

June 14, 1955

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2,710,741

APPARATUS FOR DRILLING OR HOLE TESTING

Filed July 28, 1950

5 Sheets-Sheet 1

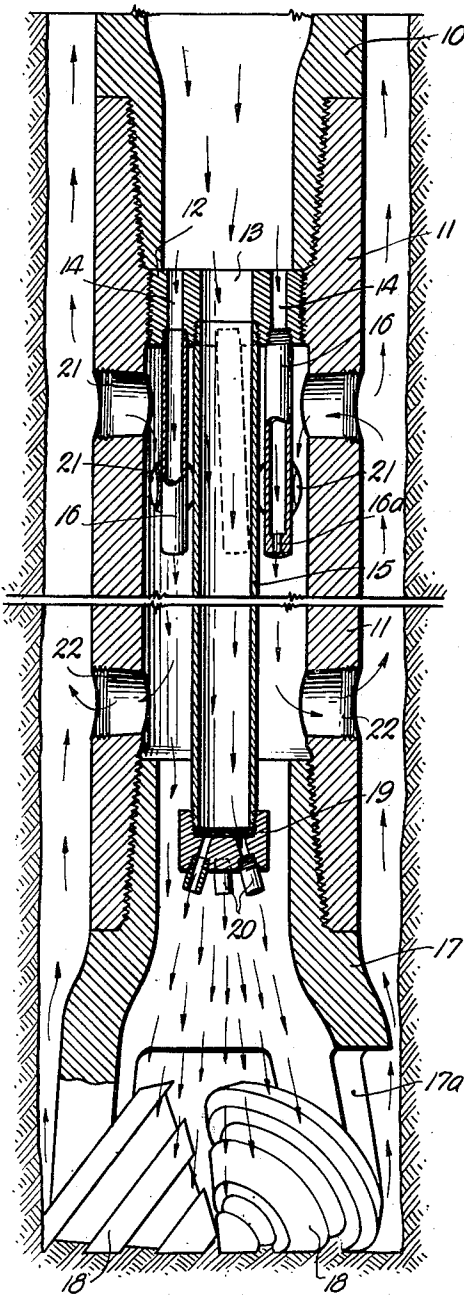


Fig. 1.

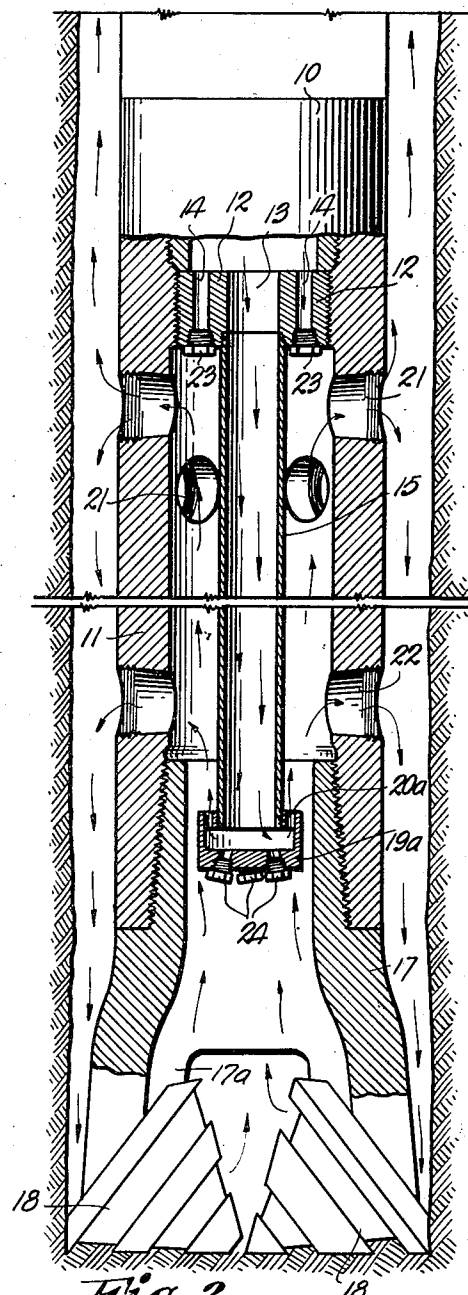


Fig. 2.

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5 Sheets-Sheet 2

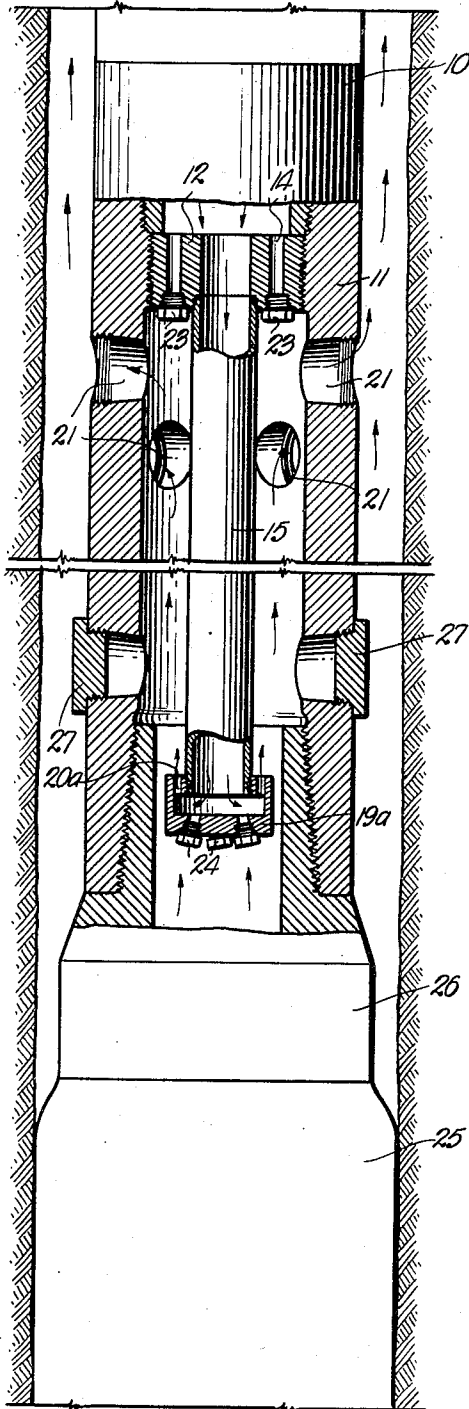


Fig. 3.

