June 4, 1968 J. CHADDERDON ET AL 3,386,521

COMBINATION WELL DRILLING TOOL

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Fig. 1

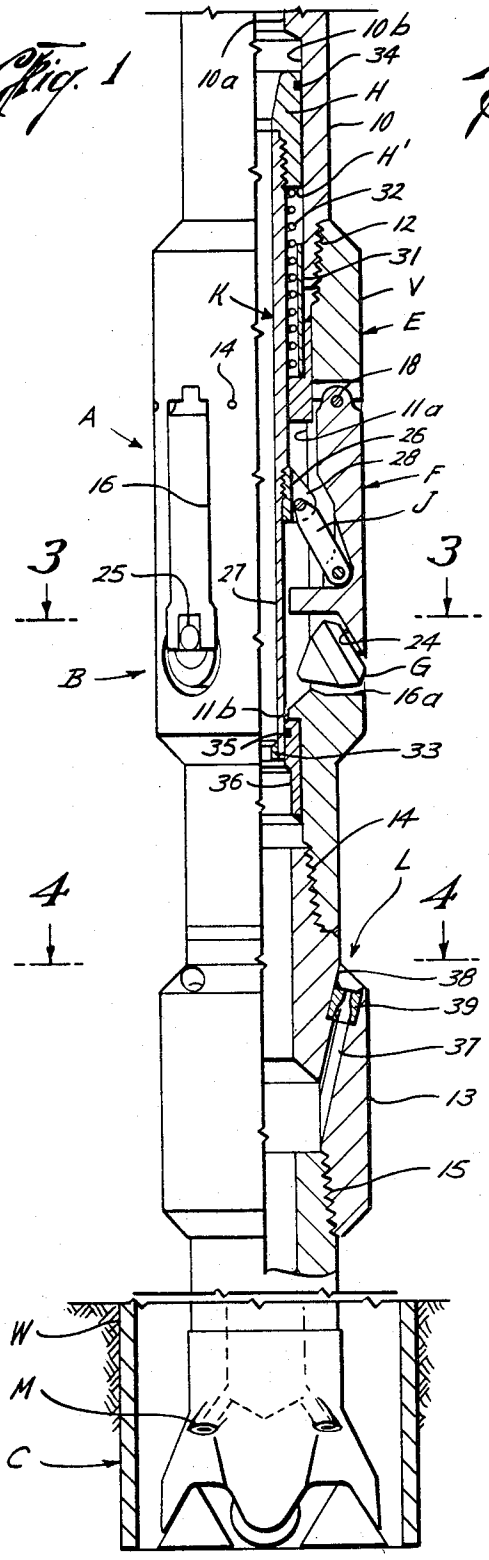
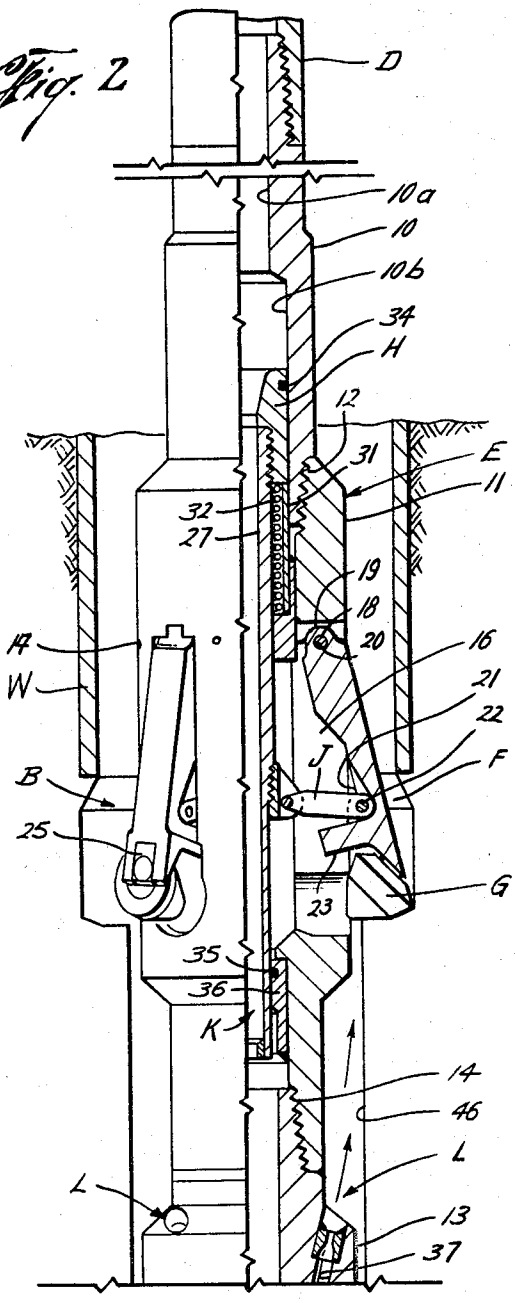


