

Oct. 24, 1961

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3,005,507

FLUID BY-PASS FOR ROTARY DRILL BITS

Filed Sept. 30, 1957

4 Sheets-Sheet 1

FIG. 1.

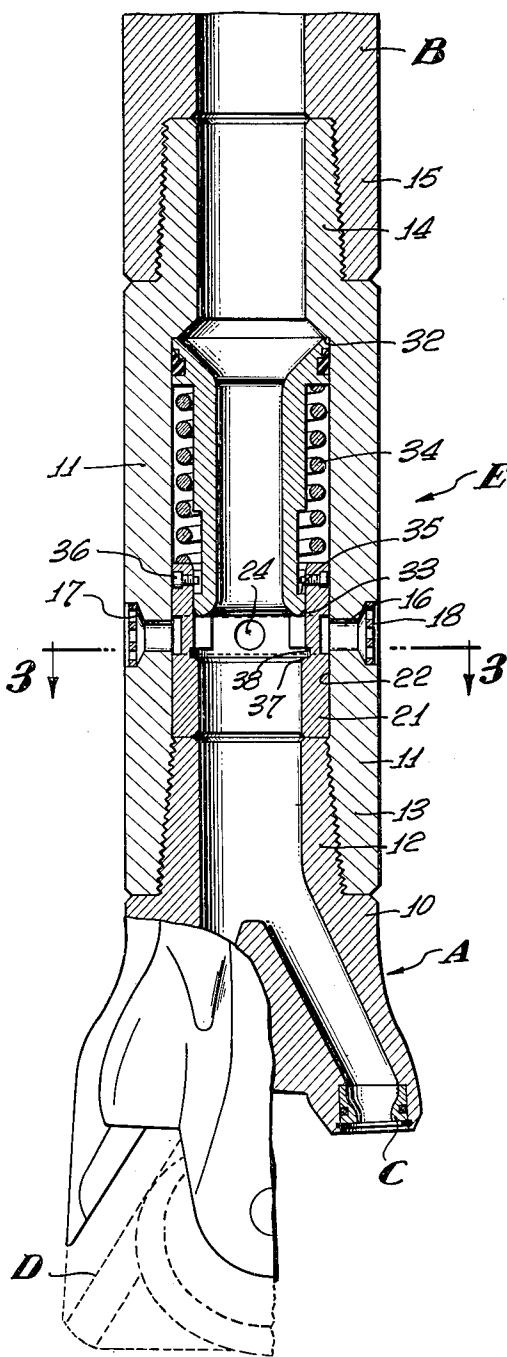


FIG. 2.

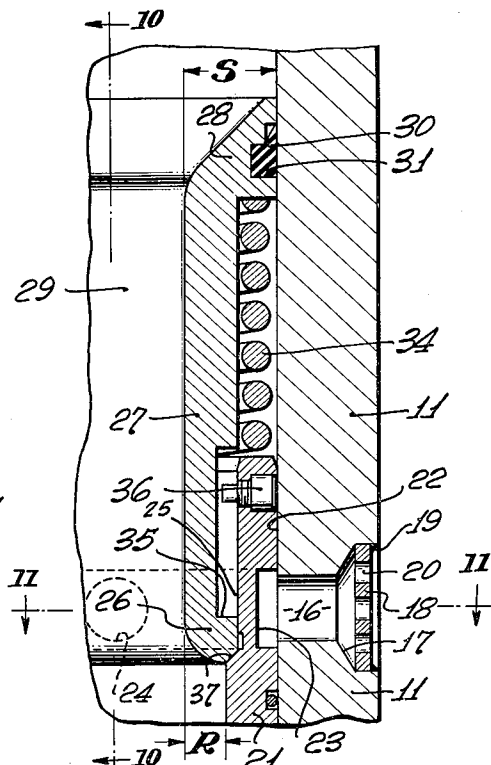
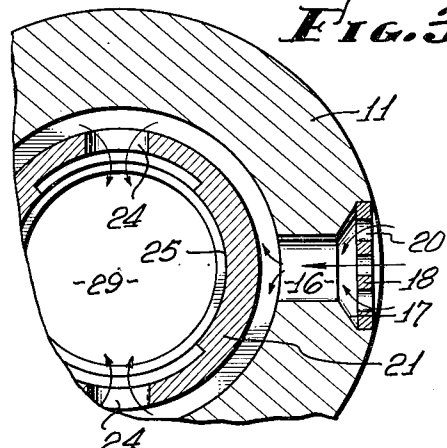


FIG. 3.



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FIG. 4.