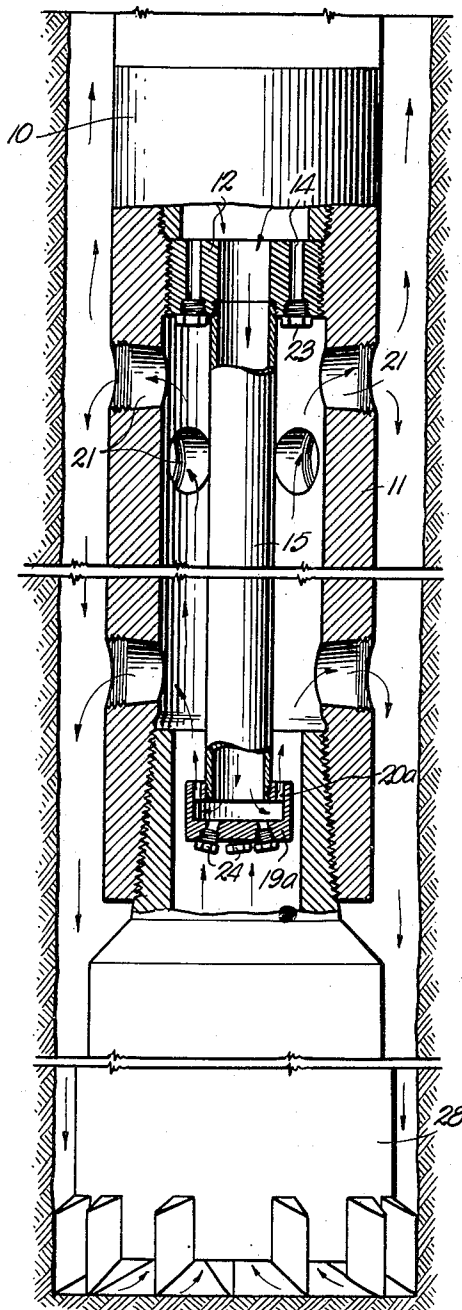


Fig. 4.

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5 Sheets-Sheet 3

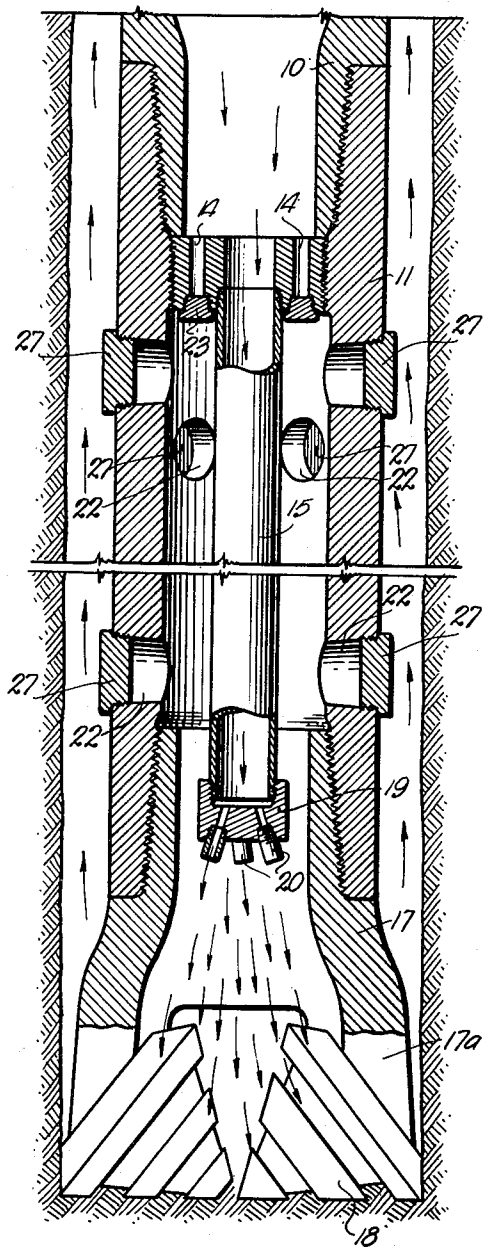


Fig. 5.

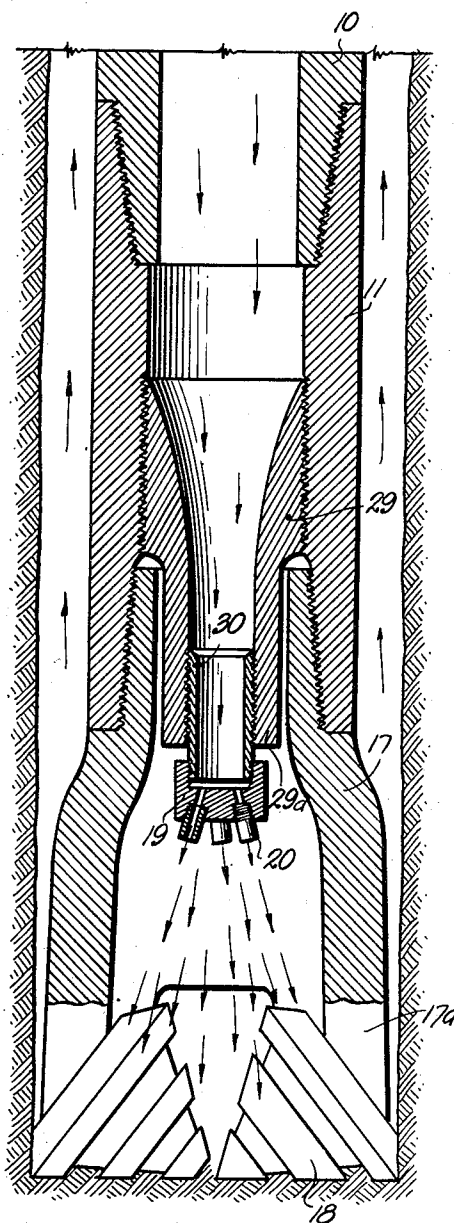


Fig. 6.

