeve portion **58**. This flow of fluid is indicated by the arrows in Fig. 11.

The skirt portion **62** of the sleeve **57** is movable in the space **68** surrounding the venturi member and is subject to a lower pressure differential that is effected responsive to flow of drilling fluid through the venturi-shaped bore **69** of the venturi member **66** by way of downwardly diverging ports **70** that are formed in the wall of the venturi member as best shown in Figs. 10 and 11. The venturi member is threadedly mounted in an internal collar **71** of the bore of the section **53**.

In this form of the invention the jets **60** and **61** operate in the same manner as the jets previously described, with the flow through the jets being normally shut off by the sleeve type control member **57**, as shown in Fig. 10, however the drilling fluid flows through the sleeve-like control member and enters the restricted end of the fixed venturi member **66** so that the drilling fluid has an increased velocity. This increase in the velocity of the fluid through the venturi member **66** produces a reduction in pressure at the port **70** and induces flow exteriorly of the venturi through the port **70**, as shown by the arrows, to maintain a low pressure on the lower end of the skirt portion **62** of the control member **57**. The pressure above the control member **57** acting on the annular upper end thereof is greater and moves the control member downwardly against action of the spring, which pressure is supplemented by the added pressure that acts on the shoulder **63** as soon as the fluid begins to pass around the exterior side of the sleeve, as shown by the arrows in Fig. **11**, therefore the sleeve valve or control member **57** is moved downwardly incidental to differential in pressure for uncovering the jet ports.

From the foregoing, it is obvious that I have provided an apparatus for controlling pressure and flow volume of the drilling fluid within a bore hole so as to maintain a lower pressure on the formation and increased flow velocity of the drilling fluids.

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

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 coupling 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 the 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, a pressure responsive sleeve valve reciprocable axially in said bore of the coupling and having a part in covering relation with said inlet in one axial position and in uncovering relation with said inlet in another axial position, said pressure responsive sleeve valve having a venturi passage extending therethrough in the axial direction thereof to pass the drilling fluid, said venturi passage having upper and lower ends with the lower end of larger diameter than the upper end to cause an increase in velocity flow of the drilling fluid in the lower end of said venturi passage for creating a differential pressure on the respective ends of the pressure responsive sleeve valve 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 a spring acting on said lower end of said pressure responsive sleeve valve for normally retaining said covering part in covering relation with said inlet of the passage, said spring being yieldable under movement of said sleeve valve responsive to said increase of the pressure of the drilling fluid above the venturi-shaped 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 venturi passage to the drill bit.

References Cited in the file of this patent

UNITED STATES PATENTS

1,241,813	Bignell	Oct. 2, 1917
2,108,955	Zublin	Feb. 22, 1938
2,128,352	Creighton	Aug. 20, 1938
2,227,545	Haslam	Jan. 7, 1941
2,239,586	Appleby	Apr. 22, 1941
2,312,018	Beckman	Feb. 23, 1943
2,556,829	Teague	June 12, 1951
2,634,101	Sloan	Apr. 7, 1953

FOREIGN PATENTS

201,368	Germany	Dec. 6, 1907