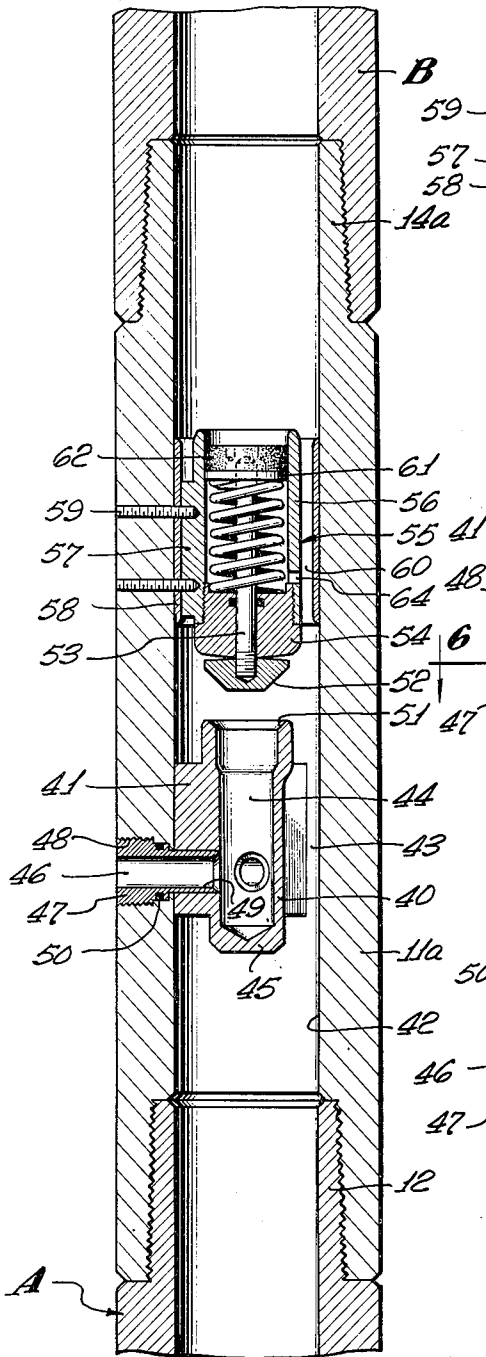


FIG. 5.

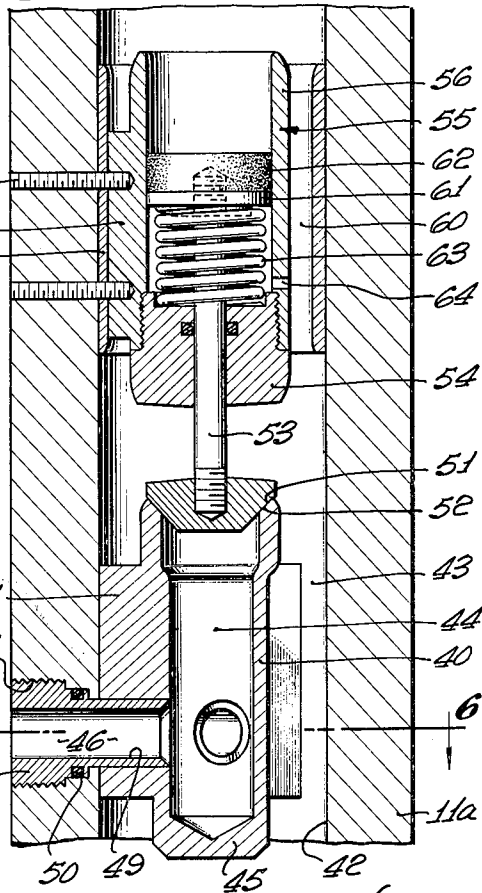
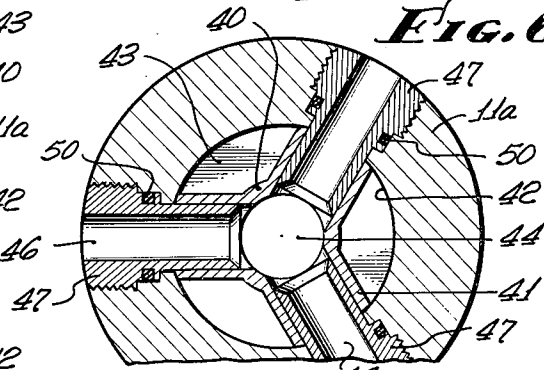


FIG. 6.



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FIG. 7.

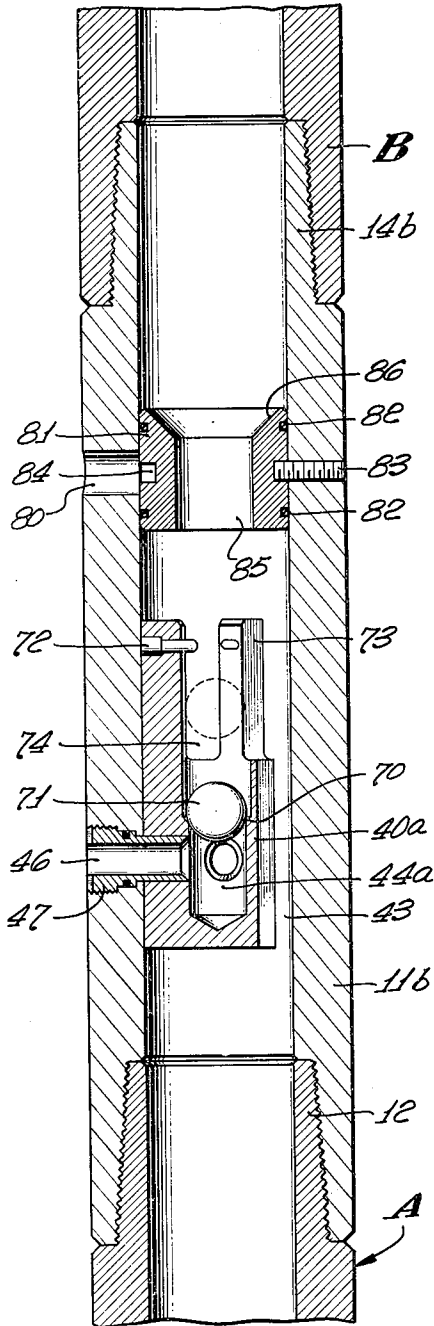


FIG. 8.