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5 Sheets-Sheet 4

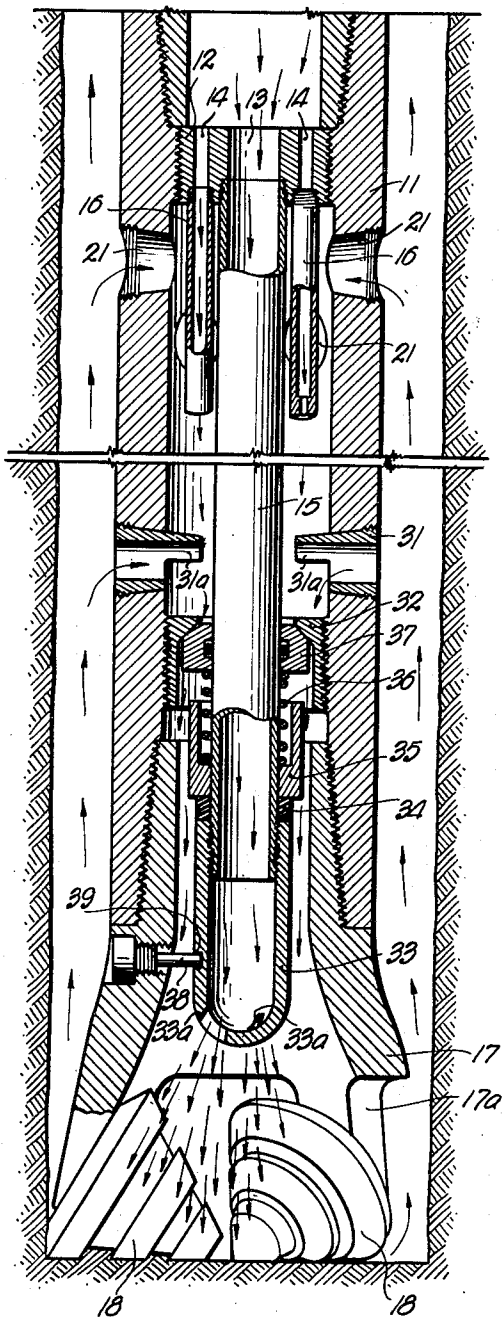


Fig. 7.

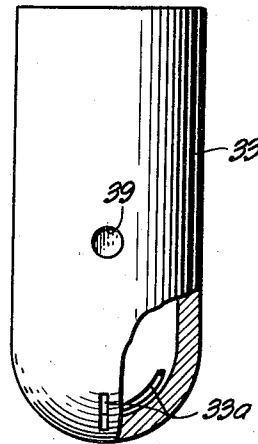


Fig. 8.

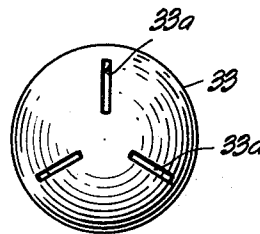


Fig. 9.

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APPARATUS FOR DRILLING OR HOLE TESTING

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5 Sheets-Sheet 5

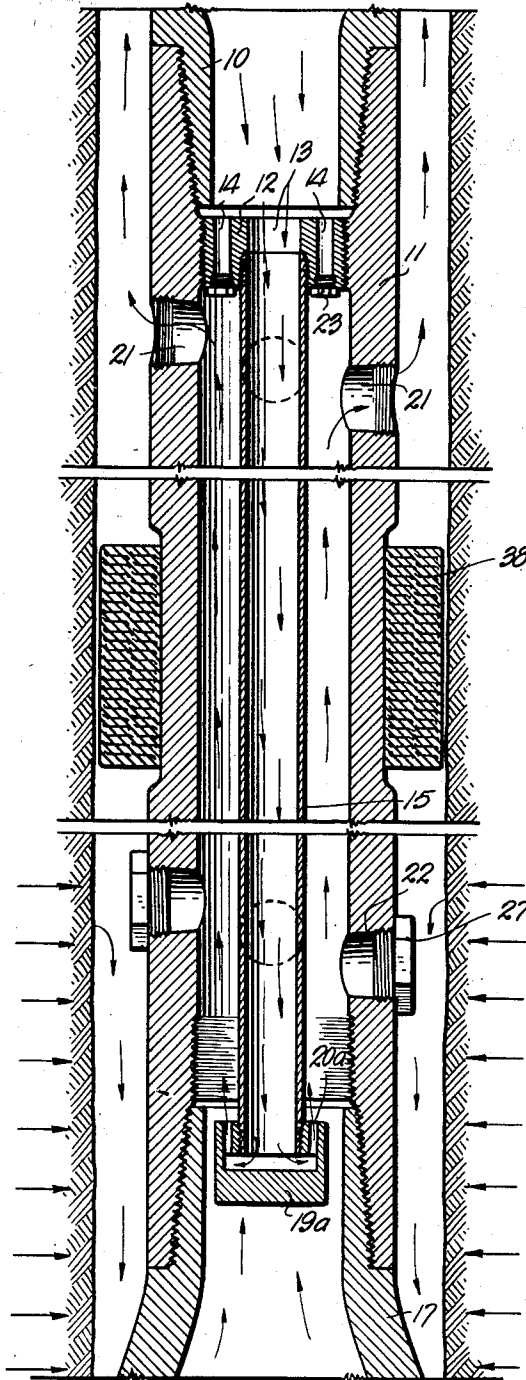


Fig. 10.