Fig. 2



Kirk R. Shirley
Jack Chadderdon
INVENTORS

BY J. Vincent Martin
Joe E. Edwards
Jack K. Springgate
ATTORNEYS

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Fig. 3

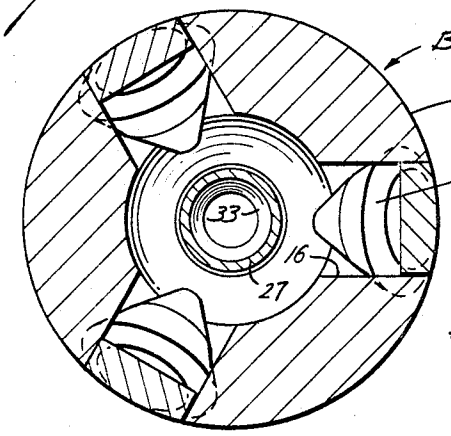


Fig. 4

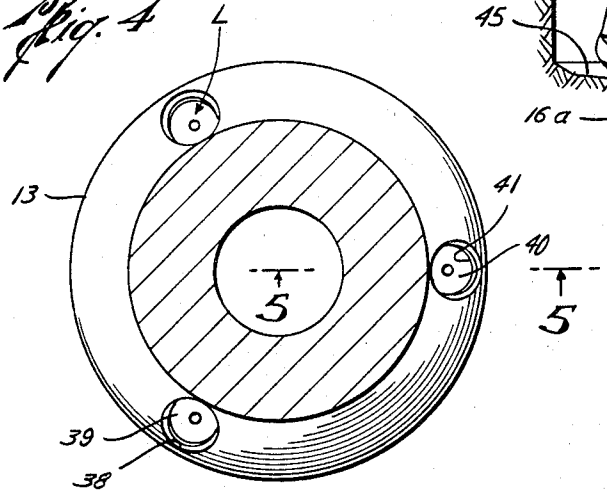


Fig. 5

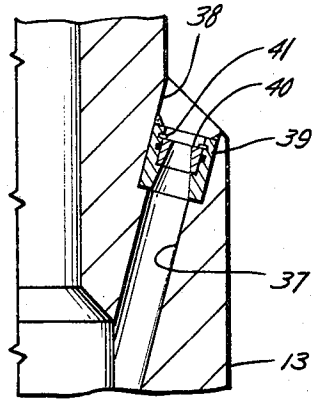
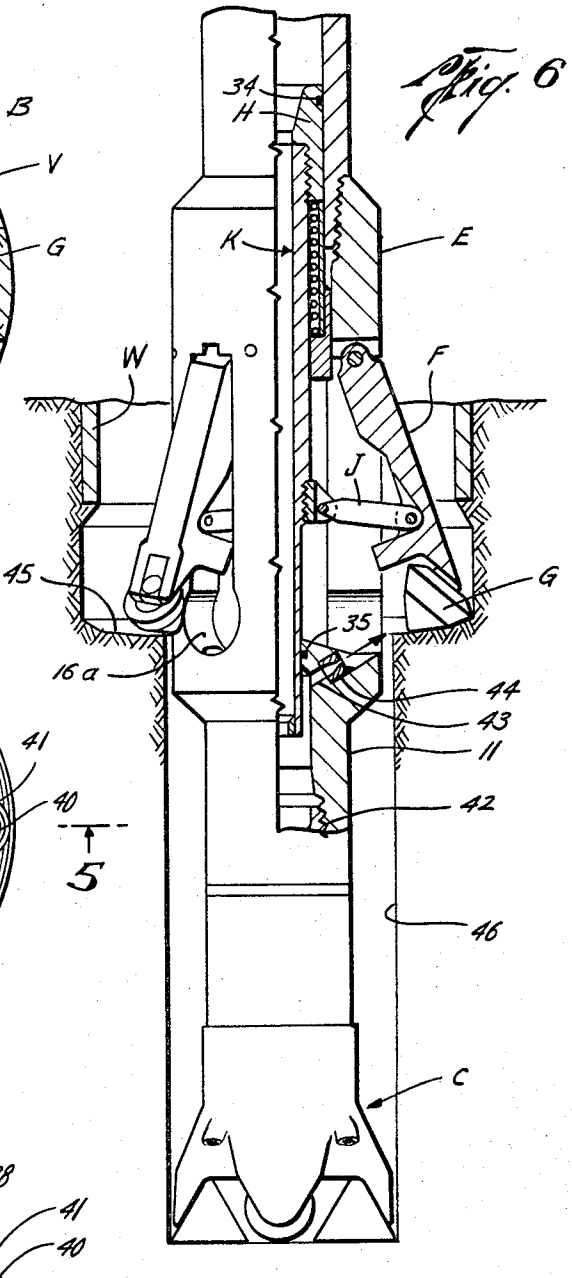


Fig. 6



Kirk R. Shirley
Jack Chadderdon
INVENTORS

BY J. Vincent Martin
Joe E. Edwards
Jack L. Spriggett
ATTORNEYS

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COMBINATION WELL DRILLING TOOL

Jack Chadderdon, Houston, Tex., and Kirk R. Shirley, Long Beach, Calif., assignors to A-Z International Tool Company, Houston, Tex., a corporation of Texas

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3 Claims. (Cl. 175—269)

ABSTRACT OF THE DISCLOSURE

This specification discloses a combination well drilling tool which includes a lower drill bit, an upper expansible reamer having a cone-type rock-bit cutter and a connecting sub therebetween with jet nozzles directed outwardly and upwardly to cause drilling fluid to lift cuttings from the lower drill bit through the narrow space between the body of the reamer and the wall of the well bore formed by the lower drill bit. This abstract is neither intended to define the invention of the application which, of course, is measured by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

The present invention relates to an improved well tool for drilling and reaming a well bore and particularly to an improved well drilling tool having means for controlling the flow of drilling fluids to remove cuttings from the drilling area and from the reaming area of the tool.

The present invention is an improvement on the K. R. Shirley Patent No. 3,171,503 issued Mar. 2, 1965. This patent discloses expansible rotary drill bit cutters which are pressure actuated for performing an underreaming operation which, as is well-known, is an enlargement of a previously drilled bore. This tool operates only to perform such underreaming operation and does not perform the actual drilling operation of the well bore which it is enlarging.

An object of the present invention is to provide an improved well drilling tool which will drill a well bore and at substantially the same time will ream the well bore to the desired diameter while expeditiously removing cuttings from the cutting areas.

A further object is to provide an improved drilling tool to drill a well bore in progressive stages and in which the drilling fluid is separately directed toward the drilling area of each stage to provide efficient removal of cuttings from the well bore.

Another object of the present invention is to provide an improved drilling tool which has two areas of cutting for drilling a well bore and having streams of drilling fluid directed to each cutting area with each stream moving in a direction which does not interfere with the removal of cuttings from the other cutting area.