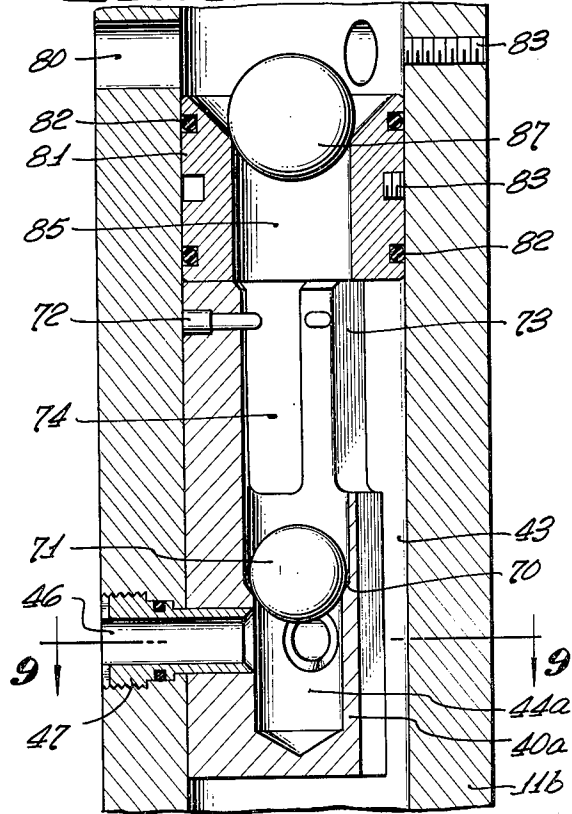
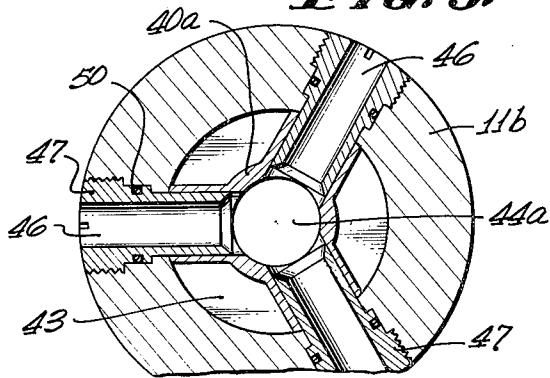


FIG. 9.



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FLUID BY-PASS FOR ROTARY DRILL BITS

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Filed Sept. 30, 1957, Ser. No. 687,215

16 Claims. (Cl. 175—324)

The present invention relates to the drilling of well bores by the rotary method in which drilling mud is circulated through the drilling string and drill bit.

Certain types of rotary drill bits used in the drilling of well bores contain nozzles or outlet openings of relatively small areas, in order to discharge the drilling fluid, such as drilling mud, at a comparatively high velocity directly towards the bottom of the hole, or the drill bit cutters, or both. The relatively small area of the openings through the drill bit nozzles restricts the flow of the drilling mud in the well bore into the tubular drilling string while it is being lowered in the well bore. In some situations, such restriction results in damage to the formation, caused by the drilling string and bit building up a comparatively high pressure in the drilling mud and forcing or ramming it into the formation.

Not only does the restricted fluid circulation area through the drill bit produce the aforesaid undesirable effect, but it also decreases the facility with which the drilling mud can drain from the drill pipe or other drilling string while being removed from the well bore. The result is often the pulling of a "wet" job; that is, the spilling of the drilling mud on the derrick floor when a stand of drill pipe is being disconnected. This presents a hazardous condition at the working area to the rig crew. It also results in the drill pipe performing a swabbing action in the well bore while being elevated therein, with the danger of a blow-out.

An object of the present invention is to provide an apparatus which prevents the drilling string and bit from developing a high pressure in the well bore drilling mud while the drilling string and bit are being run in the well bore.

Another object of the invention is to provide an apparatus which prevents the drilling string from swabbing the well bore while being elevated therein, or from pulling a "wet" job.

A further object of the invention is to provide an apparatus which enables the fluid in the well bore to by-pass around the drill bit into the drilling string while the latter is being lowered in the well bore, such by-passing being prevented while drilling fluid is being pumped through the drilling string in the performance of the drilling operation.

An additional object of the invention is to provide an apparatus which enables the fluid in the well bore to by-pass around the drill bit from the interior of the drill bit to its exterior during elevation of the drilling string in the well bore.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through an embodiment of the apparatus, with the side ports open;

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FIG. 2 is an enlarged fragmentary longitudinal section of the apparatus shown in FIG. 1, with the side ports closed;

FIG. 3 is a fragmentary cross-section on an enlarged scale taken along the line 3—3 on FIG. 1;

FIG. 4 is a view similar to FIG. 1 of another embodiment of the invention;

FIG. 5 is an enlarged longitudinal section of the apparatus shown in FIG. 4, with the by-pass portion thereof closed;

FIG. 6 is a cross-section taken along the line 6—6 on FIG. 5;

FIG. 7 is a view similar to FIG. 1 of still another embodiment of the invention;

FIG. 8 is an enlarged longitudinal section of the apparatus shown in FIG. 7, with parts in another relative position;

FIG. 9 is a cross-section taken along the line 9—9 on FIG. 8;

FIG. 10 is a longitudinal section taken along the line 10—10 on FIG. 2;

FIG. 11 is a cross-section taken along the line 11—11 on FIG. 2.

As disclosed in the drawings, a rotary drill bit A is connected to the lower end of a string of drill pipe B, or similar tubular drilling string, that extends to the top of the hole. While the drilling string and drill bit are being rotated, drilling mud or the like is pumped down the drill string, passing outwardly through discharge nozzles C in the drill bit for action upon the drill bit cutters D, or directly upon the bottom of the well bore being produced. In some types of drill bits, the area through the nozzles C is relatively small, to cause the fluid issuing therefrom to have a comparatively high velocity and impart a jetting or blasting action upon the bottom of the hole or the cutters, or both, which is conducive to more effective drilling action of the drill bit in the well bore.

The relatively small area through the drill bit nozzles C restricts the passage of the drilling mud in the well bore into the string of drill pipe B while it is being lowered in the well bore, producing a substantial back pressure in the drilling mud which is exerted upon the walls of the formation. Under some conditions, such pressure may be sufficiently high as to actually break down the formation, with a consequent loss of drilling mud thereinto, or permanent damage to a producing formation.