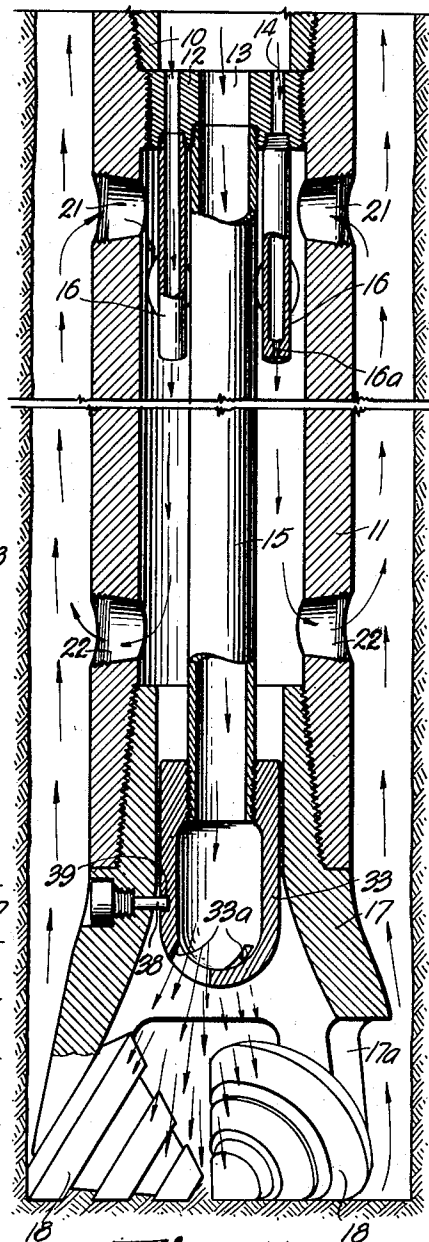


Fig. 11.

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APPARATUS FOR DRILLING OR HOLE TESTING

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Application July 28, 1950, Serial No. 176,351

21 Claims. (Cl. 255—314)

This invention relates to improvements in well drilling practice, hole testing, and apparatus used therefor, and refers more particularly to a means of drilling in which local circulations of the drilling mud or drilling fluid and cuttings take place in the vicinity of the drill bit to break up, disintegrate, and reduce the particle size of the cuttings and more effectively lubricate and clean the cutting edges of the bit. The circulation in the vicinity of the bit can also control the fluid drawn from the formation or from the hole below the bit for testing purposes or to remove junk from the hole.

An object of the invention, therefore, is to provide a means of drilling which to a great extent eliminates balling up of the bit.

Another object is to provide an operation whereby pump pressures upon the drilling fluid may be considerably reduced with an increase of fluid circulation at or about the cutting surfaces of the bit.

A further object is to provide disintegration of the cuttings in the vicinity of the bit, thus facilitating the combining of the cuttings with the drilling fluid. The cuttings, in the form of a suspensoid, are then more easily removed from the hole.

A still further object is to provide jetting of the drilling fluid upon the cutters at a more efficient cleaning angle by means of an adjustable spray head, and to provide a means for testing the well fluids without completely shutting down drilling operations.

In the drawings, which show different embodiments of the invention, like parts in the various views have been designated by corresponding numbers.

Fig. 1 is a cross sectional view of the lower end of a drill pipe with a sub and bit assembled for normal drilling operations.

Fig. 2 is a cross sectional view similar to that of Fig. 1 excepting reverse circulation of the fluid about the cutters.

Fig. 3 is a cross sectional view of a modification used with a packer for producing or testing a formation.

Fig. 4 is another modification utilizing the drilling sub as a fishing tool.

Fig. 5 is a cross sectional view of the assembly eliminating local circulation and with the jets for cleaning the bit attached to a pipe extending through the sub instead of the bit housing.

Fig. 6 is a further modification showing a drilling operation similar to that shown in Fig. 5 with an insert supporting the jet assembly within the sub in place of a vertical tube.

Fig. 7 is another modification with local circulation through the sub and an adjustable spray head and valve mechanism controlling the circulation through the sub and bit.

Fig. 8 is an enlarged detail of the spray head.

Fig. 9 is a lower end view of the spray head shown in Fig. 8.

Fig. 10 is a cross sectional view in which the sub is used as a progressive testing tool.

Fig. 11 is a modification similar to that shown in Fig. 7 with an enlarged nozzle substantially closing the upper throat or passageway through the bit.