Another object is to provide an improved combination drilling tool including an expansible cutter and a usual drill bit wherein the bit acts as a pilot bit drilling a bore smaller than the final desired diameter and wherein the expansible cutter functions as a second stage drill to ream the bore to final size.

A still further object of the present invention is to provide an improved combination drilling tool for drilling and reaming a well bore in which both the pilot or lead cutter and the reaming cutter are of the cone rock-bit type, whereby maximum drilling efficiency is obtained.

Still another object is to provide an improved combination drilling tool, of the character described, in which the drilling fluid for the reaming area is so located and directed that it assists the upward flow of the drilling fluid and cuttings from the lower drilling area, whereby cuttings from both areas are efficiently brought to the surface.

As illustrated, the present invention provides a single tool which will at substantially the same time drill a well bore and ream such well bore to the final desired size. An upper reaming section B similar to the tool disclosed in the aforementioned Shirley patent is combined with a lower drill bit section C. As shown, both sections include cutters of the cone rock-bit type. A controlled circulation of drilling fluid to the lower drill bit section C and the upper reaming section B is included in this improved tool.

The construction and design to carry out the invention will be hereinafter described, together with other features thereof.

The invention will be more readily understood from reading of the following specification by reference to the accompanying drawing forming a part thereof wherein an example of the invention is shown and wherein:

FIGURE 1 is a view partly in section and partly in elevation showing the tool in the bottom of a well bore within the casing string.

FIGURE 2 is a similar view and illustrates the combined drilling and reaming of the tool.

FIGURE 3 is a horizontal sectional view taken on line 3—3 of FIGURE 1.

FIGURE 4 is a horizontal sectional view taken on line 4—4 of FIGURE 1.

FIGURE 5 is a vertical sectional view taken on line 5—5 of FIGURE 4.

FIGURE 6 is a view partly in section and partly in elevation showing the combined drilling and reaming of another form of the present invention.

The combined drilling and reaming tool of the present invention has particular application in the drilling of well bores after a section of casing has been set and a blowout preventor connected to the upper end of the casing at the surface. By using the drilling tool of the present invention to continue drilling of the well bore below the casing string, a smaller size and considerably less expensive blowout preventor can be used to allow the combined tool to be lowered therethrough while still being able to drill a well bore having a diameter larger than can be drilled with an ordinary drill bit. This is accomplished by the two-stage drilling of the well bore which includes drilling a well bore smaller than desired with the pilot or lead bit and enlarging the well bore to the desired final diameter with the reaming section of the tool.

As illustrated, the present invention provides a single tool A which will simultaneously drill a well bore and ream such well bore. An upper reaming section B having expansible cutters similar to the tool disclosed in the aforementioned Shirley patent is combined with the lower drill bit section C. A controlled circulation of drilling fluid to the lower drill bit section C and to the upper reaming section B is included in this tool.

The tool of the present invention is adapted to be secured at its upper end to the lower end of a string of drill pipe D, shown in FIGURE 2, which extends to the top of the well bore by means of which the tool is ordinarily lowered through a string of well casing W to lower end of said casing where the combined drilling and enlarging operation is to be carried out.

The lower drill bit section C is secured to the upper reaming section B either by a connecting sub, as illustrated in FIGURES 1 and 2, or directly, as illustrated in FIGURE 6. In general, upper reamer section B comprises a main body portion E within which are provided cutter-carrying elements F having cutters G at their lower ends, and actuating piston H is movable within the bore of the main body portion E having connection through the links J to the cutter-carrying elements or arms F. When the