The restricted fluid passage area through the drill bit also retards the rate at which fluid can drain from the drill string B when the latter is being removed from the well bore, sometimes resulting in a swabbing action by the drill bit on the fluid in the well bore of an extent sufficient to produce a blow-out. In addition, the inability of the drilling mud level to lower rapidly enough in the drill string, while the latter is being removed from the well bore, results in drilling mud still being present in the stand of pipe above the rotary table when such stand of pipe is being disconnected from the drill pipe therebelow, the drilling mud dropping out of the stand of drill pipe onto the derrick floor.

In the several forms of inventions illustrated in the drawings, the above noted undesired characteristics of employing a drill bit with restricted nozzle or passage areas therein is prevented. As disclosed in FIG. 1, the drill bit body 10 is threadedly secured to an annular body 11 of a fluid by-pass apparatus E, as, for example, by having the upper threaded pin 12 of the bit screwed into a lower threaded box 13 of the body. The upper end of the body 11 may be constituted as a threaded pin 14 threadedly secured to the lower box 15 of a section of drill pipe or drill collar B thereabove. The string of

drill pipe extends to the top of the well bore in a known manner.

The body 11 of the fluid by-pass apparatus is provided with a plurality of circumferentially spaced side ports 16 extending completely through its wall. The outer portion of the body surrounding each port may be counter-bored to provide an enlarged port region 17 into which a screen 18 is inserted and attached to the body in any suitable manner, as through use of welding material 19. The cross-sectional area of each by-pass port 17 is relatively large, but each of the holes 20 through the screen is relatively small to prevent relatively large particles from passing from the exterior of the apparatus through the ports 16 to the interior thereof.

Disposed within the body 11 and extending across and on opposite sides of the body ports 17 is an inner sleeve member 21 snugly engaging the inner cylindrical wall 22 of the body, with its lower end engaging the upper end of the pin 12 of the bit body 10. This sleeve 21 has a circumferential groove 23 in its exterior which communicates with the body ports 17, and it also has a plurality of circumferentially spaced side ports 24 opening into the circumferential groove 23 and the interior of the sleeve 21 itself. The inner sleeve has guide portions 25 projecting inwardly of its adjacent ported regions, which function as a guide for the lower portion or valve head 26 of a control sleeve 27 slidable longitudinally in the by-pass body 11. This control sleeve 27 extends upwardly to a substantial extent above the upper end of the inner sleeve 21 and terminates at its upper portion in an annular piston 28, the periphery of which is slidable along the inner wall 22 of the body.

The control sleeve 27 has an opening or passage 29 extending therethrough of a diameter substantially less than the minimum diameter through the inner sleeve 21. The diameter of the interrupted cylindrical surface of the guide portions 25 is greater than the passage diameter through the control sleeve 27, but substantially less than the inside diameter of the inner wall 22. The upper or annular piston portion 28 of the control sleeve carries a piston ring 30 in a ring groove 31 which slidably and sealingly engages the inner wall 22 of the body 11. This ring will prevent downward passage of fluid between the piston and the inner wall of the body.

The control sleeve 27 is initially held in an upward position, with its piston 28 engaging a downwardly facing stop shoulder 32 on the body and with the lower end 33 of the control sleeve above the inner sleeve ports 24, by a helical compression spring 34 surrounding the control sleeve, its lower end bearing against the upper end of the inner sleeve 21 and its upper end bearing against the piston 28. This spring may exert a substantial force tending to keep the control sleeve 27 in its upper position illustrated in FIG. 2, in which the sleeve ports 24 are open. For example, the spring 34 may be sufficiently heavy as to exert a force of about 300 pounds upon the control sleeve 27 tending to hold it in its upward position.

When the inner sleeve 21 and control sleeve 27 are out of the body 11, the parts are maintained in assembled relation with the spring 34 compressed by the engagement of an upwardly directed shoulder 35 on the control sleeve 27 with a plurality of screws 36 threaded in the upper portion of the inner sleeve 21 and extending inwardly of the inner sleeve over the stop shoulder 35 on the control sleeve. In view of such arrangement, the control sleeve 27 and inner sleeve 21, with the spring 34 compressed therebetween, can be inserted as a unit into the by-pass body 11 from its lower end, after which the threading of the drill bit A into the lower portion of the body will force the inner sleeve 21 upwardly to a slight extent and will definitely locate the circumferential groove 23 of the inner sleeve in alignment with the by-pass ports 16 through the main body member 11.

The control sleeve 27 is shiftable downwardly completely across the ports 24 until its valve head 33 engages

a companion valve seat 37 provided in the inner sleeve. The engaging surfaces between the head 33 and seat 37 may be tapered, if desired. To insure proper sealing engagement between the valve head and its companion seat, arcuate relief grooves 38 are provided through the lower end of the guide portions 25, along which the valve head 33 slides, into which particles and the like can be forced during the seating of the valve head against its companion seat 37.

In the operation of the apparatus illustrated, the spring 34 tends to keep the control sleeve 27 in its upper position, in which the sleeve ports 24 are open. Accordingly, as the string of drill pipe B, with the drill bit A attached to its lower end, is lowered through the drilling mud or other fluid in the well bore, the fluid will enter the drill string through the drill bit nozzles C. It will also enter the drill string through the by-pass apparatus E, flowing through the screen openings 20 and the by-pass ports 16 into the circumferential groove 23, thence inwardly through the sleeve ports 24 to the interior of the sleeve 21 and then upwardly through the central passage 29 in the control sleeve 27 into the drill pipe B thereabove. The external hydrostatic head can also act on the underside of the piston portion 28 since the fluid in the annular space between the control sleeve 27 and the inner wall 22 of the body is always communicable with the ports 16. In the FIG. 1 position, fluid can pass from the ports 16, groove 23 and around the valve head 26 into such annular space. The same is true when the valve head 26 engages the seat 37, as shown in FIG. 2. The minimum area of the passage just described may be made rather large, to permit the drilling mud in the well bore to flow rather freely into the drill pipe B, and to minimize the building up of pressure in the fluid in the well bore as a result of lowering the string of drill pipe therewithin.