Referring to the drawings, and particularly Fig. 1, at 10 is shown the lower tool joint of a drill pipe. To this is screwed a cylindrical sleeve or sub 11. Besides being threaded to engage the threads of the drill pipe, the upper portion of the sub is internally threaded to receive a bushing 12. Through the center of the bushing is an enlarged passageway 13, and at equally spaced intervals around the central duct are a plurality of smaller passageways 14. The central duct 13 and the smaller passageways 14 are threaded below, and into these threaded ducts are screwed to a large central pipe 15 and smaller pipes 16, the latter terminating in restricted jet openings 16a. The lower extremity of the central pipe 15 extends into the body 17 of the drill bit. The drill bit body is externally threaded to be screwed into the lower end of the sub. On the lower arms 17a of the bit are mounted cones 18 which rotate with the drill pipe and sub during drilling of the well. Screwed onto the lower extremity of pipe 15 is a spray head 19 drilled and tapped to receive jets 20. The jets are so arranged with respect to the cones that the drilling fluid passing down through the central pipe 15 is sprayed onto the cone surfaces to remove cuttings therefrom and lubricate the bit during drilling. In the wall of the sub, between the upper bushing 12 and the drill bit body 17, are two sets of holes. The upper set, numbered 21, is equally spaced about the circumference of the sub body. A similar set of holes is drilled in the wall of the sub just above the top of the drill bit body. These holes have been numbered 22 in the drawings. The purpose of these apertures is to permit circulation of the drilling fluid through the wall of the sub and through the body of the sub to augment the passage of drilling fluid discharged through pipe 15 and pipes 16. This secondary or local circulation through the body of the sub and the annular space between the sub and the well bore disintegrates the cuttings rising in the hole with the drilling fluid and puts the cuttings in a condition to be more easily removed from the well. The passage of fluids through and about the sub and bit assembly is briefly as follows: the drilling fluid passing downwardly through pipe 10 is discharged under high pressure from the jets 20 onto the cones of the bit. At the same time a portion of the fluid is discharged through pipes 16 and restricted jets 16a into the annular space between the pipe 15 and the inner wall of the sub. This fluid likewise passes into the drill bit and onto the cones, but in doing so it creates a zone of lower pressure within the sub body around the pipes 16 drawing in well fluid from the annulus surrounding the body of the sub. Drilling fluid is drawn into the sub through openings 21 and a portion of the fluid is discharged through openings 22. Thus there is provided a downward flow at high pressure of a large volume of drilling fluid through the body of the sub and bit, and an upward flow of drilling fluid around the sub and bit, as well as a secondary circulation of fluid into the sub body through openings 21, and a discharge of fluid through openings 22. The disintegrating force of jets 16a upon cuttings which pass through the sub body reduces the size of the particles and puts them in condition to be more readily suspended in the rising column of fluid which transfers the cuttings from the drill bit to the surface.

In the assembly shown in Fig. 2, the arrangement of the sub, the bit, and central bushing 12 with its discharge pipe 15, is the same as in Fig. 1. In this modification, however, ducts 14 through bushing 12 have been closed by screw plugs 23, and spray head 19 has

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been replaced by a different type of head designated by the numeral 19a. The spray head 19a has the ducts through its bottom closed by screw plugs 24. The interior of the head is hollowed out to form a chamber with discharge holes 20a drilled in the spray head surrounding the lower extremity of pipe 15. In drilling with this assembly there is a reverse circulation of the drilling fluid as compared with the fluid circulation shown in Fig. 1. In other words, the fluid passing down through the drill pipe is directed into pipe 15 and is discharged from the spray head upwardly into the body of the sub. This draws the drilling fluid from the annular space surrounding the sub and drill bit upwardly around the cones and into the body of the bit. The jetting action of spray nozzles 20a causes the fluid to pass upwardly into the sub body and out through holes 21 and 22. In this fashion there is created a circulation of drilling fluid upward above the holes 21 in the annular space surrounding the sub and drill pipe, and downward in this annular space below the holes 21. At the same time, the flow around the cones is from the annulus surrounding the bit and into the body of the bit, thence upward into the sub body due to the jetting action of the upwardly directed spray nozzles 20a in the head 19a.

The flow of fluid upward from the bit into the sub body carries cuttings with it; the cuttings are disintegrated as they pass through the high velocity stream jetted from spray head 19a. Cuttings are recirculated until they are small enough to be easily carried upwardly by the slow moving fluid in the annulus between the drill pipe and the well bore.

Fig. 3 indicates the sub mounted at the lower extremity of the drill pipe with a packer 25 located on a sleeve 26 screwed into the bottom of the sub. Here the sub assembly is used for testing the well fluid or the formation fluid below the packer. As in Fig. 2, holes 14 in bushing 12 are plugged and the lower holes 22 in the sub body are closed by means of plugs 27. Spray nozzle 19a jetting upwardly is attached to the lower extremity of pipe 15.

In operation, the drilling fluid or testing fluid flows downwardly in the internal bore of the drilling stem, or pipe 10, thence through pipe 15 where it is jetted upwardly into the interior of the sub. The jetting action creates a low pressure area in the sub body and in the area immediately below the spray head 19a. This induces flow from the formation upward through the body of the sub, out through holes 21, and upward to the surface in the annulus surrounding the drill pipe. At the surface, the fluid is collected in tanks or in mud vats and its characteristics determined.

In Fig. 4, the assembly is used as a fishing tool with a junk basket 28 screwed into the lower end of the sub. Here again, ducts 14 in the bushing 12 are plugged and spray head 19a is affixed to the lower extremity of pipe 15. The drilling fluid is pumped as before, downwardly through central pipe 15 and jetted from the holes 20a upwardly into the body of the sub. Again a low pressure area is created below the spray head 19a creating a circulation upward through the junk basket 28 and downward in the annular space surrounding the junk basket. Since the flow of fluid is upward into the bottom of the junk basket, metal parts or accumulated junk in the hole will rise and collect in the basket. Part of the fluid discharged and drawn into the sub body from below passes out through holes 21 and thence up the hole, while a portion of that discharged through these holes will be recirculated downwardly in the space surrounding the sub. Fluid discharged through holes 22, to a great extent, will be circulated downwardly and drawn into the junk basket by the action of the jets.

In Fig. 5 the sub and bit assembly is adapted for conventional drilling. Again, ducts 14 are plugged, as

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are holes 21 and 22 in the wall of the sub. The spray head 19a has in this modification been replaced by the spray head 19, as shown in Fig. 1, so that the fluid passing through the drill pipe into pipe 15 is discharged through jets 20 directly onto the cones. Circulation of the fluid from the bottom of the drill bit is upward in the annular space surrounding the bit, sub and drill pipe.

The high velocity fluid from the jets impinges upon the surface of the cutters in such a manner as to peel off and reduce the size of the cuttings. It will be noted that the nozzles which direct the fluid against the cutters are an integral part of the sub and are not connected to the body of the drilling bit. Thus there is less likelihood of the fluid passageways being clogged than in the conventional type bit relying upon ducts formed in the body of the bit.