piston H is moved downwardly, the lower end of the links J is swung outwardly and being connected to the lower portions of the cutter-carrying arms F, said arms are swung outwardly to move the cutter G outwardly into an expanded position as shown in FIGURES 2 and 6. In such position, a rotation of the drill string rotates the main body portion E, the drill bit C and the cutter-carrying elements F, whereby the drill bit section C will drill a well bore and the cutters G will enlarge or ream the well bore to the final desired diameter. When the piston returns to its upper position, as shown in FIGURE 1, the links J connected therewith function to retract the cutter-carrying elements F and the cutters G. The sealing means K is secured to the actuating piston H and extends below the longitudinal slots in the body member E in which the arms F are positioned to provide a flowpath for the circulation of drilling fluids downwardly into the lower portion of the body and to the lower drill bit section C. The lower portion of the body E or the connecting sub is provided with upwardly directed passages L through which drilling fluids are directed toward the cutting area of the cutters G, it being understood that direct impingement on the cutters G is normally avoided to prevent excessive erosion of the cutters by the drilling fluid. Additionally, the lower drill bit section C is provided with the usual fluid passageways through which the drilling fluids are also directed onto the cutting area of the cutters of the drill bit C to wash cuttings away from the cutting surface.

The body portion E comprises an upper tubular section **10** having its upper end connected to the drill pipe D, a lower housing **11** which is connected to the upper section by the threads **12**. A connecting sub **13** is connected to the lower housing **11** by the threads **14** and to the lower drill bit section C by the threads **15**. The upper section **10** has a bore **10***a* which communicates with the bore of the drill pipe D and a counterbore **10***b* within which the piston H is slideable. The housing **11** has an axial bore **11***a* extending substantially therethrough and terminating in a shoulder **11***b*.

A plurality of vertically extending slots **16** are formed within the body for the reception of the cutter-carrying elements or arms F and, as shown, three such slots are provided, although the number may vary. Each slot **16** extends longitudinally of the housing **11**, and openings **17** for the reception of the ends of the pivot pin **18**, which pivots a cutter element within the slot, are drilled in the side walls of each slot. The lower end of each slot terminates in a circular opening **16***a* through which the cone cutter G mounted on the lower end of each cutter-carrying arm F may move.

Each cutter-carrying element or arm F is substantially rectangular in cross section, being provided with an ear **19** having a transverse opening **20** therein. The width of each arm is substantially the same as the width of the slot **16**, and when the arm F is in position within the slot, the pivot pin **18** extends through the opening **20** with its ends engaged in the openings **17** of the housing **11**, whereby each arm is pivotally mounted within each slot. The inner face of each cutter arm is formed to have a boss **21** having a transverse opening therein, is preferably formed integral with the arm and has a width less than the width of the arm so that one of the connecting links J may be received on each side of the boss **21**. Below the boss **21** and disposed at one side of the cutter arm F is an inwardly projecting drive lug **23**. The surface on one side of the drive lug **23** is in substantial contact with one side wall of the slot **16**, whereby when the arm F is in position within the slot and rotation is imparted to the housing **11**, such rotation is transmitted to the cutter arm by reason of the housing contacting such surface on the lug **23**.

Below the drive lug **23** the lower portion of the cutter is bevelled outwardly to provide bevelled surfaces **24**, and in the lower portion of this lower end a slot **25** is formed.

The slot **25** and bevelled surfaces **24** are provided to receive the cutter assembly G which is the standard cone-type bit. The cutter assembly G is provided with the usual cutter shaft and bearing arrangement (not shown) for securing the cutters to the lower end of the arms F. It will be evident that with each cutter arm pivoted within its respective slot, the cutters may be moved inwardly as shown in FIGURES 1 and 3 to a fully retracted position. By reason of the pivot pin **18** at the upper end of the arms, the arms may be swung outwardly beyond the confines of the outer surface of the housing **11** so that the cutters G will be expanded as shown in FIGURES 2 and 6.

For effecting simultaneous expansion of the cutter arms F, each cutter arm has connection through the links J with a connecting element **26**, which element is directly connecting through the tubular sleeve **27** with the lower end of the annular piston H. The element **26** has a plurality of outwardly projecting lugs **28** through which the links J for each of the arms F are pivotally connected to the element **26**.