When the drill pipe B has been run in the well bore and the drilling action is to commence, the drilling mud is pumped down through the drill pipe B. The passage 29 through the control sleeve 27 has a lesser diameter than the passage through the drill pipe thereabove, which develops a back pressure on the control sleeve 27 sufficient in extent to overcome the compression of the spring 34 and shift the control sleeve downwardly until its valve head 33 engages its companion seat 37 (FIG. 2). So long as fluid is being pumped at a sufficient volumetric rate through the drill pipe B to provide the necessary pressure on the piston 28, the control sleeve 27 will be held in its downward position in engagement with the valve seat 37, to close the sleeve port 24, and thereby prevent any of the drilling mud from passing laterally through the by-pass apparatus E to the exterior of the drill pipe B. Accordingly, all of the drilling mud pumped down through the string of drill pipe B must pass through the drill bit A and through its nozzles C, issuing therefrom at the desired high velocity to impose a jetting or blasting action on the bottom of the well bore, or the drill bit cutters, in order to keep the bottom and cutters free of cuttings.

Not only is the back pressure built up above the control sleeve 27 effective to hold it in a downward position closing the sleeve ports 24, but the control sleeve provides a differential area which adds to the hydraulic force tending to hold the control sleeve in its lower position. When the control sleeve engages the valve seat 37, the effective area R across the lower end of the control sleeve 27, over which fluid pressure can act and tending to urge the control sleeve in an upward direction, is much less than the effective area S of the annular piston 28 over which the fluid pressure is acting and tending to shift and hold the control sleeve in a downward direction. In view of the differential area relationship, even if the unit pressure above and below the control sleeve 27 were equal, the latter would still be urged in a downward direction against the force of the spring 34 and retained in engagement with the valve seat 37 to close the sleeve ports 24.

So long as drilling mud is being pumped down through the drill pipe B, the control sleeve 27 will remain in its lower position closing the ports 24, insuring that all of the drilling mud will be directed through the drill bit A. However, when the pumping action ceases, the spring 34 will shift the control sleeve 27 upwardly to its initial position, opening the sleeve ports 24 and establishing communication through the sleeve 21 and the ported main body 11 between the interior of the string of drill pipe and its exterior. This action can occur since the cessation of pumping eliminates the pressure differential within the by-pass apparatus E. Since the substantially equal external and internal hydrostatic heads of fluid are acting over equal and opposite areas S of the sleeve valve 27, the spring 34 need not overcome any substantial pressure differentials and can readily elevate the sleeve to port opening position. Accordingly, during elevation and removal of the drill pipe from the well bore, the fluid can drain from the drill pipe B through the nozzles C of the drill bit, but a large and major portion of such fluid can also drain through the sleeve ports 24, circumferential groove 23, by-pass ports 16 and screen openings 20 to the exterior of the bit. The drill pipe is thereby drained in a rapid manner during its removal from the well bore, which minimizes the swabbing action of the string of drill pipe on the fluid in the well bore as the pipe is being elevated therewithin, and which also insures that the stand of pipe above the rotary table will be in a dry state upon its disconnection from the string of drill pipe therebelow.

If it is desired to remove the internal mechanism of the by-pass apparatus E, such action can occur very simply by disconnecting the drill bit A from the body 11, the spring 34 expanding slightly to engage the stop screws 36 with the control sleeve shoulder 35, whereupon the inner sleeve 21, control sleeve 27 and the spring 34 can be removed safely and as a unit from the body.

In the embodiment of the invention illustrated in FIGS. 4, 5 and 6, the main tubular body 11a is connected to the upper end 12 of the drill bit A, as before, with its upper end 14a threadedly secured to the adjacent section of drill pipe or drill collar B. A tubular body member 40 is mounted centrally in the passage of the body 11a, and has circumferentially spaced, radial arms 41 extending therefrom to the inner wall 42 of the main body member. There are arcuate passages 43 defined between the tubular body member 11a, radial arms 41 and inner wall 42 of the main body, through which the drilling fluid can pass. The tubular body member 40 has a central passage 44 extending from its open upper end to a lower end wall 45. This central passage 44 communicates with ports or passages 46 formed in nozzle members 47 threaded within companion threaded holes 48 in the main body 11a of the apparatus, the inner portion of these nozzle members extending in radial bores 49 in the radial arms 41, so that there is communication between the exterior of the main body 11a and the central passage 44 in the tubular body member 40. Leakage of fluid between the nozzles 47 and the body member 11a can be prevented by suitable side seal rings 50 mounted in the nozzles.

Because of the radial passages 46 and the central passage 44 in the tubular body member 40, drilling fluid in the well bore can flow inwardly through the nozzles into the central passage and then into the main body 11a. As explained hereinbelow, the drilling mud in the string of drill pipe B, under some conditions, can also flow in a reverse direction from the interior of the main body 11a to its exterior. During the actual drilling operation, it is desired to prevent the drilling fluid from flowing downwardly through the central passage 44 and out through the radial ports 46 in the nozzles 47. A device above the tubular body member 40 is provided in the main body 11a to accomplish this result.

As disclosed, the upper end of the tubular body mem-

ber 40 is formed as a valve seat 51 adapted to be engaged by a companion valve head 52 threadedly secured to a valve stem 53 which extends upwardly through the lower cylinder head 54 of a cylinder 55. The cylinder includes a skirt 56 threaded onto the head 54 and extending upwardly therefrom, the upper end of the skirt being open. The cylinder skirt 56 has circumferentially spaced centering ribs 57 extending therefrom, which engage an outer sleeve 58, snugly fitting the inner cylindrical wall 42 of the main body 11a of the tool. The cylinder 55 and sleeve 58 are secured to the main body by a plurality of radial screws 59 threaded in the main body member 11a and into the outer sleeve 58 and ribs 57. Arcuate passages 60 are formed between the ribs 57, the cylinder sleeve portion 56 and the outer sleeve 58 through which drilling mud can pass in both directions through the apparatus.