Fig. 6 is a modification of the assembly shown in Fig. 5. Here the sub 11 is shown as a solid sleeve screwed onto the bottom tool joint of the drill pipe with an improved type of bit threaded into the lower end of the sub. Above the thread for the bit body is an internally threaded section of the sub body into which is screwed an insert 29. This insert has an appending tubular portion 29a into which is screwed a nipple 30. Onto the lower extremity of the nipple is attached spray head 19. The drilling fluid, as before, is pumped downwardly through the internal bore of the drill pipe, sub, and insert, and discharged from the jets in the bottom of head 19. These jets are set so that the fluid will clean the cutting elements 18, and carry the cuttings to the surface in the annular space surrounding the drill pipe, as in conventional drilling operations. In this modification, as in the assembly shown in Fig. 5, the spray nozzle supplying fluids to the cutting elements is a part of the sub and not merely ducts through the body of the bit.

The modification shown in Fig. 7 provides a sub 11 similar to that shown in Fig. 1. Jet pipes 16 direct a portion of the drilling fluid into the body of the sub surrounding the central pipe 15. Apertures 21 in the upper portion of the sub are open. Shown screwed into the lower apertures 22 are bushings 31 with visor extensions 31a protruding into the annulus surrounding pipe 15. (These bushings are not essential to the operation of the invention; they may be used if desired as they are easily replaced should they become worn from the passage of fluid through them.) Onto the extremity of pipe 15 is attached spray head 33, detailed in Figs. 8 and 9. Slots 33a in the bottom of the head are arranged to distribute the fluid onto the cutting elements so that cuttings will be peeled from the cutters as they rotate. To properly adjust the spray head with respect to the cutters, a pin 38 is screwed through one leg of the bit and seats in an aperture 39 in the surface of the spray head. The lower portion of the sub is internally threaded above the bit body to receive valve seat 32. On the shoulder formed by the top of the spray head is a rubber ring 34, and above the ring is a spring retention cup 35. Within the cup is a coil spring 36 whose lower end seats in the cup and upper end within the valve.

In operation, a major portion of the drilling fluid passing downwardly through the drill pipe is discharged from slots 33a in the spray head onto the cones. That part of the fluid jetted through ducts 14 and pipes 16 passes through the body of the sub and by valve 37 to join the fluid being sprayed from head 33 in the body of the bit. The reduced pressure area created within the sub by the flow of fluid through jets 16a draws liquid from the annulus surrounding the sub through holes 21 and restricted openings in the bushings or beans 31. Besides this circulation downward through the sub and drill bit body, there is upward circulation of fluid in the annulus surrounding the assembly and drill pipe. If, for any reason, the cutting elements become balled

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up and the fluid attempts to flow upward through the body of the bit, the valve 37 will seat and the upward flow will be shut off. Under these conditions, the flow of drilling fluid will be principally through central pipe 15, since the passage of the fluid through the body of the sub has been checked by closure of the valve 37. The high velocity jetting action of the fluid from the spray head 33 will rapidly remove the material collected in the body of the bit and the cuttings accumulated on the cutting surfaces of the cones. After valve 37 is closed, circulation above the valve is downward within the body of the sub due to the jet action of pipes 16 into the annulus between the sub and well bore through bushings 31, thence upward in the direction shown by the arrows and back into the body of the sub through holes 21. The disintegrating action of the jets 16a, and the high velocity circulation set up by these jets, rapidly disintegrates the cuttings which had accumulated around the drill bit and balled up the cutting elements. After the cones and bit body are flushed of cuttings, the pressure in the area below the valve will be reduced. The valve will open and normal circulation will be resumed when the pressure of the fluid above becomes greater than that below the valve.

The rubber actuating ring 34 is compressed when the valve is open. When the pressure of the fluid below the valve approaches that of the fluid above, the resiliency of the ring serves to start the upward movement of the retainer cup and closing of the valve.

Fig. 10 shows the drilling sub 11 equipped with a packing marked 38, to be used for testing formations while the drilling operation is momentarily interrupted. Packing 38 is installed on the outside of the sub relatively equidistant from the top and bottom of the sub. The outside diameter is slightly smaller than the diameter of the well bore to allow drilling fluid to bleed by while drilling is in progress. It will be noted from the figure that the drilling is conducted in this modification will reverse circulation, similar to that shown in Fig. 2. Ducts 14 in bushing 12 are closed with plugs 23, the upper apertures 21 in the sub body are open and the lower apertures 22 are closed by means of plugs 27. Spray head 19a is employed to jet the drilling fluid upwardly through the annulus surrounding pipe 15, so the fluid is discharged through holes 21 and then rises to the surface in the annular space surrounding the drill pipe. A low pressure area is created below the spray head causing fluids from the formation to flow into the annular space below the packing 38 and into the sub below the spray head. Since the packing 38 restricts the flow between the annulus above and below the packing, the pressure below drops as the fluid flows through the cutting elements of the bit. The pressure in the annulus below the packing can be varied by varying the flow of drilling fluid through pipe 15, which is accomplished by varying the mud pump pressure and the velocity and pressure of the fluid discharged from the orifices 20a in the spray head.

It will be seen that when the pressure in the annulus below the packing 38 is reduced below that of the formation fluid, flow will be created from the formation into the annulus. An analysis of the drilling fluid upon its return to the surface will then indicate the presence or lack of gases or fluids in the formation being tested. To resume drilling operation, the pump pressure is reduced so that the bleed by the packing 38 becomes sufficient to increase the pressure in the annulus below the packing and shut off the flow from the formation. The pump pressure is maintained at a value sufficient to furnish circulation around the cutting elements but not enough to cause a pressure drop in the annulus below the packing.