The ring **29** is secured as by welding in the bore **11***a* of the housing **11** and provides an upwardly facing shoulder **30** against which the lower end of the stop ring **31** and the lower end of the spring **32** abut. When the annular piston H is in its raised position, as illustrated in FIGURE 1, to which it is urged by the coil spring **32**, the connecting element **26** is also raised to be in proximity to the upper, inner surface of each cutter arm F. By reason of the connection of the links J, the links are swung to the position shown in FIGURE 1 which causes their lower ends to move inwardly and maintain each arm retracted within the housing. An orifice ring **33** is mounted within the lower portion of the bore of the tubular sleeve **27**, and when pressure fluid is pumped downwardly through the drill stem, the annular piston H, the connecting sleeve **27** and its orifice ring **33**, the orifice ring creates a restriction which will cause the pressure build-up above the piston H. When this increased pressure overcomes the force of the coil spring **32**, the piston H, the sleeve **27** and the connecting element **26** move downwardly with respect to the housing and the cutter arms F. This moves the upper pivot point between the connecting links J and the element **26** downwardly which results in an outward swinging movement of the lower ends of the links J; such outward swinging movement causes the cutter arms F to pivot about the upper pin whereby the lower ends of the arms are swung outwardly to move the cutters G to an expanded position.

In order to control the radial expansion of the cutter arms, the downward movement of the annular piston H is limited by the stop ring **31** which surrounds the spring **32** and sleeve **27** and rests on the shoulder **30** formed on the ring **29**. When the lower end H′ of the piston engages the upper end of the stop ring **31**, further downward movement of the piston is prevented to thereby limit the extent to which the lower end of links J is swung.

The sealing means K is provided by the combined assembly of the piston H having a seal ring **34** sealing against the counterbore **10***b* of the upper section **10**, the sleeve **27** and the lower seal **35** which is provided between the exterior of the sleeve **27** at a point below the lower end of the slot **16**. The seal ring **35** is positioned in a groove in the element **36** which is welded or otherwise suitably secured in the lower portion of the bore of the housing **11** against the shoulder **11***b*. Thus, the sealing means K provides a seal flowpath extending through the interior of the upper reaming section B from a position above the slots **16** to a position below the slots **16**, whereby drilling fluids circulating downwardly through the drill stem flow through such flowpath and will be sealed from flowing outwardly through the slots **16**.

The connecting sub **13** is provided with a central bore **13***a* in communication with the flowpath of the sealing means K and a plurality of upwardly directed passageways **37** which communicate from the bore **13***a* of the sub

13 to the exterior of the sub. Referring specifically to the section illustrated in FIGURE 5, the outer end of each passageway 37 is provided with a counterbore 38 into which a suitable bushing 39 is secured as by welding. The bushing 39 is provided with an internal bore in communication with the passageway 37 and a suitable counterbore for receiving the nozzle insert 40 which is held in place by the snap ring 41. The nozzle insert 40 is made of a suitable hard faced material as is normally used for drilling fluid nozzles to provide extended life for the insert. The nozzle includes a restriction in the passageway to control the flow therethrough and to direct the flow in a preselected direction with respect to the cutters G.

The drilling fluid passageways M in the lower drill bit section C are also provided with suitable nozzle insert similar to nozzle inserts 40. Normally, it is desired that the diameter of the openings through the nozzle inserts 40 and through the nozzle inserts in the drill bit C be of substantially the same size to distribute the drilling fluid evenly to the cutting areas. In one unit it was found that a three-eights inch diameter opening in each of three nozzles in the sub 13 and in each of three nozzles in the drill bit C functioned to efficiently remove the cuttings from both cutting areas.

The upward inclination of the passageways L and the velocity of fluid discharged through the nozzles 40 into the annulus around sub 13 will create a suction effect to coact and assist the fluid from the passageways M to move the cuttings upwardly through the annulus to the surface. The proper apportioning of the flow through the passageways L and M and the upward inclination of the passageways L provide efficient removal of cuttings from both cutting areas and prevent the balling-up of the cutters. Such removal of cuttings is normally considered necessary to drill with cone rock-bit-type cutters.