A piston 61 is slidable in the cylinder 55, being secured to the upper end of the valve stem 53. This piston has a piston ring 62, in the form of a rubber or rubber-like member, mounted thereon which slidably and sealingly engages the inner wall of the cylinder 55. This seal ring 62 is adapted to prevent downward passage of fluid between the piston 61 and the cylinder wall. The piston 61, stem 53 and valve head 52 are urged in an upward direction with respect to the cylinder 55 by a helical compression spring 63 in the cylinder bearing against the lower cylinder head 54 and the piston 61 itself. One or more ports 64 are provided in the lower portion of the cylinder sleeve 56 to provide communication between the cylinder 55 on the lower side of the piston 61 and one or more of the longitudinally extending arcuate passages 60 through the valve apparatus.

In the use of the apparatus disclosed in FIGS. 4, 5 and 6, the spring 63 normally maintains the valve head 52 in an upward position substantially removed from its companion valve seat 51 therebelow. The lowering of the string of drill pipe B, with the drill bit A attached thereto, through the drilling mud or other fluid in the well bore, will not only allow such drilling fluid to flow through the drill bit nozzles into the string of drill pipe B, but also permits the drilling fluid in the well bore to flow through the nozzle ports 46 into the central passage 44, discharging through its upper valve seat 51 into the body 11a of the tool and mingling with the drilling mud that enters the body 11a through the drill bit A for upward flow through the arcuate passages 60 in the valve structure and into the drill pipe sections thereabove. The area of the nozzle ports 46 and the central passage 44 are quite substantial, to permit the ready ingress of a large quantity of the well bore fluid into the string of drill pipe, and preventing the building up of any substantial pressures in the drilling mud in the well bore during the lowering of the drill pipe B and drill bit A there-within.

When the drill bit is to operate upon the bottom of the hole, the drilling mud is pumped down through the drilling string B. The pressure of the drilling mud will act on the piston 61 and move it downwardly against the force of the spring 63 to engage the valve head 52 with its companion seat 51, closing the central passage 44. Accordingly, all of the drilling mud must then flow through the arcuate passages 43 around the tubular body member 40 and enter the drill bit, discharging from its nozzles at a high velocity. All of the drilling mud pumped down the drill string passes out through the drill bit A to perform the desired purposes in the well bore.

Not only is a back pressure built up on the upper surface of the piston 61 to urge it and hold it downwardly, to secure the valve head 52 against the companion valve seat 51, but the flow of the drilling mud through the arcuate passages 60 in the valve structure past the lower ports 64 reduces the pressure of the fluid in the cylinder below the piston 61 and creates a pressure differential with respect to the pressure of the fluid above the piston that

will urge the piston 61, valve stem 53 and valve head 52 downwardly to maintain the valve head 52 engaged with its companion seat 51.

After the drilling operation with the bit A has been completed and it is desired to remove the string of drill pipe B from the well bore, the pumping of the drilling mud ceases, which then permits the spring 63 to raise the piston 61, stem 53 and valve head 52 and remove the latter from engagement with its seat 51. As the drill pipe is being removed from the well bore, the drilling mud can drain therefrom, not only through the drill bit nozzles but also through the open central passage 44 and the side ports 46 in the by-pass apparatus.

In the form of inventions disclosed in FIGS. 7, 8 and 9, essentially the same tubular body member and nozzle arrangement is employed as in the form of invention illustrated in FIGS. 4, 5 and 6. However, in lieu of the central passage 44a through the tubular body member 40a being closed by a piston operated valve structure, the tubular body member is provided with a valve seat 70 therewithin engageable by a ball valve element 71 when the latter moves downwardly within the body 40a. The central passage 44a in the tubular body member has a greater diameter above the valve seat 70 than the ball valve element 71, to permit the latter to move longitudinally in the tubular body member toward engagement with the valve seat 70 and upwardly away from engagement with the valve seat. Upward movement of the valve element 71 is limited by its engagement with radial stop pins 72 disposed in upwardly extending arms 73 of the tubular body member and projecting into its passage 44a. In view of the provision of the circumferentially spaced arms 73, by-pass openings 74 are provided therebetween through which the drilling mud can pass when the ball valve element 71 is raised from its seat 70 and when it engages the stop pins 72.

With the apparatus disclosed in FIGS. 7, 8 and 9, the lowering of the string of drill pipe B and drill bit A in the well bore will permit the drilling mud in the well bore to flow upwardly through the drill bit nozzles into the main body 11b of the apparatus, then passing through the arcuate passages 43 to the upper portion of the main body. Drilling fluid can also flow through the ports 46 in the nozzles 47 into the central passage 44a, carrying the ball valve element 71 upwardly to the extent limited by its engagement with the stop pins 72, and then flowing outwardly through the by-pass openings 74, continuing on into the drill pipe sections B thereabove.

When the drilling operation is to be performed, the drilling mud is pumped down through the string of drill pipe B and will move the ball valve element 71 downwardly into engagement with its valve seat 70, holding it in such engagement. As a result, the by-pass ports 46, 44a are closed, and all of the drilling mud must flow down through the arcuate passages 43 into the drill bit A to discharge from its nozzles.