The operation shown in Fig. 11 is somewhat comparable to that shown in Fig. 7 with the valve 37 closed. In Fig. 11 the diameter of the spray nozzle 33 has been

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enlarged to substantially the inner diameter of the passageway through the bit. Consequently, there is a passage of drilling fluid directly from the drill pipe through pipe 15 and out of the slots 33a of head 33 onto the cones. A local circulation is set up in the sub body annulus and the annulus between the well bore and sub body. This latter circulation is created by jets 16a discharging fluid downwardly through the sub body annulus, out through holes 22 and back into the sub body through the upper holes or apertures 21. The circulation through the sub body disintegrates the cuttings and renders them more readily suspendable in the fluid passing to the surface.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth together with other advantages which are obvious and which are inherent to the invention.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. A sub and bit assembly comprising a hollow body adapted to be mounted at the lower end of a rotary drill pipe, a tubular member of smaller diameter than the internal diameter of the sub body positioned within said body and having communication with the drill pipe, an upwardly jetting discharge nozzle at the lower extremity of the tubular member, closable apertures in the upper and lower wall of the sub body, a hollow open-ended member attached to the bottom of the sub body, and packing means in the well bore annulus adjacent the sub body providing upward circulation through the open-ended member and sub body and well bore annulus above said packing means.

2. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end, a vertically elongated duct within said body communicating at its upper end with said drill pipe to receive fluid therefrom and having a discharge opening at its lower end, the outside diameter of said duct being smaller than the inside diameter of the sub body to provide an annular chamber between the two, said sub body being perforated in the region above the level of said discharge opening to provide passageways extending laterally from said chamber to the space outside the sub body, and means for closing the perforations in said sub body at will.

3. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end, a vertically elongated duct within the body communicating at its upper end with said drill pipe to receive fluid therefrom and having a discharge opening at its lower end, the outside diameter of said duct being smaller than the inside diameter of the sub body to provide an annular chamber between the two, said sub body being perforated above the level of said discharge opening to provide passageways extending laterally from said chamber to the space outside the sub body, and said discharge opening being constructed and arranged to jet fluid upwardly therefrom into said annular chamber.

4. A sub assembly as in claim 3 having an annular packing encircling said sub body above the lower end thereof but below the level of said perforations to substantially seal against the wall of the well bore.

5. A sub assembly for a rotary drill pipe compris-

ing a vertically elongated hollow sub body extending downwardly from the lower end of the drill pipe, means including a vertically elongated member within said body forming with the interior of the body an annular chamber closed at its upper end and open at its lower end, a vertical passageway in said member communicating at its upper end with the drill pipe to receive fluid therefrom and having a discharge opening at the lower end of said member, said discharge opening being above the level of the lower end of said sub body, said sub body being perforated in the region above the level of said discharge opening to provide passageways extending laterally from the chamber to the space outside the sub body, and means for closing the perforations in said sub body at will.

6. A sub assembly for a rotary drill pipe comprising a vertically elongated hollow sub body extending downwardly from the lower end of the drill pipe, means including a vertically elongated member within said body forming with the interior of the body an annular chamber closed at its upper end and open at its lower end, a vertical passageway in said member communicating at its upper end with the drill pipe to receive fluid therefrom and having a discharge opening at the lower end of said member, said discharge opening being above the level of the lower end of said sub body, said sub body being perforated in the region above the level of said discharge opening to provide passageways extending laterally from the chamber to the space outside the sub body, and said discharge opening being constructed and arranged to jet fluid upwardly therefrom into said annular chamber.

7. A sub assembly as in claim 6 having an annular packing encircling said sub body above the lower end thereof but below the level of said perforations to substantially seal against the wall of the well bore.

8. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end and also being perforated in two restricted regions, both spaced above said lower end, thereby to provide lateral passageways between the interior and exterior of the body, one of said perforated regions being spaced above the level of the other and said body being imperforate in the intermediate zone between the two regions, a fluid barrier in said sub body positioned above the upper perforated region and closing off from the interior of the drill pipe the portion of the sub body below said barrier, a pipe carried by said barrier and extending downwardly therefrom within the sub body, said pipe communicating at its upper end with the space above the barrier to receive fluid from the drill pipe and having a discharge opening positioned at a level intermediate said upper and lower perforated regions.

9. A sub assembly as in claim 8 having means for closing the perforations in either one of said perforated regions selectively.

10. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end and also being perforated in two restricted regions, both spaced above said lower end, thereby to provide lateral passageways between the interior and exterior of the body, one of said perforated regions being spaced above the level of the other and said body being imperforate in the intermediate zone between the two regions, a fluid barrier in said sub body positioned above the upper perforated region and closing off the interior of the drill pipe from the portion of said sub body below the barrier, conduit means carried by said barrier and extending downwardly therefrom within the sub body, said conduit means communicating at its upper end with the space above said barrier to receive fluid from the drill pipe, and said conduit means having a plurality of

fluid discharge openings positioned at a level intermediate said upper and lower perforated regions.

11. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end and also being perforated in two restricted regions both spaced above said lower end thereby to provide lateral passageways between the interior and exterior of the body, one of said perforated regions being spaced above the level of the other and said body being imperforate in the intermediate zone between the two regions, a fluid barrier in said sub body positioned above the upper perforated region and closing off the interior of the drill pipe from the portion of said sub body below the barrier, conduit means carried by said barrier and extending downwardly therefrom within the sub body, said conduit means communicating at its upper end with the space above said barrier to receive fluid from the drill pipe, said conduit means having a plurality of fluid discharge openings positioned at a level intermediate said upper and lower perforated regions, and said conduit means also having a fluid discharge opening positioned at a level intermediate the lower perforated region and the lower extremity of the sub body.

12. A sub assembly as in claim 11 wherein said last discharge opening is constructed and arranged to jet fluid upwardly therefrom within the sub body.

13. A sub assembly as in claim 11 having an upwardly closing check valve within said sub body at a level intermediate said last discharge opening and said lower perforated region, and a fluid barrier including said valve sealing off the interior portion of said sub body above said last level from the portion below when said valve is closed.