The tool of the present invention illustrated in FIGURE 6 is substantially identical with the tool A of FIGURES 1 to 5. The same elements are labeled with the same designations in all illustrations of both forms of the tool. The difference in the tool illustrated in FIGURE 6 from tool A is that the lower sub 13 of tool A has been omitted and the drill bit C has been connected directly to the lower end of the housing 11 by the threads 42. In this form of the device the sealing means K provides a flowpath for drilling fluid in communication with the passageways 43. The passageways 43 extend completely through the housing 11 at a point below the lower seal ring 35, and each passageway 43 is provided with a suitable bushing and nozzle insert indicated generally at 44 which functions and is constructed similar to the structure shown in FIGURE 5. The passageways 43 are inclined upwardly and each one intersects with a circular opening 16*a* at the lower end of a slot 16. In this form, the drilling fluids will be directed through the passageways 43 and the bushings and nozzle inserts 44 upwardly at a slight angle toward the cutting area or surface 45 on which the cutters G are performing the reaming.

By directing the drilling fluids upwardly on discharge from the passageways 43 in the form illustrated in FIGURE 6, the streams flowing therefrom will coact and assist in the upward flow of the drilling fluid and cuttings from the well bore 46 which is being drilled by the lower drill bit section C. In each form of the invention illustrated in the figures the usual passageways for the circulation of drilling fluids are provided in the drill bit C and the drilling fluid is circulated to remove the cuttings from the lower end of the well bore while additional fluid circulation is provided for the upper reaming section B. The upper fluid circulation is directed upwardly with sufficient velocity to remove the cuttings from under the cutters G. The direction of the fluid passages in both forms of the invention is inclined upwardly toward the

cutting area of the cutters G and the control of the flow through the respective fluids passages L and M coacts to provide more efficient combined drilling and reaming.

The sealing means K provides a flowpath for drilling fluid through the tool which seals both above and below the longitudinal slots in which the movable cutter arms are positioned, so that the fluids circulated downwardly through the drill stem will pass through the tool without being dissipated by passage outwardly through the slots 16. Thus, both the direction and the amount of flow of drilling fluid to be directed at each cutting area are controlled to provide an efficient drilling and reaming by the tool of the present invention.

What is claimed is:

1. A combination drilling tool for drilling a well bore comprising:
- an upper reaming section having a body with a central bore therethrough and an expansible cutter mounted therein for radial movement outwardly therefrom,
- said expansible cutter having a cone-type rock-bit cutter,
- a drill bit section having cutters for drilling a pilot well bore slightly larger than the diameter of said body,
- a sub connecting between said upper reaming section and said drill bit section,
- said sub having a central bore therethrough in communication with said central bore through said body,
- said drill bit section defining a passageway communicating with the central bore of said sub to direct drilling fluid toward the cutting area of said lower drill bit section,
- jet nozzles in said sub in communication with the central bore therethrough,
- said jet nozzles being directed upwardly and outwardly of said sub whereby drilling fluid flowing through said jet nozzles assists in the movement of well cuttings from said lower drill bit section through the narrow space between said body and said pilot well bore and washes the cuttings from said expansible cutter upwardly from the cutting area of said expansible cutter.

2. The combination according to claim 1, wherein:
- said passageway and said jet nozzles are of preselected sizes to apportion the flow of drilling fluid directed to the cutting area of said lower drill bit section in relation to the flow of drilling fluid through said jet nozzles to assure that cuttings from said lower drill bit section are carried through the narrow space between said body of said upper reaming section and the wall of said pilot well bore.

3. The combination according to claim 1 including:
- jet nozzles in said lower drill bit section and communicating with said passageway,
- said jet nozzles of said connecting sub and said jet nozzles of said lower drill bit section each having substantially the same size opening whereby a substantial portion of the drilling fluid flows through said jet nozzles in said connecting sub to force cuttings from said lower drill bit section through said narrow space between said body and said pilot well bore.

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JAMES A. LEPPINK, *Primary Examiner.*