When it is desired to remove the drill pipe B from the well bore, the ball valve element 71 will remain seated, so that no part of the drilling mud in the string of drill pipe can drain outwardly through the ports 46 in the nozzles 47. To secure an increased drainage area from the string of drill pipe, a plurality of drain side ports 80 are provided in the main body 11b of the apparatus above the tubular body member 40a. These drain ports 80 are normally closed by a sleeve valve 81 disposed thereacross, this sleeve valve being provided with suitable side seal rings 82 on opposite sides of the drain ports to prevent leakage therearound. The sleeve valve is retained in this position across the ports 80 by one or more shear screws 83 threaded into the main body 11b, with its inner portion disposed within a circumferential groove 84 in the sleeve 81. The sleeve valve 81 has an inner passage 85 therethrough of a comparatively large diameter, so as not to restrict the passage of fluid through the string of drill pipe. The upper portion of this passage

85 is surrounded by a valve seat 86 adapted to be engaged by a valve element 87 in the form of a ball. This ball valve element is normally not present in the drill string B, but is only dropped or pumped through the drill string when the latter is to be removed from the well bore. Upon engaging its seat 86 it will close the passage 85 through the sleeve valve 81, allowing pressure to be built up in the fluid thereabove to a sufficient extent as to shear the screws 83 and shift the sleeve valve 81 and ball 87 downwardly to a position below the drain ports 80. The sleeve valve 81 will come to rest on the upper end of the tubular body member 44a (FIG. 8). The fluid in the drill pipe will now drain out through the drain ports 80, which collectively have a comparatively large area to permit the drainage to occur at a fairly rapid rate.

It is, accordingly, apparent that by-pass apparatus for use in conjunction with a rotary drill bit has been provided which assures the ready ingress and egress of drilling mud with respect to the interior of the string of drill pipe. The by-pass ports are only opened during the running of the string of drill pipe in the well bore and its removal therefrom. The by-pass ports are closed during the actual drilling operation to insure that all of the drilling mud is discharged through the drill bit nozzles for effective jetting or blasting action upon the bottom of the well bore, or upon the cutters, or both.

The inventors claim:

1. In drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string; said drill string having a side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; valve means shiftable to port closing position in response to downward pumping of fluid through the drill string, said valve means including means responsive to pressure externally of said drill string to equalize the hydrostatic head of fluid internally of the drill string and tending to shift said valve means from port closing position to port opening position and also tending to hold said valve means in port opening position; and spring means engaging said valve means to shift said valve means to port opening position; said spring means exerting a force sufficient to maintain said valve means in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

2. A drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string, said nozzle being normally open to permit fluid to flow upwardly therethrough into the drill string during lowering of the drill string in the well bore and said drill string being open to permit such upward flow of fluid therewithin; said drill string having a side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a sleeve valve having a passage therethrough and slidable in said drill string across said port to close the same in response to downward flow of fluid in the drill string, said sleeve valve including means responsive to pressure externally of said drill string to equalize the hydrostatic head of fluid internally of the drill string and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in the drill string; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

3. A drilling apparatus for a well bore: a tubular drill

string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string, said nozzle being normally open to permit fluid to flow upwardly therethrough into the drill string during lowering of the drill string in the well bore and said drill string being open to permit such upward flow of fluid therewithin; said drill string having a side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a sleeve valve having a passage therethrough and slidable downwardly in said drill string and across said port to close the same in response to downward flow of fluid in the drill string, said sleeve valve including means responsive to pressure externally of said drill string to equalize the hydrostatic head of fluid internally of the drill string and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and spring means engaging said sleeve valve to shift it upwardly in said drill string to port opening position upon diminution in the downward flow of fluid in the drill string; said spring means exerting a force sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

4. A drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string; said drill string having a first side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a sleeve in said drill string disposed across said first side port and having a second side port communicating with said first side port; a sleeve valve having a passage therethrough and slidable in said drill string and sleeve across said second port to close the same in response to downward flow of fluid in the drill string, said sleeve valve including means responsive to pressure externally of said drill string to equalize the hydrostatic head of fluid internally of the drill string and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and means for shifting said sleeve valve to port opening position upon decrease in the downward flow of fluid in the drill string; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

5. A drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string; said drill string having a first side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a sleeve in said drill string disposed across said first side port and having a second side port communicating with said first side port; a sleeve valve having a passage therethrough and slidable downwardly in said drill string and sleeve across said second side port to close the same in response to downward flow of fluid in the drill string, said sleeve valve including means responsive to pressure externally of said drill string to equalize the hydrostatic head of fluid internally of the drill string and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and spring means engaging said sleeve valve and sleeve to shift said sleeve valve upwardly in said drill string to port opening position upon diminution of the downward flow of fluid in the drill string; said spring means exerting a force sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

6. A drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string; said drill string having a first side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a sleeve in said drill string disposed across said first side port and having a second side port communicating with said first side port; a sleeve valve having a passage therethrough and slidable downwardly in said drill string and sleeve across said second side port to close the same in response to downward flow of fluid in the drill string, said sleeve valve including means responsive to pressure externally of said drill string to equalize the hydrostatic head of fluid internally of the drill string and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; spring means engaging said sleeve valve and sleeve to shift said sleeve valve upwardly in said drill string to port opening position upon diminution of the downward flow of fluid in the drill string; said spring means exerting a force sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle; and co-engageable stop means on said sleeve and sleeve valve to limit upward movement of said sleeve valve relative to said sleeve.

7. In drilling apparatus for a well bore: a tubular body adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a side port for allowing flow of fluid between the interior and exterior of the drill pipe; a sleeve valve having a passage therethrough and slidable in said body across said port to close the same in response to downward flow of fluid in the tubular body, said sleeve valve including means responsive to pressure externally of said body to equalize the hydrostatic head of fluid internally of the body and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in said body; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said tubular body and drill string in the well bore to permit drainage of drilling fluid from the drill string through said port.