14. A sub and bit assembly comprising a hollow sub body adapted to be mounted at the lower end of a rotary drill pipe, a tubular member of smaller diameter than the internal diameter of the sub body positioned within said body and having communication with the drill pipe, a discharge opening in the lower end of the tubular member, an upper set of apertures and a lower set of apertures in the sub body forming lateral fluid passageways between the annulus formed by the well bore exteriorly of the sub body and the annulus within the sub body surrounding the tubular member, a bit attached to the lower end of the body having a vertical passageway therethrough communicating with the inner sub body annulus surrounding the tubular member, and supplemental nozzles having communication with the drill pipe and adapted to jet fluid therefrom into the upper portion of the sub body above the level of the discharge opening in the lower end of the tubular member, thereby to set up a secondary circulation through the sub body.

15. A sub and bit assembly comprising a hollow sub body adapted to be mounted at the lower end of a rotary drill pipe, a tubular member of smaller diameter than the internal diameter of the sub body positioned within said body and having communication with the drill pipe, an upper set of apertures and a lower set of apertures in the sub body forming lateral fluid passageways between the annulus formed by the well bore exteriorly of the sub body and the annulus within the sub body surrounding the tubular member, a bit attached to the lower end of the sub body having a vertical passageway therethrough communicating with the inner sub body annulus surrounding the tubular member, and an upwardly directed nozzle at the lower extremity of the tubular member adapted to set up an upward flow of fluid through the bit and sub body annulus and a downflow circulation in the well bore annulus surrounding the sub body and bit.

16. A sub and bit assembly comprising a hollow sub body adapted to be mounted at the lower end of a rotary drill pipe, a tubular member of smaller diameter than the internal diameter of the sub body positioned within said body and having communication with the

drill pipe, a discharge opening in the lower end of the tubular member, an upper set of apertures and a lower set of apertures in the sub body forming lateral fluid passageways between the annulus formed by the well bore exteriorly of the sub body and the annulus within the sub body surrounding the tubular member, a bit attached to the lower end of the body having a vertical passageway therethrough communicating with the inner sub body annulus surrounding the tubular member, and and upwardly seating valve between the sub body annulus and the bit passageway.

17. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end, a vertically elongated duct within said body communicating at its upper end with said drill pipe to receive fluid therefrom and having a discharge opening at its lower end, the outside diameter of said duct being smaller than the inside diameter of the sub body to provide an annular chamber between the two, said sub body being perforated in two restricted regions, both spaced above the level of said discharge opening, thereby to provide passageways extending laterally from said chamber to the space outside the sub body, one of said perforated regions being spaced above the level of the other, said sub body being imperforate in the region between said two perforated regions, the length of said imperforate region in an axial direction being greater than the diameter of said perforations, and means for closing the perforations in either one of said perforated regions selectively.

18. A sub assembly for a rotary drill pipe, comprising a tubular sub body extending downwardly from the lower end of the drill pipe, said body being open at its lower end, a vertically elongated duct within said body communicating at its upper end with said drill pipe to receive fluid therefrom and having a discharge opening at its lower end, the outside diameter of said duct being smaller than the inside diameter of the sub body to provide an annular chamber between the two, said sub body being perforated in two restricted regions, both spaced above the level of said discharge opening, thereby to provide passageways extending laterally from said chamber to the space outside the sub body, one of said perforated regions being spaced above the level of the other, said sub body being imperforate in the region between said two perforated regions, the length of said imperforate region in an axial direction being greater than the diameter of said perforations, and each of the perforations in one of said regions having above it a generally horizontal shroud located within said chamber.

19. A sub assembly for a rotary drill pipe, comprising a vertically elongated hollow sub body extending downwardly from the lower end of the drill pipe, means including a vertically elongated member within said body forming with the interior of the body an annular chamber closed at its upper end and open at its lower end, a vertical passageway in said member communicating at its upper end with the drill pipe to receive fluid therefrom and having a discharge opening at the lower end of the member, said discharge opening being above the level of the lower end of the sub body, said sub body being perforated in two restricted regions, both spaced above the level of said discharge opening, thereby to provide passageways extending laterally from said chamber to the space outside the sub body, one of said

perforated regions being spaced above the level of the other, said sub body being imperforate in the region between said two perforated regions, the length of said imperforate region in an axial direction being greater than the diameter of said perforations, and means for closing the perforations in either one of said perforated regions selectively.

20. A sub assembly for a rotary drill pipe, comprising a vertically elongated hollow sub body extending downwardly from the lower end of the drill pipe, means including a vertically elongated member within said body forming with the interior of the body an annular chamber closed at its upper end and open at its lower end, a vertical passageway in said member communicating at its upper end with the drill pipe to receive fluid therefrom and having a discharge opening at the lower end of the member, said discharge opening being above the level of the lower end of the sub body, said sub body being perforated in two restricted regions, both spaced above the level of said discharge opening, thereby to provide passageways extending laterally from said chamber to the space outside the sub body, one of said perforated regions being spaced above the level of the other, said sub body being imperforate in the region between said two perforated regions, the length of said imperforate region in an axial direction being greater than the diameter of said perforations, and each of the perforations in one of said regions having above it a generally horizontal shroud located within said chamber.

21. A sub and bit assembly comprising a hollow sub body adapted to be mounted at the lower end of a rotary drill pipe, a tubular member of smaller diameter than the internal diameter of the sub body, positioned within said sub body and having communication with the drill pipe, a discharge opening in the lower end of the tubular member, an upper set of apertures and a lower set of apertures in the sub body forming lateral fluid passageways between the annulus formed by the well bore exteriorly of the sub body and the annulus within the sub body surrounding the tubular member, a bit attached to the lower end of the body having a vertical passageway therethrough communicating with the inner sub body annulus surrounding the tubular member, and means for closing either the upper set of apertures or the lower set of apertures selectively.

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