8. In drilling apparatus for a well bore: a tubular body adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a side port for allowing flow of fluid between the interior and exterior of the drill pipe; a sleeve valve having a passage therethrough and slidable downwardly in said body across said port to close the same in response to downward flow of fluid in said body, said sleeve valve including means responsive to pressure externally of said body to equalize the hydrostatic head of fluid internally of the body and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and spring means engaging said sleeve valve to shift it upwardly in said body to port opening position upon diminution in the downward flow of fluid in said body, said spring means exerting a force sufficient to maintain said sleeve valve in port opening position during elevation of said body and drill string in the well bore and to permit drainage of drilling fluid from the drill string through said port.

9. In drilling apparatus for a well bore: a tubular body adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a first side port for allowing flow of fluid between the interior and exterior of the drill pipe; a sleeve in said body disposed across said first side port and having a second

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side port communicating with said first side port; a sleeve valve having a passage therethrough and slidable in said body and sleeve across said second side port to close the same in response to downward flow of fluid in said body, said sleeve valve including means responsive to pressure externally of said body to equalize the hydrostatic head of fluid internally of the body and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and means for shifting said sleeve valve to port opening position upon decrease in the downward flow of fluid in said body; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

10. In drilling apparatus for a well bore: a tubular body adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a first side port for allowing flow of fluid between the interior and exterior of the drill pipe; a sleeve in said body disposed across said first side port and having a second side port communicating with said first side port; a sleeve valve having a passage therethrough and slidable in said body and sleeve across said second side port to close the same in response to downward flow of fluid in said body, said sleeve valve including means responsive to pressure externally of said body to equalize the hydrostatic head of fluid internally of the body and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; and spring means engaging said sleeve valve and sleeve to shift said sleeve valve upwardly in said body to port opening position upon diminution in the downward flow of fluid in said body; said spring means exerting a force sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

11. In drilling apparatus for a well bore: a tubular body adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a first side port for allowing flow of fluid between the interior and exterior of the drill pipe; a sleeve in said body disposed across said first side port and having a second side port communicating with said first side port; a sleeve valve having a passage therethrough and slidable in said body and sleeve across said second side port to close the same in response to downward flow of fluid in said body, said sleeve valve including means responsive to pressure externally of said body to equalize the hydrostatic head of fluid internally of the body and tending to shift said sleeve valve from port closing to port opening position and also tending to hold said sleeve valve in port opening position; spring means engaging said sleeve valve and sleeve to shift said sleeve valve upwardly in said body to port opening position upon diminution in the downward flow of fluid in said body; said spring means exerting a force sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle; and coengageable stop means on said sleeve and sleeve valve to limit upward movement of said sleeve valve relative to said sleeve.

12. In drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string, said nozzle being normally open to permit fluid to flow upwardly therethrough into the drill string during lowering of the drill string in the well bore and said drill string being open to permit such upward flow of fluid

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therewithin; said drill string having a side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a valve seat below said port; a sleeve valve having a passage therethrough and slidable in said drill string across said port into engagement with said valve seat to close said port in response to downward flow of fluid in the drill string, said sleeve valve having transverse fluid pressure actuatable surfaces; means providing fluid communication between said surfaces and the pressure fluid externally and internally of said drill string when said sleeve valve is in port opening and port closing positions; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in the drill string; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

13. In drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from said drill string, said nozzle being normally open to permit fluid to flow upwardly therethrough into the drill string during lowering of the drill string in the well bore and said drill string being open to permit such upward flow of fluid therewithin; said drill string having a side port in its lower portion above said bit for allowing fluid to flow between the interior and exterior of said drill string; a sleeve valve having a passage therethrough and slidable in said drill string across said port to close the same in response to downward flow of fluid in the drill string, said sleeve valve having transverse fluid pressure actuatable surfaces; means providing fluid communication between said surfaces and the pressure fluid internally and externally of said drill string when said valve seat is in port opening and port closing positions; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in the drill string; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

14. In drilling apparatus for a well bore: a tubular member adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a side port for allowing flow of fluid between the interior and the exterior of the drill pipe; a valve seat below said port; a sleeve valve having a passage therethrough and slidable in said body across said port into engagement with said valve seat to close said port in response to downward flow of fluid in the tubular body, said sleeve valve having transverse fluid pressure actuatable surfaces; means providing fluid communication between said surfaces and the pressure fluid internally and externally of said tubular body when said valve seat is in port opening and port closing positions; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in said body; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

15. In drilling apparatus for a well bore: a tubular body adapted to form part of a string of drill pipe to be disposed in the well bore; said body having a side port for allowing flow of fluid between the interior and exterior of the drill pipe; a sleeve valve having a passage therethrough and slidable in said body across said port to close the same in response to downward flow of fluid in the tubular body, said sleeve valve having transverse fluid pressure actuatable surfaces; means providing fluid

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communication between said surfaces and the pressure fluid internally and externally of said tubular body when said sleeve valve is in port opening and port closing positions; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in said tubular body; said shifting means exerting a force on said sleeve valve sufficient to maintain said sleeve valve in port opening position during elevation of said drill string and drill bit in the well bore to permit simultaneous drainage of drilling fluid from said drill string through said port and bit nozzle.

16. In drilling apparatus for a well bore: a tubular drill string; a drill bit secured to the drill string and having a nozzle for discharging fluid from the drill string, said nozzle being normally open to permit fluid to flow upwardly therethrough into the drill string during lowering of the drill string in the well bore and said drill string being open to permit said upward flow of fluid therewithin; a sleeve valve having a passage therethrough and an enlarged upper piston portion slidable along the drill

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string and above said port and a lower piston portion of less external diameter than the upper piston portion slidable along the drill string and across said port to close the same when said upper and lower portions are subject to downward flow of fluid in the drill string; means providing fluid communication between the pressure fluid externally of said drill string and the lower side of said upper piston portion; and means for shifting said sleeve valve to port opening position upon decrease of the downward flow of fluid in the drill string.

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